Original Article

Follow-up of Patients With New Cardiovascular Implantable Electronic Devices

Are Experts' Recommendations Implemented in Routine Clinical Practice?

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Background—A 2008 expert consensus statement outlined the minimum frequency of follow-up of patients with cardiovascular implantable electronic devices (CIEDs).

Methods and Results—We studied 38 055 Medicare beneficiaries who received a new CIED between January 1, 2005, and June 30, 2009. The main outcome measure was variation of follow-up by patient factors and year of device implantation. We determined the number of patients who were eligible for and attended an in-person CIED follow-up visit within 2 to 12 weeks, 0 to 16 weeks, and 1 year after implantation. Among eligible patients, 42.4% had an initial in-person visit within 2 to 12 weeks. This visit was significantly more common among white patients than black patients and patients of other races (43.0% versus 36.8% versus 40.5%; $P<0.001$). Follow-up within 2 to 12 weeks improved from 40.3% in 2005 to 55.1% in 2009 ($P<0.001$ for trend). The rate of follow-up within 0 to 16 weeks was 65.1% and improved considerably from 2005 to 2009 (62.3%–79.6%; $P<0.001$ for trend). Within 1 year, 78.0% of the overall population had at least 1 in-person CIED follow-up visit.

Conclusions—Although most Medicare beneficiaries who received a new CIED between 2005 and 2009 did not have an initial in-person CIED follow-up visit within 2 to 12 weeks after device implantation, the rate of initial follow-up improved appreciably over time. This CIED follow-up visit was significantly more common in white patients than in patients of other races. (***Circ Arrhythm Electrophysiol*. 2013;6:108-116.**)

Key Words: cardiac resynchronization therapy ■ implantable cardioverter-defibrillator ■ outcomes research ■ pacemakers

Recent evolution of cardiovascular implantable electronic devices (CIEDs) has been driven by improved technology and expanded indications, mostly involving implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy (CRT).[1] The ICD is the most effective therapy at reducing sudden death and all-cause mortality in survivors of cardiac arrest and patients with ventricular tachycardia and significant systolic dysfunction.[2–6] CRT improves survival and quality of life in patients with left-ventricular ejection fraction ≤35%, wide QRS complex, and advanced heart failure symptoms despite optimal medical therapy.[7,8] In some patients, CRT results in significant reversal of remodeling and improved left-ventricular ejection fraction.[9,10] There are emerging data on the benefits of CRT for less advanced heart failure.[11,12] These benefits have increased the prevalence of such devices.[2–6,13] With the aging of the US population, the prevalence of pacemakers has also increased.[14]

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Improvements in CIED technology, although beneficial, have made CIEDs more complex. To ensure proper functioning and programming, adequate monitoring is essential. The Heart Rhythm Society (HRS) and the European Heart Rhythm Association (EHRA) published an expert consensus statement outlining the minimum frequency of in-person and remote follow-up of CIEDs.[15] For patients with a new pacemaker, ICD, or CRT device, the statement recommends an in-person CIED follow-up visit 2 to 12 weeks after implantation. For patients with pacemakers (including those with CRT), the statement recommends in-person or remote monitoring every 3 to 12 months. For patients with an ICD with or without CRT, the statement recommends in-person or remote monitoring every 3 to 6 months.[15] The initial in-person follow-up is particularly important, because it is during this period that most complications like bleeding, infection, and lead dislodgement occur. It is not known whether follow-up of patients with a new CIED has been consistent with these recommendations.

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We examined practice patterns related to the follow-up of patients who received a new pacemaker, ICD, or CRT defibrillator (CRT-D) or pacemaker (CRT-P) to determine whether these patterns are consistent with HRS/EHRA recommendations. We also examined variations in practice patterns by patient factors and over time.

Methods

Data Sources

We conducted a retrospective cohort study using a nationally representative 5% sample of Medicare claims data from the US Centers for Medicare & Medicaid Services. The data included inpatient, outpatient, and carrier standard analytic files and the corresponding denominator files. The inpatient files contain institutional claims for facility costs covered under Medicare Part A, and the outpatient files contain claims by institutional outpatient providers. Available data elements include beneficiary identifiers; admission and discharge dates; and *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes. The carrier files contain noninstitutional provider claims for services covered under Medicare Part B. Unique patient identifiers, dates of service, and Current Procedural Terminology (CPT) codes are among the variables included in the carrier files. The denominator files contain beneficiary identifiers, dates of birth, sex, race/ethnicity, dates of death, and information about program eligibility and enrollment. The institutional review board of the Duke University Health System approved the study.

Study Cohort

From the carrier files, we identified 42 287 beneficiaries who received a new CIED between January, 1, 2005, and June 30, 2009; were ≥66 years; resided in the United States on the date of the implantation; and were enrolled in fee-for-service Medicare for at least 12 months before device implantation. We excluded 3797 beneficiaries whose carrier claims could not be matched to an inpatient or outpatient Medicare claim occurring within 14 days of the carrier claim. We also excluded 435 beneficiaries who received a CIED in conjunction with coronary artery bypass graft surgery *ICD-9-CM* codes 36.10 to 36.19. Figure 1 shows the derivation of the study cohort. We defined the date of implantation as the discharge date on inpatient claims and as the last date of service on outpatient claims.

To assess compliance with recommended follow-up, we required patients to be alive, to be enrolled in fee-for-service Medicare, and to not have a device removed during a specified measurement period after the implantation date. The measurement period was 4 months for initial in-person follow-up, 11 months for subsequent follow-up of ICDs and CRT-Ds, and 17 months for subsequent follow-up of pacemakers and CRT-Ps.

We used the following CPT codes on carrier claims to identify implantations of new CIEDs: 33206 for atrial pacemakers, 33207 for ventricular pacemakers, 33208 for dual-chamber pacemakers, and 33249 for ICDs. To identify CRT devices, we required the code for insertion of a left-ventricular lead (33225) on the same claim. Only new CIED implants were included in these analyses. We excluded patients who received an epicardial pacemaker or ICD and patients who received an implantable loop recorder. Corresponding inpatient claims were identified using *ICD-9-CM* codes that have been previously described,[16] and corresponding outpatient claims were identified using those *ICD-9-CM* codes and the following CPT and Healthcare Common Procedure Coding System codes: 33249, G0297, G0298, G0299, or G0300 for ICDs/CRT-Ds, and 33206, 33207, or 33208 for pacemakers/CRT-Ps. Device removal was identified using CPT codes 33241 and 33233 on inpatient, outpatient, or carrier claims. The CPT codes used to identify in-person and remote monitoring of CIEDs are listed in Table I in the online-only Data Supplement. In 2006, the Centers for Medicare & Medicaid Services listed the following CPT codes to be used by physicians reporting electronic analysis of an implanted cardiac device using remotely obtained data: 93731, 93734, 93741, or 93743, depending on the type of cardiac device implanted. The American Medical Association announced major changes to these CPT codes in January 2009. The new CPT codes more accurately reflect newer cardiac device monitoring capabilities, long-distance telemetry, and remote interrogation. The new code sets are structured differently from the CPT codes they replaced by having separate CPT codes that represent the professional and technical components.[17] We captured all in-person and remote CIED follow-up encounters, regardless of whether they were with the same health care provider. We were unable to capture device interrogations that occurred during a subsequent hospitalization.

We identified comorbid conditions using the coding algorithms described by Birman-Deych et al[18] and Quan et al.[19] Specifically, we searched all inpatient, outpatient, and carrier claims within 365 days preceding the date of cohort entry for evidence of coronary heart disease (*ICD-9-CM* codes 410–414, 429.2, and V45.81), hypertension (401–405 and 437.2), cerebrovascular disease (362.34 and 430–438), dementia (290, 294.1 and 331.2), chronic pulmonary disease (416.8, 416.9, 490–505, 506.4, 508.1, and 508.8), diabetes mellitus (250), peripheral vascular disease (093.0, 437.3, 440, 441, 443.1–443.9, 47.1, 557.1, 557.9, and V43), renal disease (403.01, 403.11, 403.91, 404.02, 404.036, 404.12, 404.13, 404.92, 404.93, 582, 583.0–583.7, 585, 586, 588.0, V42.0, V45.1, and V56), and metastatic solid tumor (196–199).

Outcomes

We determined (1) the percentage of patients with a new pacemaker, CRT-P, ICD, or CRT-D who had an in-person CIED follow-up visit 2 to 12 weeks after device implantation; (2) the percentage of patients with a new pacemaker or CRT-P who had an in-person or remote follow-up visit 3 to 12 months after the initial CIED follow-up visit that occurred within 2 to 12 weeks after implantation; (3) the percentage of patients with a new ICD or CRT-D who had an in-person or remote CIED follow-up visit 3 to 6 months after the initial CIED follow-up visit that occurred within 2 to 12 weeks after implantation; and (4) the percentage of patients with a new pacemaker, CRT-P, ICD, or CRT-D who had an initial in-person CIED follow-up visit within 1 year after device implantation. Percentages were adjusted for age and sex. We also examined whether follow-up varied over time and by patient factors, including age, sex, and race.

To examine the potential impact of in-hospital device interrogations on our findings, we examined the rates of cardiovascular hospitalizations in each group and by whether a patient had an in-person follow-up visit within 2 to 12 weeks or within 0 to 16 weeks.

Statistical Analysis

Baseline characteristics are presented as percentages and, where applicable, medians with interquartile ranges or means with SDs. Differences between CIED categories were tested using χ^2 tests for categorical variables and Kruskal–Wallis tests for continuous variables.

The primary analysis examined the percentage of patients with an initial in-person CIED follow-up visit between 2 and 12 weeks after CIED implantation. In a sensitivity analysis, this time frame was extended to 0 and 16 weeks. For all outcomes of interest, we calculated age- and sex-adjusted follow-up rates overall and for each CIED category using a direct standardization method.[20] Specifically, we calculated sex-adjusted rates by age, age-adjusted rates by sex, and age- and sex-adjusted rates by race and implantation year. We used χ^2 tests to compare differences in follow-up rates by subgroup. All tests were 2-sided and were performed using SAS version 9.1 (SAS Institute Inc, Cary, NC).

Results

Table 1 shows the baseline characteristics of the study population. The number of patients who underwent a new endocardial CIED implantation between January 1, 2005, and June 30, 2009 was 38 055, of which 28 360 received a pacemaker and 9695 received an ICD. Most patients who received an ICD

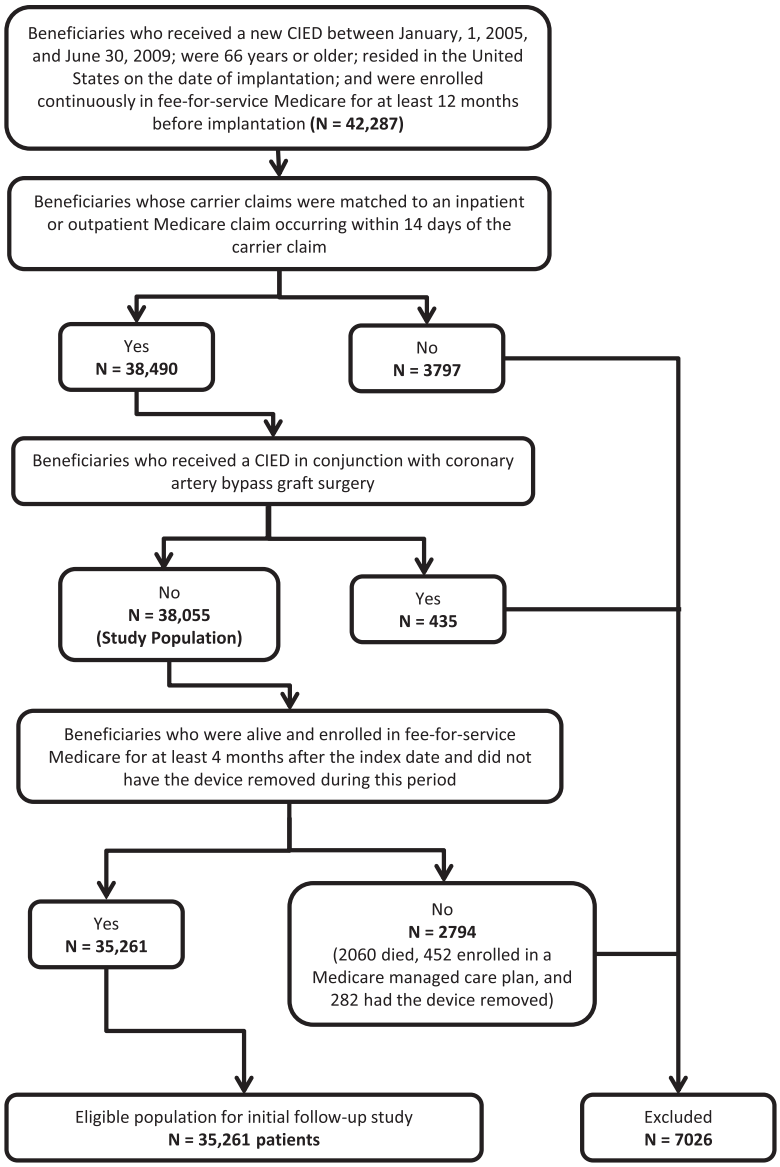

Figure 1. Derivation of the study cohort. CIED indicates cardiovascular implantable electronic device.

were men (74.2%), and most who received a pacemaker were women (52.7%). The vast majority of patients who received either device were white (87.6%). The number of ICD implants per year decreased over time (from 2522 in 2005 to 1827 in 2008). Likewise, the number of pacemaker implants in 2008 (n=5938) was slightly lower than the number of pacemaker implants in 2005 (n=6472).

Table 2 and Figure 2A provide data on compliance with the recommended initial CIED follow-up visit. Of the overall population, 42.4% had an in-person CIED follow-up visit between 2 and 12 weeks. This visit occurred for 43.9% of patients who received an ICD and 41.9% of patients who received a pacemaker. In the overall population, patients 65 to 79 years were more likely than patients ≥80 years to have this CIED follow-up visit (43.1% versus 41.8%; P=0.01). The rate of this CIED follow-up visit was significantly higher for white patients than for black patients and patients of other races (43.0% versus 36.8% versus 40.5%, respectively; P<0.001). The difference by race was observed in both CIED categories. The rate of initial follow-up improved considerably from 2005 to 2009 among the overall population (40.3%–55.1%) and in ICD recipients (40.7%–59.0%) and pacemaker recipients (40.0%–53.9%; P <0.001 for all comparisons).

The median time to the first in-person device follow-up was 41 days (interquartile range, 28–56) and did not vary by patient age, sex, or race. The median time to the first follow-up visit decreased significantly from 2005 to 2009 for the overall population (from 42 to 37 days), patients who received an ICD (from 41 to 36 days), and patients who received a pacemaker (from 42 to 37 days; P<0.001 for all comparisons).

Data on compliance with recommended subsequent CIED follow-up visits are presented in Table 3. Of patients who received an ICD, 72.4% had an in-person or remote monitoring encounter within 3 to 6 months of the initial monitoring visit. Of patients who received a pacemaker, 93.4% had an in-person or remote monitoring encounter within 3 to 12 months of the initial monitoring visit. These rates did not vary significantly with patient age or sex, but they were significantly higher for white patients than for black patients and patients of other races in the ICD group (73.2% versus 59.5% versus 63.5%,

Table 1. Baseline Characteristics of the Study Population

Characteristics	Any CIED (n=38 055)	ICD/CRT-D (n=9695)	Pacemaker/CRT-P (n=28 360)	*P* Value
Age, mean (SD), y	79.1 (7.0)	75.6 (5.9)	80.3 (7.0)	<0.001
Age group, n (%)				<0.001
65–79 y	19 802 (52.0)	7079 (73.0)	12 723 (44.9)	
≥80 y	18 253 (48.0)	2616 (27.0)	15 637 (55.1)	
Sex, n (%)				<0.001
Female	17 441 (45.8)	2501 (25.8)	14 940 (52.7)	
Male	20 614 (54.2)	7194 (74.2)	13 420 (47.3)	
Race, n (%)				<0.001
Black	2275 (6.0)	772 (8.0)	1503 (5.3)	
White	33 329 (87.6)	8285 (85.5)	25 044 (88.3)	
Other/unknown	2451 (6.4)	638 (6.6)	1813 (6.4)	
Comorbid conditions, n (%)				
Cerebrovascular disease	14 232 (37.4)	3190 (32.9)	11 042 (38.9)	<0.001
COPD	16 150 (42.4)	4725 (48.7)	11 425 (40.3)	<0.001
Congestive heart failure	23 588 (62.0)	9283 (95.8)	14 305 (50.4)	<0.001
Coronary heart disease	28 582 (75.1)	9180 (94.7)	19 402 (68.4)	<0.001
Dementia	2856 (7.5)	265 (2.7)	2591 (9.1)	<0.001
Diabetes mellitus	15 280 (40.2)	4581 (47.3)	10 699 (37.7)	<0.001
Hypertension	35 204 (92.5)	8873 (91.5)	26 331 (92.8)	<0.001
Metastatic solid tumor	6649 (17.5)	1704 (17.6)	4945 (17.4)	<0.001
Peripheral vascular disease	13 222 (34.7)	3598 (37.1)	9624 (33.9)	<0.001
Renal disease	8772 (23.1)	2725 (28.1)	6047 (21.3)	<0.001
Year of implantation, n (%)				<0.001
2005	8994 (23.6)	2522 (26.0)	6472 (22.8)	
2006	8570 (22.5)	2251 (23.2)	6319 (22.3)	
2007	8155 (21.4)	2120 (21.9)	6035 (21.3)	
2008	7765 (20.4)	1827 (18.8)	5938 (20.9)	
2009	4571 (12.0)	975 (10.1)	3596 (12.7)	

CIED indicates cardiovascular implantable electronic device; COPD, chronic obstructive pulmonary disease; CRT-D, cardiac resynchronization therapy defibrillator; CRT-P, cardiac resynchronization therapy pacemaker; and ICD, implantable cardioverter-defibrillator.

respectively; P <0.001) and in the pacemaker group (94.0% versus 85.3% versus 90.2%, respectively; P <0.001). In the ICD/CRT-D group, 1523 (47.7%) patients had an in-person visit and 1667 (52.3%) patients had a remote monitoring encounter within 3 to 6 months of follow-up. In the pacemaker/CRT-P group, 4483 (64.0%) had an in-person visit and 2524 (36.0%) had a remote monitoring encounter within 3 to 12 months after device implantation. Changing the time frame of the initial monitoring visit from 2 to 12 weeks to 0 to 16 weeks yielded similar results.

In a sensitivity analysis that extended the time frame for the initial in-person CIED follow-up visit to 0 to 16 weeks, the initial follow-up occurred in 65.1% of the overall population, 67.2% of patients who received an ICD, and 64.3% of patients who received a pacemaker (Table II in the online-only Data Supplement and Figure 2B). For the overall population, the rate varied by age (66.2% for patients 65–79 years versus 63.9% for patients ≥80 years; P<0.001) and race (65.8% for white patients versus 56.2% for black patients versus 63.0% for patients of other races; P<0.001). Although differences by race were observed in both CIED categories, differences by age were only observed in patients who received a pacemaker. The rate of the initial CIED follow-up visit improved significantly from 2005 to 2009 for the overall group and each device category. Specifically, this rate improved from 62.3% to 79.6% for the overall population, 63.3% to 84.2% in patients who received an ICD, and 61.8% to 78.4% in patients who received a pacemaker (P<0.001 for all comparisons).

During the first 2 to 12 weeks of follow-up, the cardiovascular hospitalization rate was 9.7% for ICD/CRT-D and 7.1% for pacemaker/CRT-P. During the first 16 weeks of follow-up, the cardiovascular hospitalization rate was 16% for ICD/CRT-D and 12.2% for pacemaker/CRT-P. These rates were similar between patients who completed an in-person follow-up and those who did not.

Within 1 year after CIED implantation, 78.0% of the overall population had at least 1 in-person CIED follow-up visit (82.4% for patients who received an ICD and 76.5% for patients who received a pacemaker). Age and sex differences were not observed in patients who received an ICD. A difference by age, but not by sex, was observed in patients who received a pacemaker (79.5% for patients 65–79 years versus

Table 2. In-person Monitoring Visit Between 2 and 12 Weeks After Device Implantation Among Patients Who Survived and Were Eligible for the Initial Clinic Visit

	Any CIED (n=35 261)		ICD/CRT-D (n=9001)		Pacemaker/CRT-P (n=26 260)	
	Initial Follow-up Compliance					
Characteristics	No. (%)*	*P* Value	No. (%)*	*P* Value	No. (%)*	*P* Value
All patients	14 965 (42.4)		3951 (43.9)		11 014 (41.9)	
Age group		0.01		0.19		0.06
65–79 y	8028 (43.1)		2942 (44.4)		5106 (42.6)	
≥80 y	6960 (41.8)		1019 (42.9)		5918 (41.4)	
Sex		0.56		0.44		0.96
Female	6843 (42.3)		1005 (43.2)		5816 (42.0)	
Male	8142 (42.6)		2942 (44.1)		5226 (42.1)	
Race		<0.001		0.004		<0.001
Black	761 (36.8)		267 (37.7)		495 (36.4)	
White	13 285 (43.0)		3380 (43.8)		9885 (42.6)	
Other/unknown	917 (40.5)		267 (45.6)		652 (38.8)	
Year of implantation		<0.001		<0.001		<0.001
2005	3338 (40.3)		951 (40.7)		2377 (40.0)	
2006	3195 (40.3)		815 (38.7)		2371 (40.7)	
2007	3060 (40.5)		849 (43.0)		2201 (39.4)	
2008	3008 (41.8)		752 (44.6)		2265 (41.0)	
2009	2358 (55.1)		530 (59.0)		1823 (53.9)	
Time to Initial Follow-up						
	Days, Median (IQR) (n=14 965)	*P* Value	Days, Median (IQR) (n=3951)	*P* Value	Days, Median (IQR) (n=11 014)	*P* Value
All patients	41 (28–56)		40 (27–55)		41 (28–57)	
Age group		0.70		0.61		0.93
65–79 y	41 (28–56)		40 (27–55)		41 (28–57)	
80 y	41 (28–56)		40 (27–54)		41 (28–57)	
Sex		0.44		0.39		0.23
Female	40 (27–56)		39 (27–54)		41 (28–56)	
Male	41 (28–56)		40 (27–55)		41 (28–57)	
Race		0.72		0.20		0.27
Black	41 (27–57)		42 (28–58)		40 (27–56)	
White	41 (28–56)		40 (27–55)		41 (28–57)	
Other/unknown	41 (29–56)		40 (27–52)		42 (30–58)	
Year of implantation		<0.001		<0.001		<0.001
2005	42 (29–59)		41 (29–58)		42 (30–59)	
2006	41 (28–56)		40 (27–53)		41 (28–58)	
2007	41 (27–56)		40 (26–55)		41 (28–58)	
2008	41 (28–58)		40 (28–56)		41 (28–58)	
2009	37 (25–49)		36 (25–48)		37 (24–50)	

CIED indicates cardiovascular implantable electronic device; CRT-D, cardiac resynchronization therapy defibrillator; CRT-P, cardiac resynchronization therapy pacemaker; ICD, implantable cardioverter-defibrillator; and IQR, interquartile range.

*Percentages were age- and sex-adjusted for race and implantation year, sex-adjusted rates for age, and age-adjusted rates for sex.

74.0% for patients ≥80 years; $P<0.001$). A difference by race was present for patients who received an ICD (83.0% for white patients versus 76.1% for black patients versus 81.6% for patients of other races; $P<0.001$) and for patients who received a pacemaker (77.1% versus 67.6% versus 75.4%; $P<0.001$). These rates improved significantly from 2005 to 2008 for the overall population (75.5%–81.3%; $P<0.001$) and for each device category.

Discussion

To our knowledge, ours is the first study to examine whether follow-up of patients with a new CIED in the United States is consistent with HRS/EHRA recommendations.[15] Although

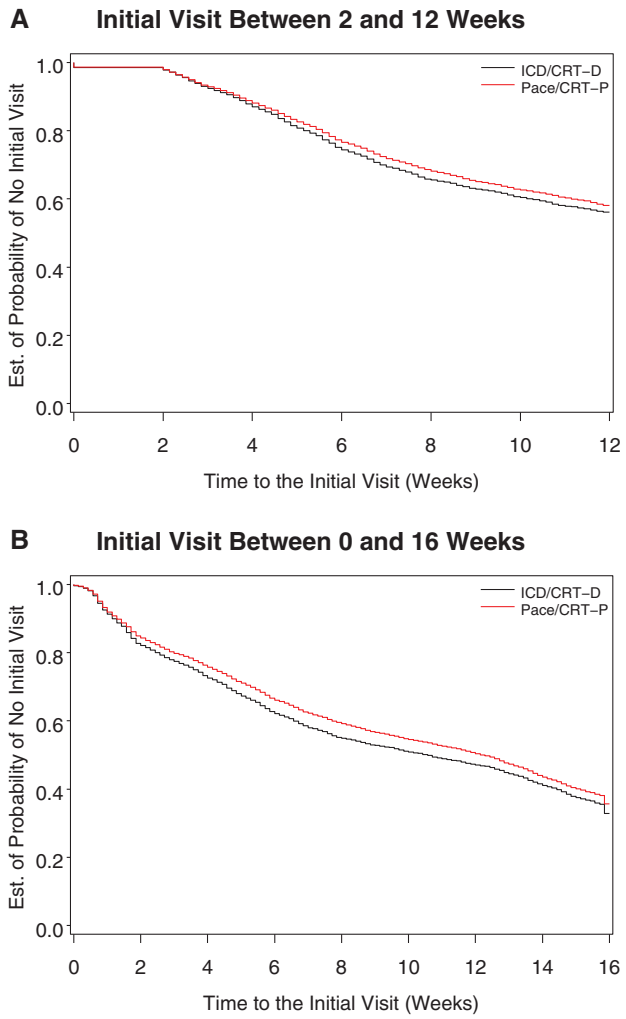

Figure 2. Kaplan–Meier curves for time to initial follow-up in the entire sample using a 2- to 12-week time frame (**A**) and a 0- to 16-Week time frame (**B**). CRT-D indicates cardiac resynchronization therapy defibrillator; CRT-P, cardiac resynchronization therapy pacemaker; and ICD, implantable cardioverter-defibrillator.

only 42.4% of the overall population had an in-person follow-up visit between 2 and 12 weeks, this rate improved significantly (to 55.1%) in 2009. This finding was true of patients with an ICD and patients with a pacemaker. Extending the time frame for the initial visit to 0 to 16 weeks increased the rate of in-person follow-up overall to 65.1%. Likewise, this rate improved considerably for ICD recipients (63.3% in 2005 to 84.2% in 2009) and pacemaker recipients (61.8% in 2005 to 78.4% in 2009). Patients with a pacemaker were more likely to have a subsequent in-person or remote follow-up encounter than patients with an ICD (93.4% versus 72.4%). This observation is surprising because of the higher complexity of ICDs compared with pacemakers. Finally, of the patient factors examined, race was the main factor associated with initial follow-up; compared with white patients, patients of other races were significantly less likely to have an initial in-person CIED follow-up visit.

Reasons for improved adherence are likely multifactorial. One potential explanation is the 2008 HRS/EHRA consensus statement; follow-up practices before this recommendation were not standardized. Other potential explanations include the introduction of new CPT codes for device follow-up in 2009, the increased complexity of devices that may have heightened healthcare providers' attention to close follow-up of CIEDs, and emerging data on the safety and efficacy of remote monitoring, especially of ICDs and CRT-Ds.[14,21–23] Indeed, most patients in the ICD/CRT-D group had a remote monitoring encounter within 3 to 6 months of follow-up. Although this was not observed in the pacemaker/CRT group, remote monitoring may still have a role in improving adherence to longer-term follow-up.

Despite substantial improvement in initial in-person CIED follow-up, some aspects of follow-up require further study. First, about 35% of the overall population did not have an initial in-person CIED follow-up visit within 16 weeks after implantation. Even when this time frame was extended to 1 year, 22% of the overall population did not have an initial in-person visit. Second, compared with white patients, patients of other races were less likely to have an initial in-person CIED follow-up within 2 to 12 weeks, 0 to 16 weeks, and 1 year after implantation of an ICD or a pacemaker. Nonwhite race was the only factor consistently associated with a significantly lower rate of CIED follow-up visits. A sex difference was only observed in the 1-year time frame, and whereas the difference between the 2 sexes was statistically significant, it does not seem to be clinically meaningful. In relation to age, patients ≥80 years were significantly less likely to have an initial in-person CIED follow-up visit within 2 to 12 weeks and 0 to 16 weeks than patients 65 to 79 years. Within 1 year, this age difference was only observed for pacemaker recipients. However, the differences in CIED follow-up by age were small and did not seem to be clinically consequential. Reasons for these age-based and racial differences are uncertain but may include differences in socioeconomic status, access to health care, and access to transportation. While factors at the patient, provider, and healthcare system levels likely play a role, the relative contribution of each factor deserves further study.

An important question is whether adherence to the HRS/EHRA recommendations results in better patient outcomes. Although intuitively this is likely to be true, this has not been shown empirically. Thus, future studies should examine the association between recommended follow-up and patient outcomes. Important outcomes include death, infection, mechanical complications with and without system revision, cardiovascular hospitalizations, cost, and cost-effectiveness. It will also be important to determine whether the HRS/EHRA recommendations are the correct follow-up in terms of having a meaningful impact on outcomes, such as readmission, mortality, and other adverse events.

Our study has some limitations. First, our results are dependent on accurate coding and identification of codes in the Medicare claims database. To the extent that in-person and remote CIED follow-up were not consistently coded, we may have underestimated the number of such visits. Second, because we included only fee-for-service Medicare beneficiaries in this analysis, our results may not apply to non-Medicare patients. Third, data on reasons for noncompliance to recommended follow-up are not available. Thus, patients eligible for a CIED follow-up visit who did not have one

Table 3. In-person or Remote Monitoring Visit Within 3 to 6 Months (ICD or CRT-D) or 3 to 12 Months (Pacemaker or CRT-P) of the Initial Monitoring Visit That Occurred Within 2 to 12 Weeks After Implantation Among Patients Who Survived and Were Eligible for Subsequent Follow-up

	ICD/CRT-D (n=3190)		Pacemaker/CRT-P (n=7007)	
	Subsequent Follow-up Compliance			
Characteristics	No. (%)*	*P* Value	No. (%)*	*P* Value
All patients	2309 (72.4)		6546 (93.4)	
Age group		0.53		0.04
65–79 y	1699 (72.3)		3224 (94.0)	
≥80 y	597 (71.2)		3321 (92.8)	
Sex		0.10		0.41
Female	574 (70.1)		3426 (93.7)	
Male	1734 (73.1)		3124 (93.2)	
Race		<0.001		<0.001
Black	129 (59.5)		242 (85.3)	
White	2025 (73.2)		5913 (94.0)	
Other/unknown	132 (63.5)		393 (90.2)	
Year of implantation		0.02		0.46
2005	591 (67.7)		1864 (93.3)	
2006	545 (71.2)		1898 (93.7)	
2007	564 (72.0)		1727 (92.8)	
2008	511 (75.4)		1057 (94.2)	
2009	62 (68.0)			
Time From Initial Follow-up to Subsequent Follow-up				
	Days, Median (IQR) (n=2309)	*P* Value	Days, Median (IQR) (n=6546)	*P* Value
All patients	115 (97–144)		135 (104–182)	
Age group		0.06		0.82
65–79 y	117 (98–145)		135 (105–182)	
≥80 y	112 (96–140)		134 (104–182)	
Sex		0.83		0.32
Female	117 (97–145)		136 (105–182)	
Male	114 (97–144)		134 (104–182)	
Race		0.06		0.45
Black	119 (98–147)		137 (105–189)	
White	115 (97–145)		134 (104–182)	
Other/unknown	106 (94–133)		139 (107–182)	
Year of implantation		0.80		0.30
2005	116 (98–142)		134 (105–182)	
2006	117 (98–144)		136 (105–182)	
2007	113 (97–144)		139 (105–183)	
2008	115 (97–147)		131 (100–183)	
2009	109 (97–138)			

Limited to patients who had an ICD or CRT-D implantation before February 1, 2009, or a pacemaker or CRT-P implantation before August 1, 2008.

CRT-D indicates cardiac resynchronization therapy defibrillator; CRT-P, cardiac resynchronization therapy pacemaker; ICD, implantable cardioverter-defibrillator; and IQR, interquartile range.

*Percentages were age- and sex-adjusted for race and implantation year, sex-adjusted rates for age, age-adjusted rates for sex.

may have had good reasons for not having a visit, such as a major illness or social circumstances that made it impossible for these patients to present for a CIED follow-up visit. In addition, we were unable to ascertain patient wishes, as some patients who were scheduled for a CIED follow-up visit and were informed of the need for the visit may have preferred not to follow up. Although we were unable to capture device interrogations unless they were billed for, device interrogations are reimbursed by Medicare and, thus, can be assumed to be billed for when they occur. Finally, we were unable to capture device interrogations that may have taken place during subsequent hospitalizations. However, we found that the

rate of cardiovascular hospitalizations was relatively low in each group and the rates were similar between patients who completed an in-person follow-up and patients who did not.

Conclusions

Although most Medicare beneficiaries who received a new CIED between 2005 and 2009 did not have an initial in-person CIED follow-up visit within 2 to 12 weeks, the rate of follow-up improved appreciably over time. This follow-up visit was significantly more common among patients aged 65 to 79 years than patients ≥80 years and among white patients than patients of other races. Despite the observed improvement in CIED follow-up, several aspects of CIED follow-up require further study. Reasons for the gap in CIED follow-up should be examined and the relative contribution of patient, healthcare provider, and healthcare system factors to this gap should be investigated. Indeed, the demonstrated gap in follow-up of patients with a new CIED and the age and racial differences support the development of quality-improvement programs, including performance measures, aimed at enhancing the care of such patients.

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CLINICAL PERSPECTIVE

Improvements in cardiovascular implantable electronic devices have made the devices more complex. Adequate monitoring is essential to ensure proper functioning and programming. The Heart Rhythm Society and the European Heart Rhythm Association published an expert consensus statement outlining the minimum frequency of in-person and remote follow-up of cardiovascular implantable electronic devices. We found that, although most Medicare beneficiaries who received a new cardiovascular implantable electronic device between 2005 and 2009 did not have an initial in-person cardiovascular implantable electronic device follow-up visit within 2 to 12 weeks after device implantation, the rate of initial follow-up improved appreciably over time. This follow-up visit was significantly more common among patients aged 65 to 79 years than patients ≥80 years and among white patients than patients of other races.