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Implantable cardioverter-defibrillator placement among patients with left ventricular ejection fraction 35 % at least 40 days after acute myocardial infarction

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Abstract

Background: Implantable cardioverter-defibrillators (ICDs) reduce the risk of sudden cardiac death among patients with persistently reduced (35 %) left ventricular ejection fraction (LVEF) at least 40 days following acute myocardial infarction (AMI). Few prior studies have used LVEF measured after the 40-day waiting period to examine primary prevention ICD placement.

Methods: We sought to determine factors associated with ICD placement among patients who met LVEF criteria post-MI within a large integrated health care system in the U.S by conducting a retrospective cohort study of Veteran patients hospitalized for AMI from 2004 to 2017 who had documented LVEF 35 % from echocardiograms performed between 40 and 455 (90 days +1

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year) days post-MI. We used multivariable logistic regression to examine factors associated with ICD placement.

Results: Of 12,893 patients with LVEF ≤ 35 % at least 40 days post-MI, 2176 (16.9 %) received an ICD between 91- and 455-days post-MI. Younger age, fewer comorbidities, revascularization with PCI, and greater use of GDMT were associated with increased odds of receiving an ICD. However, half of patients treated with a beta-blocker, ACE inhibitor or angiotensin receptor blocker, and mineralocorticoid receptor antagonist prior to LVEF assessment did not receive an ICD. Eligible Black patients were less likely (odds ratio 0.80, 95 % confidence interval 0.69–0.92) to receive an ICD than White patients.

Conclusion: Many factors affect ICD placement among Veteran patients with a confirmed LVEF ≤ 35 % at least 40 days post-MI. Greater understanding of factors influencing ICD placement would help clinicians ensure guideline-concordant care.

1. Introduction

Implantable cardioverter-defibrillators (ICD) reduce risk of sudden cardiac death in appropriately selected patients with reduced left ventricular ejection fraction (LVEF) [1,2]. Accordingly, a Class 1, Level of Evidence A clinical practice guideline recommends primary prevention ICD placement in patients with an LVEF of ≤ 35 % who are treated with optimal medical therapy for at least 40 days following acute myocardial infarction (AMI) or at least 90 days following revascularization with either percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) [3,4]. Previous research has shown that ICDs are underutilized among patients who meet primary prevention criteria [5,6]. Prior studies have relied on LVEF at the time of hospital discharge after AMI, but less is known about patients who have persistent ventricular dysfunction after discharge [7–9]. Because LVEF often improves within the post-MI period, using LVEF assessed only at the time of AMI significantly overestimates the proportion of patients eligible for ICDs. The mean LVEF in one large national study improved from 28 % to 40 % after 90 days; in fact, fewer than half of patients with LVEF ≤ 35 % during AMI hospitalization had an LVEF ≤ 35 % 90 days post-MI [10]. Further, a minority of patients with reduced LVEF at hospital discharge will have a repeat LVEF assessment performed, which is required to evaluate candidacy for primary prevention ICD placement. Among patients who meet LVEF criteria for a primary prevention ICD post-MI, there is limited understanding about the demographic and clinical factors associated with device placement. The Department of Veterans Affairs is a large integrated health care delivery system in the U.S., with coordination between inpatient and outpatient care as well as care paid for in non-VA hospitals. Studying ICD placement in this setting enables detailed understanding of ICD placement among eligible patients. Accordingly, we sought to examine the factors associated with ICD use among an eligible cohort of Veteran patients hospitalized for AMI with an LVEF ≤ 35 % on echocardiography performed at least 40-days post-MI.

2. Methods

2.1. Data sources

We obtained clinical data from three sources that encompass the settings in which Veterans receive care. First, through the VA Corporate Data Warehouse (CDW), we obtained internal VA administrative claims data and clinical records from care provided within VA facilities. The VA CDW includes information from inpatient and outpatient care as well as pharmacy data for care received by Veterans across any VA facility in the United States. Second, we included fee-basis VA claims for Veterans. This data source includes care for Veteran patients that is received outside of a VA facility, but for which VA is the payor. Third, some Veterans (primarily those 65 years of age and older) have Medicare fee-for-service (FFS) coverage in addition to the VA care that they receive. Therefore, in order to increase the comprehensiveness of data, we included all three of these data sources.

We also used the Veterans Affairs National Cardiac Device Surveillance Program (VANCDSP) to identify Veterans with ICDs. All Veterans with ICDs placed within VA or with ICDs placed outside VA who are followed for remote monitoring within VA must be registered with the VANCDSP. This study was approved by the University of California, San Francisco Institutional Review Board.

2.2. Study population

We identified all Veterans who were enrolled in the Veterans Health Administration and hospitalized with a discharge diagnosis of AMI between January 1, 2004 and December 31, 2017 from VA electronic health record data, VA purchased care claims data, and Medicare Part A and B claims data.

We identified AMI using International Classification of Diseases-Clinical Modification (ICD)-9 and 10-CM discharge codes (Supplementary Table 1) in any position. For patients hospitalized with multiple MIs during the study period, we included only the first hospitalization for AMI across all datasets. We excluded patients who had received an ICD prior to AMI hospitalization and those who died during the AMI hospitalization. Finally, we excluded patients with LVEF 35 % during follow-up echocardiographic assessment (see next section), since these patients are generally not recommended to have primary prevention ICD placement unless they have additional indications.

2.3. Left ventricular ejection fraction assessment

To assess LVEF, we used previously validated natural language processing (NLP) algorithms to scan official echocardiogram reports and extract LVEF values; the note titles are provided in Supplementary Table 2. [11] LVEF assessment also included previously curated datasets with validated values.

LVEF was assessed between 40 and 455 days following AMI admission date. This timeframe was chosen because clinical practice guidelines recommend waiting at least 40 days post-MI (or 90 days post-MI following revascularization) and for optimization of guideline-directed medical therapy (GDMT) for primary prevention ICD implantation in

patients with reduced LVEF [3]. The outer limit of 455 days was chosen as this was 1 year after the 90-day period for ICD implantation (i.e., 90 + 365 days = 455 days) Out of range LVEF values (<1 % or >100 %) were excluded.

2.4. Outcomes

Our primary outcome was ICD placement between 91- and 455-days post-MI admission date. We chose 91, instead of 40 days, for our primary outcome in this target population to have a consistent date across all patients, because patients undergoing revascularization are recommended to wait 90 days for ICD placement and many patients with AMI undergo revascularization [12–14]. For all patients, we provided an additional 1 year/365 day window after 90 days (i.e., 455 days). Our secondary outcome was all ICD placement at any time after AMI (90 days, between 91 and 455 days, and > 455 days); we included this outcome to comprehensively identify all ICD placement. ICD placement was identified using Current Procedural Terminology (CPT), ICD-9-CM procedure and 10-procedural coding system (PCS) codes (Supplementary Table 3), and the VANCDSP.

2.5. Covariates

Patient-level demographic characteristics included age, sex, race, ethnicity, annual income, rural vs. urban residence, visit to a homeless clinic in the year prior to AMI hospitalization, history of tobacco use, and marital status. We also included both cardiovascular and non-cardiovascular comorbidities: atrial fibrillation, cerebrovascular disease, valvular heart disease, peripheral vascular disease, diabetes mellitus, hypertension, dyslipidemia, chronic kidney disease, end-stage renal disease, chronic obstructive pulmonary disease, post-traumatic stress disorder, dementia, depression, and cancer (excluding non-melanoma skin cancer). Comorbidities were included if they had been recorded for at least 1 inpatient or 2 outpatient visits in the year preceding AMI hospitalization as ICD-9- and 10-CM codes in either the CDW or CMS datasets. Diagnostic coronary angiogram, percutaneous coronary intervention (PCI), and coronary artery bypass graft surgery (CABG) were assessed using CPT and ICD-9-CM procedure and ICD-10-PCS codes prior to, during, and within 30 days after AMI hospitalization (Supplementary Table 4).

GDMT prescriptions for heart failure with reduced ejection fraction (HFrEF) [15] were assessed in the 180 days preceding LVEF assessment. These medications are evidence-based beta blockers (BB), angiotensin converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB), and mineralocorticoid receptor antagonists (MRA). Angiotensin receptor-neprilysin inhibitor (ARNI) and sodium-glucose cotransporter-2 (SGLT2) were not included given limited use during the study period. Wearable cardioverter defibrillator (ZOLL LifeVest®; San Jose, California) use following LVEF determination was assessed using CPT and Healthcare Common Procedure Coding System (HCPCS) codes.

2.6. Statistical analysis

After creation of the study cohort, we identified patients who received ICDs and stratified these patients into multiple categories of timing (during hospitalization for AMI to 90 days later, between 91- and 455-days after AMI, > 455 days after AMI, and ICD never placed). We then compared demographics, comorbidities, procedural characteristics, GDMT

prescriptions, and assigned VA facility characteristics among patients who received ICDs between 91- and 455-days after AMI hospitalization to those who never received an ICD, using chi-square tests for categorical variables and *t*-tests for continuous variables; similarly, we compared characteristics across all strata of timing. We also examined ICD placement rates among patients on GDMT. We then conducted univariate analyses for all of these variables with ICD placement between 91- and 455-days compared to no ICD placement. Variables with $p < 0.10$ were then retained and included in a multivariable logistic regression model to identify patient characteristics independently associated with ICD placement. Statistical analyses were conducted using SAS Enterprise Guide 8.2 (Cary, NC).

3. Results

3.1. Study population

Between January 1, 2004 and December 31, 2017, 520,089 Veteran patients were hospitalized for AMI and had a follow-up echocardiogram within VA (Fig. 1). After exclusion of 444,298 patients whose LVEF assessment was outside the specified timeframe of 40 to 455 days post-MI, outside of interpretable range in value, or derived from notes outside of official echocardiographic assessments; 6213 patients with multiple LVEFs on a single echocardiogram report with at least one   35 % and at least one >35 % (likely because of inability in distinguishing between prior LVEF(s) and the LVEF in the current echocardiogram); 57,143 patients with LVEF   35 %; and 262 with ICD placement prior to AMI, the final study cohort consisted of 12,893 patients. Of these, 5645 (43.8 %) of whom had been initially hospitalized at a VA facility, 3324 (25.8 %) at a non-VA facility with VA as the payor, and 3924 (30.4 %) using Medicare fee-for-service insurance.

3.2. Timing of implantable cardioverter-defibrillator placement

Of the 12,893 patients who met LVEF criteria for a primary prevention ICD on echocardiography at least 40 days post-MI and up to a total 455 days later, 4470 (34.7 %) received an ICD. Of these 12,893 patients, 923 (7.2 %) had an ICD implanted within 90 days after AMI admission, 2176 (16.9 %) between 91- and 455-days after AMI admission, and 1371 (10.6 %)   455 days after AMI admission. Among patients who received ICD placement within 455 days of index AMI hospitalization, the largest number received the device within 90 days (Fig. 2). With each increasing 90-day interval, a smaller number of patients received ICDs.

An additional 1371 (10.6 %) patients had an ICD placed >455 days after AMI admission over a mean 3.5 (± 2.4) years follow-up. Overall, 8423 (65.3 %) never received an ICD. Among patients who received an ICD, 112 (5.1 %) died within one year after AMI discharge whereas 2272 (27.0 %) patients who did not receive an ICD died during that period.

3.3. Characteristics associated with ICD implantation

Comparing ICD placement among patients with an LVEF   35 % who received an ICD between 91 and 455 days post-MI to those never receiving an ICD, those who underwent ICD implantation were younger at first AMI hospitalization (65.7 vs. 70.4 years old, Table 1), more often White (72.3 % vs. 66.6 %), identified as not Hispanic or Latino (89.8 % vs.

84.8 %), more likely to live in rural areas (38.1 % vs. 32.0 %), and more likely to be married (47.4 % vs. 41.7 %). Patients who underwent ICD placement also had fewer medical comorbidities, including diabetes mellitus, hypertension, chronic kidney disease, end-stage renal disease requiring hemodialysis, cerebrovascular disease, peripheral vascular disease, cancer, dementia, valvular heart disease, and atrial fibrillation. Patients who received an ICD were more likely to have received a diagnostic angiogram or CABG during AMI hospitalization and PCI before, during, or within 30 days after AMI hospitalization. Patients who received an ICD were also more likely to receive a LifeVest® wearable cardioverter defibrillator after LVEF determination. The mortality rate at one year among patients who did not receive an ICD was 27.0 %, compared to 5.1 % among patients who received an ICD between 91 and 455 days post-MI. Characteristics of all 12,893 patients in the cohort, including those who received an ICD 90 days post-MI or > 455 days post-MI are presented in Table 2.

3.4. Guideline-directed medical therapy associated with ICD implantation

Patients implanted with an ICD were significantly more likely to be taking any of three primary guideline-directed medication classes for HFrEF within 180 days of LVEF assessment (92.8 % vs. 87.1 % for BB, 88.6 % vs. 77.1 % for ACEI/ARB, 32.5 % vs. 18.3 % for MRA). Patients implanted with an ICD were also more likely to be on a combination of BB and ACEI/ARB (83.4 % vs. 68.4 %), and combination of BB, ACEI/ARB, and MRA (29.8 % vs. 15.2 %).

Of the 12,893 patients in the cohort, 9382 (72.8 %) were on a combination of BB and ACEI/ARB within 180 days of LVEF assessment (Table 2). Among these 9382 patients taking a BB and ACEI/ARB, 3624 (38.6 %) received an ICD at any time; 1814 (50.1 %) of these were placed between 91- and 455-days post-MI. Among the 2527 patients taking a BB, ACEI/ARB, and MRA, 1249 (49.4 %) received an ICD at any time; 648 (51.9 %) of these were placed between 91- and 455-days post-MI.

3.5. Factors associated with ICD implantation

In multivariable regression, multiple demographic variables were associated with ICD implantation, including age (OR 0.97, 95 % CI 0.97–0.98 for each year increase, Table 3). Compared to White patients, Black patients were less likely to receive ICDs (OR 0.80, 95 % CI 0.69–0.93). Married patients were more likely to receive an ICD compared to those who were never married or divorced/widowed (OR 1.40, 95 % CI 1.26–1.55).

Multiple comorbidities were associated with lower odds of ICD implantation, including dementia (OR 0.50, 95 % CI 0.33–0.77), diabetes mellitus (OR 0.81, 95 % CI 0.73–0.90), and chronic obstructive pulmonary disease (OR 0.83, 95 % CI 0.74–0.93). PTSD, hypertension, chronic kidney disease, end-stage renal disease, cerebrovascular disease, peripheral vascular disease, cancer, valvular heart disease, atrial fibrillation, and tobacco use disorder were not significantly associated with ICD implantation. PCI before (OR 1.23, 95 % CI 1.05–1.46), during (OR 1.39, 95 % CI 1.22–1.57), and within 30 days of AMI admission (OR 1.35, 95 % CI 1.05–1.73) was significantly associated with ICD

placement. MRA prescription within 180 days of LVEF assessment was associated with ICD implantation (OR 1.59, 95 % CI 1.15–2.20).

4. Discussion

Among 12,893 Veteran patients with an AMI and documented LVEF 35 % on echocardiography at least 40 days later, 2176 (16.5 %) received an ICD between 91- and 455-days after AMI, in addition to 923 (7.2 %) who received an ICD prior to 90 days. Advanced age and multiple comorbidities were associated with lower odds of ICD placement. Black Veterans were less likely to receive ICDs. Previous studies have reported low rates of ICD use in eligible populations, but these have been limited by lack of data on LVEF assessments 40 days post-MI [6,8]. Using a validated NLP algorithm applied to echocardiography reports, we identified patients who definitively had a persistently reduced LVEF, thereby increasing the accuracy and specificity of this key criterion for eligibility of primary prevention ICD placement.

There are many possible reasons for non-implantation of ICDs. Physicians may miss the opportunity to refer patients for ICD placement, even though discussion regarding ICD placement is a performance measure [16]. Clinical reminders and screening tools augment referral rates for ICD [17,18]. Another common reason is patient preference, which may be related to concerns about an implanted device, complications, and inappropriate device therapies [19,20].

However, we identified significant disparities by a variety of important factors, even though all patients had the same insurance coverage. Black race was associated with reduced odds of ICD placement. Racial disparities have been identified in many cardiovascular procedures [21–23], including ICD placement in non-VA populations [24,25]. Although prior research has demonstrated the potential of more equal access to care within VA than outside VA is associated with improved outcomes in Black compared to White patients [26,27], including reduced cardiovascular events, we identified a disparity in care among patients who definitively met objective LVEF criteria. Reasons for this disparity are likely multifactorial and complex and may include clinician bias, structural inequities in care, and other barriers [28]. Future qualitative work may help elucidate the differences in observed rates of ICD use by race to facilitate the delivery of more equitable, evidence-based care.

We also found that increasing patient age and greater comorbidity burden, such as diabetes and chronic obstructive pulmonary disease, were associated with lower odds of ICD placement among eligible patients. Patients with CKD and ESRD were not significantly less likely to receive ICDs. Although prior studies have indicated reduced benefit in subpopulations with renal disease [29,30], clinical practice guidelines do not specifically comment on these clinical factors and, thus, decision-making may not have been affected.

Patients with frailty and dementia have high mortality, with approximately one-fourth of these patients dying within 1 year of ICD placement [31]. We found that more than one-fourth of patients who did not receive an ICD within 1 year of discharge had died during that timeframe. While some deaths may have been arrhythmic in origin and could

have been reduced by ICD therapy, it is also likely that many patients were appropriately not selected for ICD placement given their prognosis of a high near-term mortality risk because guidelines state ICD placement in patients without reasonable expectation of 1-year survival with good functional status is contraindicated [3]. We also found that approximately 7 % of patients had an ICD placed within 90 days of hospitalization for AMI; there may have been a variety of reasons for these ICD placements, including 40 days having passed among patients who did not receive revascularization or patients meeting an indication for secondary prevention.

We found an opportunity to improve the use of GDMT prior to LVEF assessment and ICD placement. While rates of BB and ACE/ARB were higher than 80 %, MRAs were only prescribed in approximately one-fourth of patients, consistent with prior research in non-VA populations showing that fewer than one-third of eligible patients receive all of these medication classes [32]. Even though patients treated with GDMT were more likely to receive an ICD than those not receiving GDMT, only half of patients treated with BB, ACE/ARB, and MRA received an ICD. As both ARNI and SGLT2 inhibitors are now recommended for patients with HFrEF by professional society consensus [33], it will be important to ensure that patients are prescribed these medications and at optimal doses prior to LVEF assessment and ICD placement. Although there are concerns about the out-of-pocket expenses for these medications [34], patients receiving care in VA are generally insulated from these high costs.

4.1. Study limitations

The present analysis should be interpreted in the context of several limitations. First, data on myocardial infarction and comorbidities were obtained from administrative claims codes, which may not adequately capture all relevant clinical information. However, these databases are widely used and enabled the large-scale study that we conducted. Second, we did not have available data on New York Heart Association class and life expectancy, which are important criteria for ICD eligibility. The fact that nearly one-fourth of patients who did not receive ICDs died within the first year suggests that they likely had significant comorbid disease that would have led them to not qualify for ICD placement. Third, we did not examine doses of GDMT to ensure that patients were optimized to the extent tolerated. Optimization of medications takes time, and likely explains why patients continued to receive ICDs one year or later after their AMI. Fourth, we only examined patients who qualified for primary prevention ICD placement and not secondary prevention indications. However, only one-fourth of ICDs are placed for secondary prevention [35], which means that we captured the majority of ICD placement. Fifth, some Veterans over age 65 are enrolled in Medicare Part C (Medicare Advantage), and we only had access to data from Medicare Parts A and B, so we may not have captured ICDs implanted through Medicare Part C. Approximately one-third of Veterans over age 65 have Medicare Part C; although this number has been growing, it was much smaller during the years of our study. Finally, we did not determine reasons for why individual Veterans did or did not receive an ICD. As mentioned, many factors influence ICD placement, and the decreased life expectancy and comorbidities such as dementia may have appropriately led to lower rates of placement; this

is an important area for future investigation, which could inform targeted interventions that improve care.

5.   Conclusions

In conclusion, increasing age, Black race, and patient comorbidity burden were associated with lower odds of receiving an ICD between 91- and 455-days post-MI among patients who met LVEF criteria. Future qualitative research could provide a more detailed understanding of the impact of patient, clinician, and system factors on decisions about ICD placement among patients with a reduced LVEF post-MI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding

References

[1]. Moss AJ, Zareba W, Hall WJ, Klein H, Wilber DJ, Cannom DS, et al. , Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction, N. Engl. J. Med. 346 (12) (2002) 877–883. [PubMed: 11907286]

[2]. Bardy GH, Lee KL, Mark DB, Poole JE, Packer DL, Boineau R, et al. , Amiodarone or an implantable cardioverter-defibrillator for congestive heart failure, N. Engl. J. Med. 352 (3) (2005) 225–237. [PubMed: 15659722]

[3]. Epstein AE, DiMarco JP, Ellenbogen KA, Estes NA 3rd, Freedman RA, Gettes LS, et al. , ACC/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines (Writing Committee to Revise the ACC/AHA/NASPE 2002 guideline update for implantation of cardiac pacemakers and antiarrhythmia devices) developed in collaboration with the American Association for Thoracic Surgery and Society of Thoracic Surgeons, J. Am. Coll. Cardiol. 51 (21) (2008) e1–e62. [PubMed: 18498951]

[4]. Al-Khatib SM, Stevenson WG, Ackerman MJ, Bryant WJ, Callans DJ, Curtis AB, et al. , 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: a report of the American College of Cardiology/American Heart Association Task Force on clinical practice guidelines and the Heart Rhythm Society, Circulation 138 (13) (2018) e272–e391. [PubMed: 29084731]

[5]. Narayanan K, Reinier K, Uy-Evanado A, Teodorescu C, Chugh H, Marijon E, et al. , Frequency and determinants of implantable cardioverter defibrillator deployment among primary prevention candidates with subsequent sudden cardiac arrest in the community, Circulation 128 (16) (2013) 1733–1738. [PubMed: 24048201]

[6]. Pokorney SD, Miller AL, Chen AY, Thomas L, Fonarow GC, de Lemos JA, et al. , Implantable cardioverter-defibrillator use among Medicare patients with low ejection fraction after acute myocardial infarction, JAMA 313 (24) (2015) 2433–2440. [PubMed: 26103027]

[7]. Pokorney SD, Miller AL, Chen AY, Thomas L, Fonarow GC, de Lemos JA, et al. , Reassessment of cardiac function and implantable cardioverter-defibrillator use among Medicare patients with low ejection fraction after myocardial infarction, Circulation 135 (1) (2017) 38–47. [PubMed: 27881561]

[8]. Goldstein SA, Li S, Lu D, Matsouaka RA, Rymer J, Fonarow GC, et al. , Implantable cardioverter defibrillator utilization and mortality among patients >/=65 years of age with a low ejection fraction after coronary revascularization, Am. J. Cardiol. 138 (2021) 26–32. [PubMed: 33068540]

[9]. Zhang L, Narayanan K, Chugh H, Shiota T, Zheng ZJ, Chugh SS, Factors influencing utilization of the primary prevention implantable defibrillator, PLoS One 10 (3) (2015), e0121515. [PubMed: 25794248]

[10]. Brooks GC, Lee BK, Rao R, Lin F, Morin DP, Zweibel SL, et al. , Predicting persistent left ventricular dysfunction following myocardial infarction: the PREDICTS study, J. Am. Coll. Cardiol. 67 (10) (2016) 1186–1196. [PubMed: 26965540]

[11]. Patterson OV, Freiberg MS, Skanderson M, S JF, Brandt CA, DuVall SL, Unlocking echocardiogram measurements for heart disease research through natural language processing, BMC Cardiovasc. Disord. 17 (1) (2017) 151. [PubMed: 28606104]

[12]. O'Gara PT, Kushner FG, Ascheim DD, Casey DE Jr., M.K. Chung, J.A. de Lemos, et al. , 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines, J. Am. Coll. Cardiol. 61 (4) (2013) e78–e140. [PubMed: 23256914]

[13]. Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al. , 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC), Eur. Heart J. 39 (2) (2018) 119–177. [PubMed: 28886621]

[14]. Case BC, Yerasi C, Wang Y, Forrestal BJ, Hahm J, Dolman S, et al. , Admissions rate and timing of revascularization in the United States in patients with non-ST-elevation myocardial infarction, Am. J. Cardiol. 134 (2020) 24–31. [PubMed: 32892989]

[15]. Writing Committee M, Yancy CW, Jessup M, Bozkurt B, Butler J, Casey DE Jr., et al. , 2013 ACCF/AHA guideline for the management of heart failure: a report of the American College of Cardiology Foundation/American Heart Association Task Force on practice guidelines, Circulation 128 (16) (2013) e240–e327. [PubMed: 23741058]

[16]. Heidenreich PA, Fonarow GC, Breathett K, Jurgens CY, Pisani BA, Pozehl BJ, et al. , 2020 ACC/AHA clinical performance and quality measures for adults with heart failure: a report of the American College of Cardiology/American Heart Association task Force on performance measures, Circ. Cardiovasc. Qual. Outcomes 13 (11) (2020), e000099.

[17]. Gupta A, Gholami P, Turakhia MP, Friday K, Heidenreich PA, Clinical reminders to providers of patients with reduced left ventricular ejection fraction increase defibrillator referral: a randomized trial, Circ. Heart Fail. 7 (1) (2014) 140–145. [PubMed: 24319096]

[18]. Gravelin LM, Yuhas J, Remetz M, Radford M, Foley J, Lampert R, Use of a screening tool improves appropriate referral to an electrophysiologist for implantable cardioverter-defibrillators for primary prevention of sudden cardiac death, Circ. Cardiovasc. Qual Outcomes 4 (2) (2011) 152–156. [PubMed: 21304093]

[19]. Bernier R, Ng J, Tran DT, Lockwood E, Reyes L, Cowan K, et al. , A population-based study of device eligibility, use, and reasons for nonimplantation in patients at heart function clinics, CJC Open 1 (4) (2019) 173–181. [PubMed: 32159104]

[20]. Lyons KJ, Podder M, Ezekowitz JA, Rates and reasons for device-based guideline eligibility in patients with heart failure, Heart Rhythm 11 (11) (2014) 1983–1990. [PubMed: 25101484]

[21]. Whittle J, Conigliaro J, Good CB, Lofgren RP, Racial differences in the use of invasive cardiovascular procedures in the Department of Veterans Affairs medical system, N. Engl. J. Med. 329 (9) (1993) 621–627. [PubMed: 8341338]

[22]. Oddone EZ, Horner RD, Johnston DC, Stechuchak K, McIntyre L, Ward A, et al. , Carotid endarterectomy and race: do clinical indications and patient preferences account for differences? Stroke 33 (12) (2002) 2936–2943. [PubMed: 12468794]

[23]. Groeneveld PW, Kruse GB, Chen Z, Asch DA, Variation in cardiac procedure use and racial disparity among Veterans Affairs Hospitals, Am. Heart J. 153 (2) (2007) 320–327. [PubMed: 17239696]

[24]. Hernandez AF, Fonarow GC, Liang L, Al-Khatib SM, Curtis LH, LaBresh KA, et al. , Sex and racial differences in the use of implantable cardioverter-defibrillators among patients hospitalized with heart failure, JAMA 298 (13) (2007) 1525–1532. [PubMed: 17911497]

[25]. Gauri AJ, Davis A, Hong T, Burke MC, Knight BP, Disparities in the use of primary prevention and defibrillator therapy among blacks and women, Am. J. Med. 119 (2) (2006) 167.e17–167.e21.

[26]. Kovesdy CP, Norris KC, Boulware LE, Lu JL, Ma JZ, Streja E, et al. , Association of race with mortality and cardiovascular events in a large cohort of US veterans, Circulation 132 (16) (2015) 1538–1548. [PubMed: 26384521]

[27]. Jha AK, Shlipak MG, Hosmer W, Frances CD, Browner WS, Racial differences in mortality among men hospitalized in the Veterans Affairs health care system, JAMA 285 (3) (2001) 297–303. [PubMed: 11176839]

[28]. Bailey ZD, Feldman JM, Bassett MT, How structural racism works - racist policies as a root cause of U.S. racial health inequities, N. Engl. J. Med. 384 (8) (2021) 768–773. [PubMed: 33326717]

[29]. Bansal N, Szpiro A, Reynolds K, Smith DH, Magid DJ, Gurwitz JH, et al. , Long-term outcomes associated with implantable cardioverter defibrillator in adults with chronic kidney disease, JAMA Intern. Med. 178 (3) (2018) 390–398. [PubMed: 29404570]

[30]. Jukema JW, Timal RJ, Rotmans JI, Hensen LCR, Buiten MS, de Bie MK, et al. , Prophylactic use of implantable cardioverter-defibrillators in the prevention of sudden cardiac death in dialysis patients, Circulation 139 (23) (2019) 2628–2638. [PubMed: 30882234]

[31]. Green AR, Leff B, Wang Y, Spatz ES, Masoudi FA, Peterson PN, et al. , Geriatric conditions in patients undergoing defibrillator implantation for prevention of sudden cardiac death: prevalence and impact on mortality, Circ. Cardiovasc. Qual. Outcomes 9 (1) (2016) 23–30. [PubMed: 26715650]

[32]. Albert NM, Yancy CW, Liang L, Zhao X, Hernandez AF, Peterson ED, et al. , Use of aldosterone antagonists in heart failure, JAMA 302 (15) (2009) 1658–1665. [PubMed: 19843900]

[33]. Writing C, Maddox TM, Januzzi JL Jr., Allen LA, Breathett K, Butler J, et al. , 2021 update to the 2017 ACC expert consensus decision pathway for optimization of heart failure treatment: answers to 10 pivotal issues about heart failure with reduced ejection fraction: a report of the American College of Cardiology Solution Set Oversight Committee, J. Am. Coll. Cardiol. 77 (6) (2021) 772–810. [PubMed: 33446410]

[34]. Luo J, Feldman R, Rothenberger SD, Hernandez I, Gellad WF, Coverage, formulary restrictions, and out-of-pocket costs for sodium-glucose cotransporter 2 inhibitors and glucagon-like peptide 1 receptor agonists in the Medicare part D program, JAMA Netw. Open 3 (10) (2020), e2020969. [PubMed: 33057641]

[35]. Masoudi FA, Ponirakis A, de Lemos JA, Jollis JG, Kremers M, Messenger JC, et al. , Trends in U.S. cardiovascular care: 2016 report from 4 ACC National Cardiovascular Data Registries, J. Am. Coll. Cardiol. 69 (11) (2017) 1427–1450. [PubMed: 28025065]
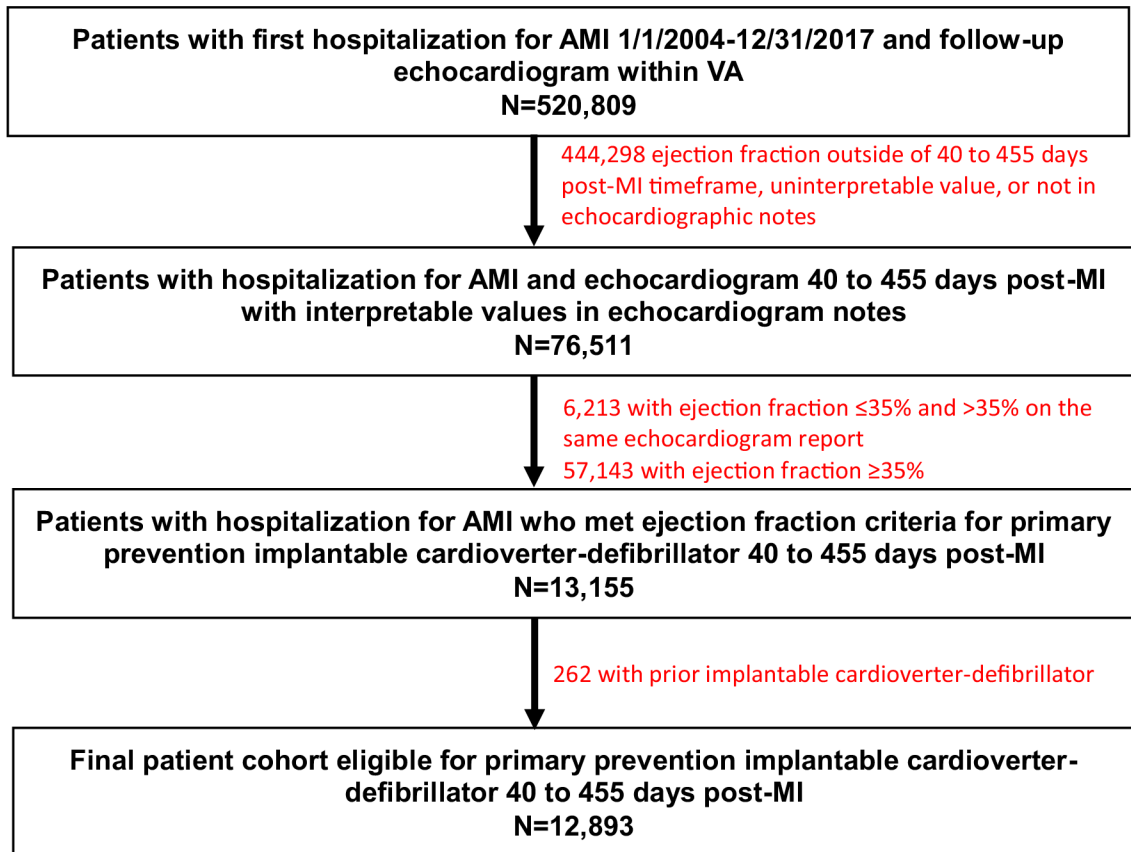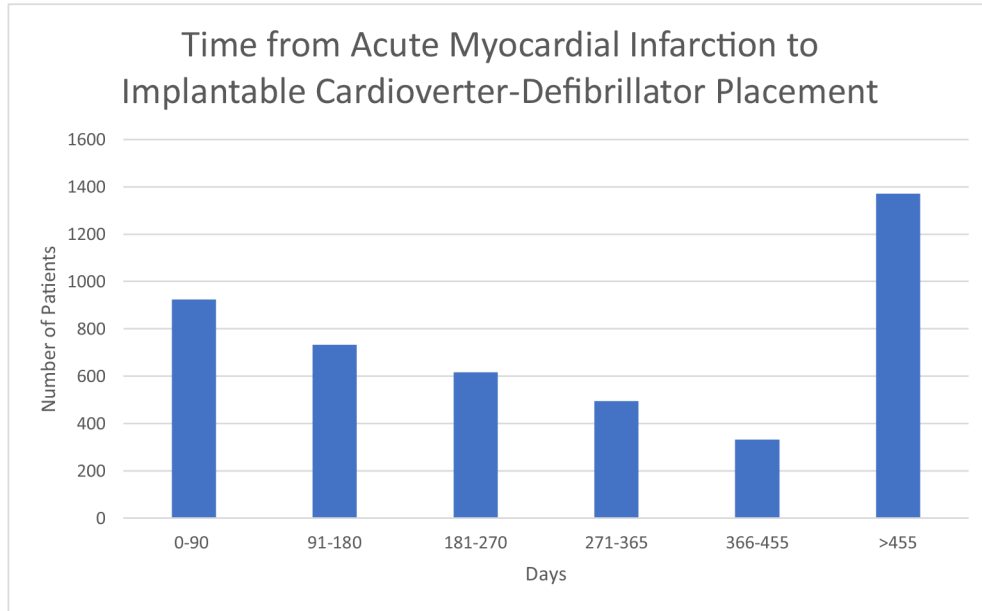
Fig. 1.
Flow diagram of study cohort.

Fig. 2.

Distribution of time from admission for acute myocardial infarction to implantable cardioverter-defibrillator placement.

Table 1

Demographic, clinical, procedural, and facility-level variables among patients meeting left ventricular ejection fraction criterion for implantable cardioverter-defibrillator placement.

	Total (*N* = 10,599)	Received ICD between 91 and 455 days after acute myocardial infarction (*N* = 2176)	Did not receive ICD (*N* = 8423)	*p*-value
Demographics				
Age (years) at time of AMI hospitalization, mean (SD)	69.4 (10.8)	65.7 (9.2)	70.4 (11.0)	<0.0001
Race				<0.0001
White	7181 (67.8 %)	1573 (72.3 %)	5608 (66.6 %)	
Black	1993 (18.8 %)	381 (17.5 %)	1612 (19.1 %)	
Other race / unknown	1425 (13.4 %)	222 (10.2 %)	1203 (14.3 %)	
Ethnicity				<0.0001
Not Hispanic or Latino	9091 (85.8 %)	1953 (89.8 %)	7138 (84.7 %)	
Hispanic or Latino	630 (5.9 %)	113 (5.2 %)	517 (6.2 %)	
Declined to answer	273 (2.0 %)	37 (1.7 %)	180 (2.1 %)	
Unknown / missing	661 (6.2 %)	73 (3.4 %)	588 (6.9 %)	
Rural residence	3520 (33.2 %)	828 (38.1 %)	2692 (32.0 %)	<0.0001
Annual income ($), median (IQR)	18,540 (11,396–32,640)	20,340 (12,188–34,803)	18,036 (11,076–32,076)	<0.0001
Married	4540 (42.8 %)	1031 (47.4 %)	3509 (41.7 %)	<0.0001
Visit to homeless clinic in year prior to AMI	1298 (12.2 %)	278 (12.8 %)	1020 (12.1 %)	0.40
Tobacco use history	9121 (86.1 %)	1957 (89.9 %)	7164 (85.1 %)	<0.0001
Wearable Cardioverter Defibrillator After LVEF	10,526 (99.3 %)	2119 (97.4 %)	8407 (99.8 %)	<0.0001
Determination				
Death within one year after first AMI discharge	2384 (22.5 %)	112 (5.1 %)	2272 (27.0 %)	<0.0001
Comorbidities				
Diabetes mellitus	5487 (51.8 %)	1038 (47.7 %)	4449 (52.8 %)	<0.0001
Hypertension	8837 (83.4 %)	1742 (80.1 %)	7095 (84.2 %)	<0.0001
Dyslipidemia	6874 (64.9 %)	1482 (68.1 %)	5392 (64.0 %)	0.0004
Chronic kidney disease	3492 (32.9 %)	533 (24.5 %)	2959 (35.1 %)	0.001
End-stage renal disease	299 (2.8 %)	25 (1.1 %)	274 (3.3 %)	<0.0001
Cerebrovascular disease	2082 (19.6 %)	352 (16.2 %)	1730 (20.5 %)	<0.0001

	Total (N = 10,599)	Received ICD between 91 and 455 days after acute myocardial infarction (N = 2176)	Did not receive ICD (N = 8423)	p-value
Peripheral vascular disease	2696 (25.4 %)	452 (20.8 %)	2244 (26.6 %)	<0.0001
Valvular heart disease	2616 (24.7 %)	454 (20.9 %)	2162 (25.7 %)	<0.0001
Atrial fibrillation	2675 (25.2 %)	486 (22.3 %)	2189 (26.0 %)	0.0005
Cancer	1379 (13.0 %)	204 (9.4 %)	1175 (13.9 %)	<0.0001
Chronic pulmonary disease	4334 (40.9 %)	779 (35.8 %)	3555 (42.2 %)	<0.0001
Dementia	396 (3.7 %)	26 (1.2 %)	370 (4.4 %)	<0.0001
Post-traumatic stress disorder	865 (8.2 %)	206 (9.5 %)	659 (7.8 %)	0.01
Depression	1368 (12.9 %)	268 (12.3 %)	1100 (13.1 %)	0.36
Coronary procedures				
PCI Before AMI	962 (9.1 %)	254 (11.7 %)	708 (8.4 %)	<0.0001
During AMI hospitalization	2286 (21.6 %)	672 (30.9 %)	1614 (19.2 %)	<0.0001
Within 30 days after AMI hospitalization	375 (3.5 %)	113 (5.2 %)	262 (3.1 %)	<0.0001
CABG Before AMI	463 (4.4 %)	103 (4.7 %)	360 (4.3 %)	0.35
During AMI hospitalization	623 (5.9 %)	164 (7.5 %)	459 (5.4 %)	0.002
Within 30 days after AMI hospitalization	345 (3.3 %)	76 (3.5 %)	269 (3.2 %)	0.48
Diagnostic coronary angiogram Before AMI	1246 (11.8 %)	278 (12.8 %)	968 (11.5 %)	0.10
During AMI hospitalization	1744 (16.5 %)	398 (18.3 %)	1346 (16.0 %)	0.010
Within 30 days after AMI hospitalization	225 (2.1 %)	55 (2.5 %)	170 (2.0 %)	0.14
Guideline-directed medical therapy 180 days before LVEF assessment				
Beta blocker	9353 (88.2 %)	2020 (92.8 %)	7333 (87.1 %)	<0.0001
ACE inhibitor or ARB	8419 (79.4 %)	1928 (88.6 %)	6491 (77.1 %)	<0.0001
Mineralocorticoid receptor antagonists	2252 (21.2 %)	707 (32.5 %)	1545 (18.3 %)	<0.0001
Combination beta blocker / ACE inhibitor or ARB	7572 (71.4 %)	1814 (83.4 %)	5758 (68.4 %)	<0.0001
Combination beta blocker / ACE inhibitor or ARB / mineralocorticoid receptor antagonist	1926 (18.2 %)	648 (29.8 %)	1278 (15.2 %)	<0.0001

Abbreviations: AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft surgery; LVEF, left ventricular ejection fraction; ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker.

Table 2

Demographic, clinical, procedural, and facility-level variables among all patients meeting left ventricular ejection fraction criterion (≤ 35 %) for implantable cardioverter-defibrillator placement.

	Total (N = 12,893)	Received ICD during hospitalization for acute myocardial infarction or within 90 days (N = 923)	Received ICD between 91 and 455 days after acute myocardial infarction (N = 2176)	Received ICD >455 days after acute myocardial infarction (N = 1371)	Did not receive ICD (N = 8423)	p-Value
Demographics						
Age (years) at time of AMI hospitalization, mean (SD)	68.7 (10.7)	67.1 (9.6)	65.7 (9.2)	64.2 (9.3)	70.4 (11.0)	<0.0001
Race						
White	8795 (68.2 %)	644 (69.8 %)	1573 (72.3 %)	970 (70.8 %)	5608 (66.6 %)	<0.0001
Black	2410 (18.7 %)	157 (17.0 %)	381 (17.5 %)	260 (19.0 %)	1612 (19.1 %)	
Other race/unknown	1687 (13.1 %)	122 (13.2 %)	222 (10.2 %)	140 (10.2 %)	1203 (14.3 %)	
Ethnicity						
Not Hispanic or Latino	11,126 (86.3 %)	812 (88.0 %)	1953 (89.8 %)	1223 (89.3 %)	7138 (84.7 %)	<0.0001
Hispanic or Latino	741 (5.7 %)	36 (3.9 %)	113 (5.2 %)	75 (5.5 %)	517 (6.1 %)	
Declined to answer	257 (2.0 %)	18 (2.0 %)	37 (1.7 %)	22 (1.6 %)	180 (2.1 %)	
Unknown/Missing	768 (6.0 %)	57 (6.2 %)	73 (3.4 %)	50 (3.6 %)	588 (7.0 %)	
Rural residence	43,322 (33.6 %)	334 (36.2 %)	828 (38.1 %)	478 (34.9 %)	2692 (32.0 %)	<0.0001
Annual income ($), median (IQR)	18,800 (11638–33,228)	20,148 (11820–33,756)	20,340 (12,188–34,803)	19,728 (12270–34,299)	18,036 (11,076–32,076)	
Married	5590 (43.4 %)	434 (47.0 %)	1031 (47.4 %)	616 (45.0 %)	3509 (41.7 %)	<0.0001
Visit to homeless clinic in year prior to AMI	1649 (12.8 %)	118 (12.8 %)	278 (12.8 %)	233 (17.0 %)	1020 (12.1 %)	<0.0001
Tobacco use history	11,169 (86.6 %)	808 (87.5 %)	1957 (89.9 %)	1240 (90.4 %)	7164 (85.1 %)	<0.0001
Wearable Cardioverter Defibrillator After	124 (1.0 %)	13 (1.4 %)	57 (2.6 %)	38 (2.8 %)	16 (0.2 %)	<0.0001
LVEF Determination						
Death within one year after first AMI discharge	2510 (19.5 %)	126 (13.7 %)	112 (5.1 %)	0 (0.0 %)	2272 (27.0 %)	<0.0001
Comorbidities						
Diabetes mellitus	6617 (51.3 %)	472 (51.1 %)	1038 (47.7 %)	658 (48.0 %)	4449 (52.8 %)	<0.0001
Hypertension	10,670 (82.8 %)	733 (79.4 %)	1742 (80.1 %)	1100 (80.2 %)	7095 (84.2 %)	<0.0001

	Total (N = 12,893)	Received ICD during hospitalization for acute myocardial infarction or within 90 days (N = 923)	Received ICD between 91 and 455 days after acute myocardial infarction (N = 2176)	Received ICD >455 days after acute myocardial infarction (N = 1371)	Did not receive ICD (N = 8423)	p-Value
Dyslipidemia	8464 (65.6 %)	652 (70.6 %)	1482 (68.1 %)	938 (68.4 %)	5392 (64.0 %)	<0.0001
Chronic kidney disease	4024 (31.2 %)	252 (27.3 %)	533 (24.5 %)	280 (20.4 %)	2959 (35.1 %)	<0.0001
End-stage renal disease	330 (2.6 %)	11 (1.2 %)	25 (1.1 %)	20 (1.5 %)	274 (3.3 %)	<0.0001
Cerebrovascular disease	2422 (18.8 %)	140 (15.2 %)	352 (16.2 %)	200 (14.6 %)	1730 (20.5 %)	<0.0001
Peripheral vascular disease	3175 (24.6 %)	189 (20.5 %)	452 (20.8 %)	290 (21.2 %)	2244 (26.6 %)	<0.0001
Valvular heart disease	3122 (24.2 %)	250 (27.1 %)	454 (20.9 %)	256 (18.7 %)	2162 (25.7 %)	<0.0001
Atrial fibrillation	3248 (25.2 %)	278 (30.1 %)	486 (22.3 %)	295 (21.5 %)	2189 (26.0 %)	<0.0001
Cancer	1574 (12.2 %)	76 (8.2 %)	204 (9.4 %)	119 (8.7 %)	1175 (13.9 %)	<0.0001
Chronic pulmonary disease	5221 (39.7 %)	363 (39.3 %)	779 (35.8 %)	419 (30.6 %)	3555 (42.2 %)	<0.0001
Dementia	413 (3.2 %)	10 (1.1 %)	26 (1.2 %)	7 (0.5 %)	370 (4.4 %)	<0.0001
Post-traumatic stress disorder	1056 (8.2 %)	70 (7.6 %)	206 (9.5 %)	121 (8.8 %)	659 (7.8 %)	0.06
Depression	1633 (12.7 %)	93 (10.1 %)	268 (12.3 %)	172 (12.5 %)	1100 (13.1 %)	<0.0001
Coronary procedures						
PCI before AMI	1203 (9.3 %)	92 (10.0 %)	254 (11.7 %)	149 (10.9 %)	708 (8.4 %)	<0.0001
PCI during AMI	2950 (22.9 %)	222 (24.1 %)	672 (30.9 %)	442 (32.2 %)	1614 (19.2 %)	<0.0001
PCI within 30 days after AMI hospitalization	452 (3.5 %)	26 (2.8 %)	113 (5.2 %)	51 (3.7 %)	262 (3.1 %)	<0.0001
CABG before AMI	581 (4.5 %)	49 (5.3 %)	103 (4.7 %)	69 (5.0 %)	360 (4.3 %)	0.31
CABG during AMI hospitalization	787 (6.1 %)	52 (5.6 %)	164 (7.5 %)	112 (8.2 %)	459 (5.4 %)	<0.0001
CABG within 30 days after AMI hospitalization	436 (3.4 %)	27 (2.9 %)	76 (3.5 %)	64 (4.7 %)	269 (3.2 %)	0.04
Diagnostic coronary angiogram before AMI	1593 (12.4 %)	144 (15.6 %)	278 (12.8 %)	203 (14.8 %)	968 (11.5 %)	<0.0001
Diagnostic coronary angiogram during AMI hospitalization	2231 (17.3 %)	217 (23.5 %)	398 (18.3 %)	270 (19.7 %)	1346 (16.0 %)	<0.0001
Diagnostic coronary angiogram within 30 days after AMI hospitalization	302 (2.3 %)	37 (4.0 %)	55 (2.5 %)	40 (2.9 %)	170 (2.0 %)	0.0006
Guideline-directed medical therapy 180 days before LVEF assessment						
Beta blocker	11,431 (88.7 %)	849 (92.0 %)	2020 (92.8 %)	1229 (89.6 %)	7333 (87.1 %)	<0.0001
ACE inhibitor or ARB	10,373 (80.5 %)	788 (85.4 %)	1928 (88.6 %)	1166 (85.0 %)	6491 (77.1 %)	<0.0001

	Total (N = 12,893)	Received ICD during hospitalization for acute myocardial infarction or within 90 days (N = 923)	Received ICD between 91 and 455 days after acute myocardial infarction (N = 2176)	Received ICD >455 days after acute myocardial infarction (N = 1371)	Did not receive ICD (N = 8423)	p-Value
Mineralocorticoid receptor antagonist	2915 (22.6 %)	339 (36.7 %)	707 (32.5 %)	324 (23.6 %)	1545 (18.3 %)	<0.0001
Combination beta blocker / ACE inhibitor or ARB	9382 (72.8 %)	742 (80.4 %)	1814 (83.4 %)	1068 (77.9 %)	5758 (68.4 %)	<0.0001
Combination beta blocker / ACE inhibitor or ARB / mineralocorticoid receptor antagonist	2527 (19.6 %)	308 (33.4 %)	648 (29.8 %)	293 (21.4 %)	1278 (15.2 %)	<0.0001

Abbreviations: AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft surgery; LVEF, left ventricular ejection fraction; ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker.

Table 3

Multivariable logistic regression analysis of demographic, clinical, procedural, and facility-level factors associated with implantable cardioverter-defibrillator placement between 91 and 455 days compared to no implantable cardioverter-defibrillator placement.

	Odds ratio (95 % CI)	p-Value
Demographics		
Age (years) at time of AMI hospitalization, per year	0.97 (0.97–0.98)	<0.0001
Race		
White	Ref	
Black	0.80 (0.69–0.93)	0.003
Other race/unknown	0.92 (0.75–1.12)	0.39
Ethnicity		
Not Hispanic or Latino	Ref	
Hispanic or Latino	0.96 (0.76–1.21)	0.72
Declined to answer	0.87 (0.58–1.31)	0.50
Unknown/Missing	0.68 (0.50–0.92)	0.01
Rural Residence	1.16 (1.04–1.30)	0.007
Married	1.40 (1.26–1.55)	<0.0001
Death within one year after first AMI discharge	0.19 (0.16–0.23)	<0.0001
Comorbidities		
Diabetes mellitus	0.81 (0.73–0.90)	0.0002
Hypertension	0.89 (0.77–1.03)	0.12
Dyslipidemia	1.27 (1.13–1.43)	<0.0001
Chronic kidney disease	0.91 (0.80–1.03)	0.13
End-stage renal disease	0.70 (0.37–1.36)	0.29
Cerebrovascular disease	0.98 (0.85–1.13)	0.81
Valvular heart disease	0.91 (0.80–1.03)	0.14
Peripheral vascular disease	0.94 (0.82–1.07)	0.32
Atrial fibrillation	1.04 (0.92–1.18)	0.51
Cancer	0.90 (0.76–1.07)	0.25
Chronic pulmonary disease	0.83 (0.74–0.93)	0.0009
Dementia	0.50 (0.33–0.77)	0.002
Post-traumatic stress disorder	1.06 (0.89–1.27)	0.49
Tobacco use disorder	1.13 (0.96–1.33)	0.16
Coronary procedures		
PCI before 1st AMI hospitalization	1.23 (1.05–1.46)	0.01
PCI during 1st AMI hospitalization	1.39 (1.22–1.57)	<0.0001
PCI after 1st AMI hospitalization	1.35 (1.05–1.73)	0.02
CABG during 1st AMI hospitalization	1.21 (1.00–1.48)	0.05
Diagnostic angiogram before 1st AMI hospitalization	1.17 (1.00–1.37)	0.05
Diagnostic angiogram during 1st AMI hospitalization	1.04 (0.90–1.19)	0.60
Guideline-directed medical therapy 180 days before LVEF assessment		

	Odds ratio (95 % CI)	p-Value
Beta blocker	1.11 (0.81–1.51)	0.51
ACE inhibitor or ARB	1.30 (0.93–1.81)	0.13
Mineralocorticoid receptor antagonist	1.59 (1.15–2.20)	0.005
Combination beta blocker / ACE inhibitor or ARB	1.25 (0.85–1.84)	0.25
Combination beta blocker / ACE inhibitor or ARB / mineralocorticoid receptor antagonist	1.18 (0.83–1.66)	0.36
Facility characteristic		
Academic affiliation	0.84 (0.62–1.14)	0.26

Abbreviations: AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft surgery; LVEF, left ventricular ejection fraction; ACE, angiotensin converting enzyme; ARB, angiotensin receptor blocker.