Racial Disparity and Technology Diffusion: The Case of Cardioverter Defibrillator Implants, 1996–2001

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Background: Although implantable cardioverter defibrillator (ICD) therapy is widely endorsed for preventing sudden cardiac death (SCD), prior research documented a large black–white disparity in ICD therapy among the elderly. No studies have examined this disparity among nonelderly adults or over time as ICD therapy became widely diffused.

Objective: This study compares disparity in use of ICD therapy for 1996–1998 to 1999–2001 between African Americans and other adults.

Methods: The National Hospital Discharge Survey is used to compare ICD utilization between black and other adults diagnosed with ventricular tachycardia, ventricular fibrillation or cardiac arrest.

Results: Adjusting for patient and hospital characteristics, ICD use per 100 at-risk patients rose from 11.0 to 27.3 among African Americans and from 24.0 to 37.5 among other adults between 1996–1998 and 1999–2001. Although the disparity was evident throughout the study period, it declined by 40%. Compared with their nonblack counterparts, black adults at risk for SCD were five years younger on average ($p<0.01$) and more likely to be female ($p<0.01$).

Conclusions: As ICD therapy became more widely available, use of this technology increased faster for black versus other adults, and the disparity in use declined but was not eliminated. Policymakers and clinicians should focus on increasing access among underserved populations to promising new technologies. Research focusing only on the elderly may miss important racial disparities when there is a race difference in the age distribution of disease risk. Further research should explore the relationship of technology diffusion to disparities in health service use.

Key words: race/ethnicity ■ vascular ■ heart ■ technology ■ utilization

© 2007. From Center for State Health Policy, Rutgers University, New Brunswick, NJ (Stanley, research associate; DeLia, assistant research professor & senior policy analyst). Send correspondence and reprint requests for *J Natl Med Assoc.* 2007;99:201–207 to: Dr. Joel C. Cantor, Professor and Director, Center for State Health Policy, Rutgers University, 55 Commercial Ave., Third Floor, New Brunswick, NJ 08901; phone: (732) 932-4653; fax: (732) 932-0069; e-mail: jcantor@ifh.rutgers.edu

INTRODUCTION

Sudden cardiac death (SCD), cardiovascular mortality associated with ventricular arrhythmia, remains the most common of cause of death due to cardiovascular disease.[1] Patients with previous history of sustained ventricular arrhythmia and patients with a history of myocardial infarction and ventricular arrhythmia have a SCD incidence of 10–20% per year.[1] African Americans are more likely than whites to experience sudden death at a younger age and have age-adjusted rates for SCD that were 23–27% higher than whites, except in the 65–74 age group.[2-4]

Implantable cardioverter defibrillator (ICD) therapy is an accepted and often preferred treatment for SCD in at-risk populations.[5-9] African Americans are less likely to be treated with ICD therapy. In California from 1992–1994, rates of ICD implantation in patients with ventricular arrhythmia were 9% for African Americans and 20% for whites.[10] From 1987–1995, when 9% of Medicare beneficiaries were African American, only 3% of those with Medicare coverage receiving ICD therapy were African American.[11,12] In random samples of Medicare recipients, ICD implantation rates from 1992–2000 were 11–14% in white and 6–7% in African-American patients at risk for SCD.[13,14]

Studies of the Medicare population may understate the racial disparity in ICD therapy, since SCD occurs earlier in adulthood among African Americans. To address this issue, this paper examines differences in ICD therapy between African Americans and whites using hospital discharge data for adults aged ≥18. In the 1990s, ICD therapy became widely dispersed geographically.[13] To assess whether the diffusion of this technology has had an effect on the racial disparity in ICD therapy, rates of ICD use by patient race are examined for the years 1996–2001.

In 1985, the Food and Drug Administration approved the use of ICD therapy for cases where drug therapy failed to prevent sustained ventricular tachycardia or ventricular fibrillation, a portent or event of SCD.[15] In 1996, the American Heart Association, in a consensus statement issued jointly with the North American Society of Pacing and Electrophysiology, reported that "... ICD is effective therapy for terminating ventricular arrhythmias and preventing SCD ...".[16] However, national studies have demonstrated racial disparity in ICD utilization in people over 65.[12-14]

Research in other areas such as AIDS treatment, meningitis vaccine development and asthma therapy has shown that disparities in treatment can be reduced with diffusion of technology and innovation.[17-19] Historically, ICD implant frequency lagged behind in the southern United States, where a disproportionate number of elderly African Americans reside.[14] Groeneveld, looking at increasing frequency of ICD implants in the south over time, found that technology diffusion reduced but did not eliminate race disparity in ICD therapy in Medicare beneficiaries.

No national studies have examined the racial disparity in ICD usage in younger populations. This is a significant gap in the literature, since SCD occurs commonly among African Americans aged <65.[2] Evaluations showing improvement in race disparity of ICD implantation may be erroneous since a significant part of the African-American population at risk is <65, and previous studies focus on the elderly.

METHODS

Data Source

In this paper, racial disparity in ICD therapy is analyzed using the National Hospital Discharge Survey (NHDS) for the years 1996–2001. The NHDS is based on a stratified, multistage probability sample of inpatient discharges from nonfederal, short-stay hospitals in the United States.[20] In stage 1, 112 primary sampling units (PSUs) are selected. In stage 2, hospitals are sampled from the PSUs. Hospitals with ≥1,000 beds or ≥40,000 discharges per year are selected with certainty. In stage 3, discharges are sampled from hospitals selected in stage 2.

The NHDS public use files contain survey weights to generate nationally representative estimates of hospital utilization. However, to protect confidentiality of respondents, the public use files do not identify PSUs

Table 1. Characteristics of patients at risk for sudden cardiac death (SCD) by race, 1996–2001*

	All Patients at Risk for SCD†		
Characteristics	**Nonblack**	**Black**	**Race Unstated**
Age (Mean)‡	68.7	63.2	68.6
Female§	37.2%	45.6%	38.1%
Expected Payer§			
Medicare	58.8%	55.1%	60.7%
Medicaid	1.9%	7.1%	2.9%
Private	35.8%	33.4%	33.2%
Self-pay	1.7%	2.5%	1.8%
All others	1.9%	1.9%	1.4%
Region§			
Northeast	28.2%	15.6%	10.8%
Midwest	18.5%	14.6%	47.4%
South	38.2%	62.3%	13.4%
West	15.1%	7.7%	28.4%
Hospital Size§			
6–99 beds	13.8%	10.3%	17.8%
100–199 beds	23.6%	16.3%	28.2%
200–299 beds	18.3%	19.4%	22.3%
300–499 beds	29.3%	33.0%	20.1%
≥500 beds	15.1%	20.9%	11.5%
Hospital Ownership§			
Proprietary	10.7%	10.6%	5.8%
Government	9.8%	17.3%	3.1%
Nonprofit	79.5%	72.1%	91.1%

Source: National Hospital Discharge Survey, 1996–2001; * Patients with diagnosis of sustained ventricular tachycardia or ventricular fibrillation; † All figures are calculated using survey weights provided with NHDS. The nonblack category includes white patients and patients of other known race; ‡ Difference between black and nonblack is significant at p<0.01, and the difference between race unstated and nonblack is not significant according to analysis of variance tests; §Characteristic varies significantly by race at p<0.01 according to Chi-squared tests.

and do contain information needed to properly calculate standard errors of point estimates. Instead, the National Center for Health Statistics, which administers the public use files, provides variance curves from which standard errors can be approximated. The NHDS public use files provide information on patient and hospital demographics, length of stay, diagnoses and procedures. Diagnoses and procedures are coded using the 9th Revision of the International Classification of Disease. Persons with multiple discharges may be sampled more than once. However, a procedure of ICD placement occurring more than once in the same person would be very unusual, so the reported rates are assumed to measure independent ICD placements.

Patient race is underreported in the NHDS, which is a problem that can compromise analysis of utilization by race. However, when comparing NHDS to other data sources, such as the National Health Interview Survey and Medicare administrative data, underreporting of race in NHDS data does not appear to reduce available information on African Americans. Instead underreporting tends to occur most frequently among whites.[21]

This study addresses the problem of underreported race by comparing ICD therapy for patients identified as African American, other (known) race and race unknown. We find that rates for patients with unknown race are similar to rates for patients of known nonblack race, which is consistent with the literature that documents underreporting of racial information by white patients.

Measures

The disparity in ICD utilization is measured as the difference in rates of ICD use between African Americans and others who are at risk for SCD. Individuals at risk for SCD are defined as patients with ≥1 of the following diagnoses as coded in the 9th Revision of the International Classification of Diseases (ICD-9): ventricular tachycardia (427.1), ventricular fibrillation (427.4) or cardiac arrest (427.5). The ICD utilization rate is defined as the number of individuals receiving ICD therapy (procedure codes 37.94–37.99) as a proportion of the number identified as being at risk for SCD. These rates are expressed as percentages and calculated separately for African Americans, other patients of known race and patients with unidentified race for the years 1996–2001. The category of nonblack patients of known race includes individuals identified as white, American Indian/Alaska native, Asian, native Hawaiian/other Pacific Islander, multiple race indicated and "other." Persons classified as "other" account for 3% of the (weighted) sample of individuals at risk for SCD.

In this paper, the term "African American" is used interchangeably with "black." Also, race is classified without regard to Hispanic ethnicity. Initial analysis of differences by race use the combined sample from 1996–2001, providing maximum statistical power. Since the sample of ICD users in any given year is small, analysis is done using data organized into two three-year periods: 1996–1998 and 1999–2001. Except where noted, all analyses apply survey weights from the NHDS.

The risk of SCD and utilization of ICD therapy are expected to vary by factors other than patient race, including age, gender, insurance coverage and treating facility characteristics. Since these factors may vary by race, it is important to understand what relationship they may have to the disparity in ICD utilization rates. The relevant data for this purpose that are available in the NHDS include patient age, gender, geographic region and expected source of payment as well as hospital size (number of beds) and hospital ownership (nonprofit, for-profit or public). Direct measures of socioeconomic status (e.g., patient income, education) are not available

Table 2. Population estimates of patients at risk for sudden cardiac death* and receiving implantable cardioverter defibrillator therapy by race, 1996–1998 and 1999–2001†

Year and Race	Number at Risk for SCD	Number Receiving ICD	ICD Utilization per 100 at Risk
1996–1998			
Black	65,174	2,086	3.2
Nonblack	580,523	46,549	8.0
Race unstated	136,986	10,823	7.9
1999–2001			
Black	63,607	5,820	9.2
Nonblack	518,928	63,043	12.1
Race unstated	177,933	21,367	12.0
All Years			
Black	128,781	7,906	6.1
Nonblack	1,099,451	109,592	10.0
Race unstated	314,919	32,190	10.2

Source: National Hospital Discharge Survey, 1996–2001; * Patients with diagnosis of sustained ventricular tachycardia or ventricular fibrillation; † All figures are calculated using survey weights provided with the NHDS. The nonblack category includes white patients and patients of other known race.

in the NHDS. However, we expect that patient economic circumstances are roughly correlated with expected payer and region.

Analysis

In descriptive analysis, data on ICD utilization and risk of SCD are stratified by variables described above for African-American, nonblack patients of known race and unclassified patients. Analysis of variance (ANOVA) tests are performed to determine whether the average age of individuals at risk and individuals receiving treatment varies by race. Chi-squared tests are performed to determine whether differences by race exist in categorical variables.

Logistic regression is used to determine whether a change in ICD rates by race between 1996–1998 and 1999–2001 are influenced by the patient and hospital characteristics described above. Specifically, the odds of ICD use among patients at risk for SCD are modeled as a function of time interacted with race and the other factors described above. If there is a gap in ICD therapy between blacks and others that closed over time, then this should be reflected in the odds ratios (ORs) corresponding to the race/year interactions. Using nonblacks in 1996–1998 as the reference category, the OR for this category in 1999–2001 measures the increase over time in the odds of nonblack patients receiving ICD holding other factors in the model fixed. Specifically, an OR of >1 indicates an increase in these odds. Since all ORs are relative to nonblack patients in 1996–1998, the change for blacks is measured as the OR for blacks in 1999–2001 divided by the ORs for blacks in 1996–1998. If there is a disparity in ICD therapy that narrowed over time, then the growth in the ORs for blacks will be greater than the corresponding growth for others. To show how the other variables in the model affect the change in ICD use by race, a logit model without these control variables is compared with the full model.

Logistic regression models are estimated using the "logit" command in Stata® 8.0. Since the PSUs are not available on public use files, it is not possible to calcu-

Table 3. Relative odds of receiving implantable cardioverter defibrillator (ICD) therapy among at-risk patients, 1996–1998 and 1999–2001

Characteristics	Nonadjusted Odds Ratios*	Adjusted Odds Ratios*
Race and Year		
Nonblack, 1996–1998	†	†
Nonblack, 1999–2001	1.82	2.00
Black, 1996–1998	0.41	0.37
Black, 1999–2001	1.33	1.29
Race unstated, 1996–1998	1.04	1.09
Race unstated, 1999–2001	1.90	2.37
Age (Years)		0.98
Female		0.47
Expected Payer		
Private insurance		†
Medicaid		0.68
Medicare		1.03
Self-pay		0.57
All other insurance		0.47
Region		
Northeast		†
Midwest		1.11
South		0.87
West		1.24
Hospital Size		
<100 beds		0.01
100–199 beds		0.30
200–299 beds		0.79
300–499 beds		†
≥500 beds		1.57
Hospital Ownership		
Nonprofit		†
For profit		0.66
Public		0.85

Source: National Hospital Discharge Survey, 1996–2001; * All odds ratios are significantly different from 1.0 at p<0.01; † Variable used as the reference category. Related odds ratios are relative to this group.

late standard errors in the logit model to reflect the complex survey design. To compensate, robust standard errors are calculated.[22,23] Although this adjustment does not fully account for the survey design, it is more conservative in that it produces larger standard errors to reflect the greater level of uncertainty in estimating the model compared with ordinary logistic regression.

RESULTS

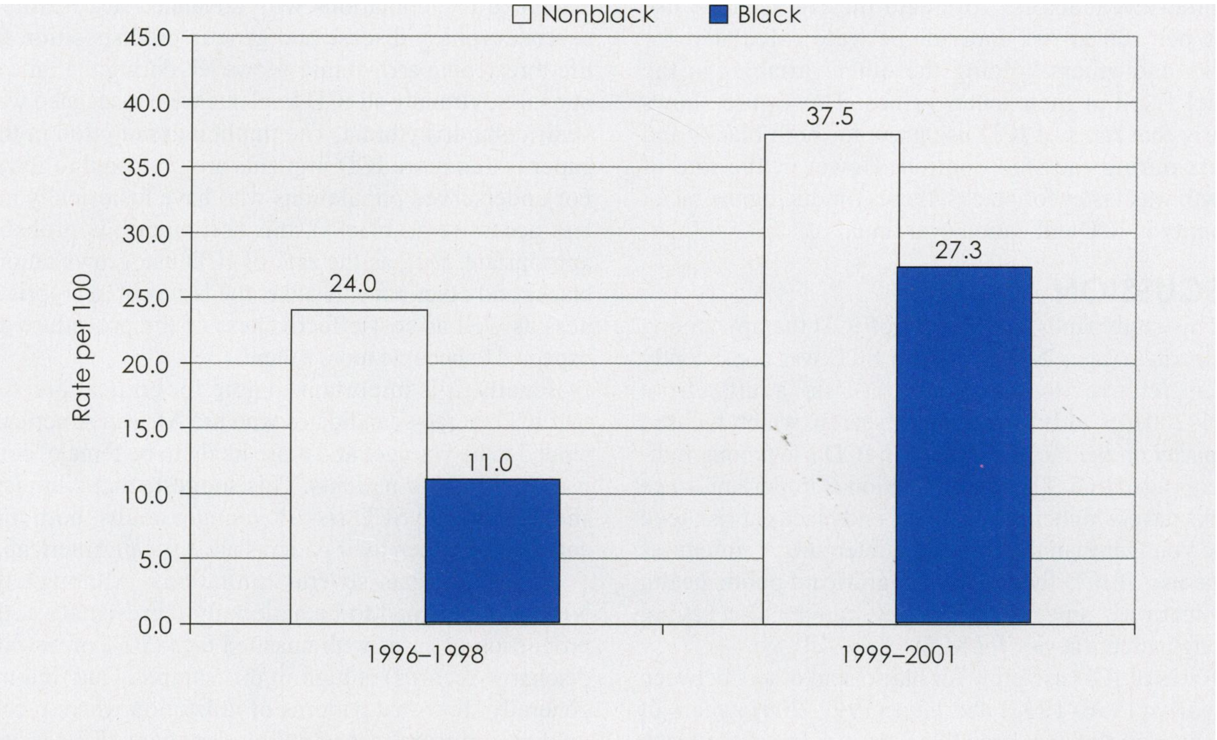
Diagnostic evidence of risk for SCD (cardiac arrest, ventricular tachycardia or ventricular fibrillation) was noted in 18,585 (unweighted) adult patient discharges in the NHDS from 1996–2001, representing a total of 1,543,151 (weighted) individuals. As well, there were 1,726 total (unweighted) episodes of ICD therapy, representing a total of 149,688 (weighted) individuals. When weighted, the overall study population was 9% black, 71% nonblack (race known) and 20% race not stated, and the treated population 6% black, 73% nonblack and 22% race not stated.

On average, African Americans at risk for SCD were significantly younger than others (Table 1). More than 50% of African Americans in the study population were aged <65, compared with 32% of others who were <65 ($p<0.0001$). Blacks and others at risk for SCD differed in other ways as well (Table 1). Blacks at risk for SCD were more likely than others at risk to be women and more likely to have Medicaid or self-pay as their expected payer. Blacks at risk for SCD are heavily concentrated in the south, reflecting the high concentration of the black population in that region in general. Finally, African Americans at risk of SCD are more likely to receive care in larger hospitals and in public hospitals.

A disparity in ICD therapy rates among patients at risk for SCD was evident throughout the study period (Table 2). From 1996–2001, the ICD therapy rate for blacks was only 6%, compared with 10% for patients of both other and unclassified race. ICD therapy rates increased for all race groups between 1996–1998 and 1999–2001 (Table 2). However, because the rate of increase was larger for blacks than for others, the racial disparity in ICD use fell by 40% between the two periods. Specifically, the gap in ICD use per 100 individuals at risk fell from 4.8 in 1996–1998 to 2.9 in 1999–2001 (i.e., (4.8 - 2.9) / 4.8 = 0.40). Moreover, by 1999–2001, the rate of ICD use among blacks caught up to and may have surpassed the rate of ICD use experienced among patients of nonblack race in 1996–1998.

Logistic regression analysis confirms that the racial disparity pertaining to ICD therapy—with and without

Figure 1. Predicted rates of receiving implantable cardioverter defibrillator therapy among at-risk patients by race and year*†



Source: based on adjusted logistic regression model in Table 3; * Predicted rates evaluated at the mean age for each group defined by race; † Race Unstated not shown.

adjustment for other factors—did shrink from 1996–2001 (Table 3). The analysis compares the odds of receiving an ICD implant by blacks versus others in the two time periods. In 1996–1998, the odds of receiving ICD therapy were 59% less for blacks relative to others. In 1999–2001, the odds of receiving ICD therapy were only 27% less for blacks relative to others. Performing the same calculations in the adjusted model produces similar results. Specifically, the odds of receiving ICD therapy were 63% less for blacks relative to others in 1996–1998 and only 36% less in 1999–2001.

Although they did not change the relationship between race and the use of ICD therapy over time, other variables in the model did appear to influence the odds that an individual of any race receives an ICD implant (Table 3). The odds of receiving an ICD implant declined with age by 2% per year. Women at risk for SCD had approximately one-half the odds of receiving an ICD implant as men. Compared with patients expected to be covered by private insurance, Medicaid and self-pay patients had lower odds of receiving an ICD implant, while Medicare patients had the same odds. The odds of receiving ICD therapy were relatively lower in the south and higher in the midwest and west. The odds of receiving ICD therapy increased with the size of the hospital in which the patient was admitted. Finally, the relative odds of ICD implantation were lowest in for-profit hospitals and highest in private nonprofit hospitals.

Figure 1 illustrates how the racial disparity in ICD use changed over time after adjusting for patient and hospital-level factors. To create the figure, ICD use rates per 100 at-risk individuals were calculated for blacks and others holding the other variables in the model fixed at their mean values. The figure shows clearly that rates of ICD use grew for both blacks and others during the study period. However, the rate of growth was faster for blacks, thereby reducing the racial disparity in ICD utilization over time.

DISCUSSION

This study finds that the use of ICD therapy among black adults (ages ≥18) at risk for SCD was consistently lower relative to nonblack, at-risk adults from 1996–2001. It adds to previous research, which focused primarily on the racial disparity in ICD use among individuals aged ≥65. The age distinction is important, since blacks have a higher risk of SCD, and blacks at risk tend to be younger than their white counterparts. Limitations in the use of ICD therapy have significant public health implications, since ICD therapy can be life saving among patients at risk for SCD.

Rates of ICD use grew for blacks and others between the early (1996–1998) and later (1999–2001) years of the study, with faster growth occurring within the black population. As a result, the racial disparity in the rate of ICD use fell by 40%. Our findings also show that African Americans are disproportionately represented in groups that are less likely to receive ICD therapy. For example, they are more likely to be classified as self-pay or covered by Medicaid and to live in the south, where ICD therapy has been historically less widely available. Nevertheless, adjustment for these factors does not alter the findings described above (i.e., the existence of a disparity in ICD implantation, which has fallen over time but was not eliminated).

The reduction in the disparity of ICD use may have been influenced by the greater availability of ICD technology over time, particularly in the south. This is consistent with previous literature on the relationship between technology diffusion and racial disparities in other health services.[17-19] It is not known whether the racial disparity in ICD use continued to decline since the end of our study period in 2001. Our findings do not address important questions about the relationship between technology diffusion and racial disparities in access to and use of services. It may be, for example, that the relationship between the diffusion of ICD technology, which occurs in tertiary settings and most often requires referrals, may be weaker than this relationship for services that are delivered in primary care settings, such as preventive services or prescription drugs. Cost, availability of reimbursement or other barriers to access may also mediate the relationship of technology diffusion and disparities.

The clinically derived standard for the optimal rate of ICD use among at-risk populations is evolving, as use has expanded to populations with advanced heart failure, severe coronary disease and genetic predisposition for life-threatening arrhythmia. However, during the time of our study, virtually all ICD implants were associated with ventricular arrhythmia. The implicit assumption in this paper is that more ICD implants are preferred to fewer. For underserved populations who have historically had less access (e.g., blacks), this assumption is probably appropriate. But, as the rate of ICD use grows among blacks and other patients alike, the issues of appropriateness as well as cost-effectiveness of the procedure are expected to become more salient.

Finally, it is important to note for clinical practice that ICD therapy candidates who are African Americans tended to be younger and more likely to be female, compared with other patients. This suggests that clinicians should evaluate SCD risk in younger adults, both men and women, when their patients are African American.

This study has several limitations. Although the NHDS is designed to be nationally representative, the proportion of cases with unstated race (20% of hospital discharge records) is high in this sample. Our findings generally show that patterns of utilization where race is unknown mirror those of nonblack patients. This is consistent with previous literature showing that underreported race data is more common among whites and is unrelated to the reporting of medical procedures.[21,24] This implies that our estimates of disparity in treatment are robust.

The NHDS also lacks some potential correlates of ICD utilization, such as patient income and education. While the addition of such variables would strengthen our analysis, variables included in this study, such as expected payer, can be viewed as proxy measures of socioeconomic status.

The limited use of ICD in the general population led to sample sizes that were too small for year-by-year trend analysis. As a result, the analysis had to treat six years of data as only two data points. Also, the censoring of primary sampling units in the public release files of the NHDS precluded more precise estimates of standard errors in the estimation and modeling. Although robust methods were used to provide conservative estimates of standard errors, these problems add some degree of uncertainty to the findings.

Although Medicare data provide rich information for analysis of racial disparities in use of health services, our study suggests that investigations limited to the elderly can understate disparities when the underlying conditions occur at an earlier age among minority populations, as in the case of SCD. Like previous studies, this study showed that with the diffusion of a medical technology, utilization disparities declined. Further research is needed to more fully understand the relationship between technology diffusion, patterns of referrals for services and other factors that may influence disparities. Evidence suggests, however, that assuring access to promising new technologies by traditionally underserved populations should be of particular concern for policymakers and clinicians.

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