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Trends in Implantable Cardioverter-Defibrillator Racial Disparity

The Importance of Geography

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OBJECTIVES The study was designed to determine whether racial disparity in utilization of the implantable cardioverter-defibrillator (ICD) has improved over time, and whether small-area geographic variation in ICD utilization contributed to national levels of racial disparity.

BACKGROUND Although racial disparities in cardiac procedures have been well-documented, it is unknown whether there has been improvement over time. Low ICD utilization rates in predominantly black geographic areas may have exacerbated national levels of disparity.

METHODS Discharge abstracts from elderly black and white Medicare beneficiaries hospitalized with ventricular arrhythmias from 1990 to 2000 were analyzed to determine if ICD implantation occurred within 90 days of initial hospitalization. Multivariate logistic regression models were constructed to assess the relationship between ICD implantation, year of admission, and the percentage of black inhabitants in each patient's county of hospitalization while controlling for clinical, hospital, and demographic characteristics.

RESULTS There was improvement in ICD implantation racial disparity: In the period 1990 to 1992, black patients had an odds ratio of 0.52 (95% confidence interval [CI] 0.42 to 0.64) for receiving an ICD compared with whites. However, by 1999 to 2000, the odds ratio for blacks had risen to 0.69 (95% CI 0.61 to 0.78) (test-for-trend $p = 0.01$). Approximately 20% of this trend could be explained by reduction in geographic variation in ICD use between areas with larger black and predominantly white populations.

CONCLUSIONS Rates of ICD implants became more equal among whites and blacks during the 1990s, although persistent disparity remained at the decade's end. Geographic equalization in cardiovascular procedure rates may be an essential mechanism in rectifying disparities in health care. (J Am Coll Cardiol 2005;45:72–8) © 2005 by the American College of Cardiology Foundation

Driven by increasing evidence of clinical benefit, development of non-thoracotomy implantation techniques, and expanded opportunities for reimbursement (1–4), utilization of the implantable cardioverter-defibrillator (ICD) has increased markedly over the past 15 years (5,6). Nevertheless, there are indications that this technology is not used equally in different racial groups, with the rate of implantation among white patients consistently exceeding the rate among blacks (7). The recent Institute of Medicine Report, *Unequal Treatment*, has encouraged exploration of the root causes of these disparities in order to identify opportunities for improvement (8). One such contributor may be geographic differences in the availability of medical technology. Black patients may be less likely to receive some medical technologies because they live in areas where the technologies are underutilized (9). For example, approximately 54% of elderly black Americans live in the southern U.S. (10), and previous studies have suggested that many southern states have below-average utilization of beneficial medical procedures (11,12).

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Rapid-growth, innovative technologies such as ICDs may be particularly prone to racial disparity, as technologies that are rapidly diffusing through the health care system may be at greatest risk of being used unequally (13). However, the phenomenon of technology diffusion may also present an opportunity for reduction in racial disparities, as policies might be designed to accelerate the delivery of new technology to geographic areas that are historically slow to adopt innovation (14,15). In this study, we examined 11 consecutive years of Medicare administrative data recording ICD use among elderly patients with ventricular arrhythmias to determine if there were trends indicating improvement in racial disparity, and whether such trends were influenced by geographic differences in the rate of ICD utilization.

METHODS

Setting. The purpose of this study was to compare the rate of ICD implantation among a broadly defined cohort of elderly whites and blacks who were potentially eligible for

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Abbreviations and Acronyms

CI	= confidence interval
ICD	= implantable cardioverter-defibrillator
MEDPAR	= Medicare Provider Analysis and Review
ZIP	= Zoning Improvement Plan

the procedure, and to analyze time trends in racial disparity in ICD utilization during the 1990s. Stanford University's Administrative Panel on Human Subjects in Medical Research approved the research protocol. The primary sources of data were Medicare Provider Analysis and Review (MEDPAR) administrative records from a random 20% sample of all elderly Medicare beneficiaries from 1990 to 2000. We identified elderly Medicare beneficiaries who were hospitalized with an admitting, primary, or secondary diagnosis of ventricular fibrillation, ventricular tachycardia, or cardiac arrest (International Classification of Diseases, Ninth Revision, Clinical Modification codes 427.4, 427.41, and 427.5) (16). These were the only diagnoses for which reimbursement for ICD implantation had been approved by the Center for Medicare and Medicaid Services during the years of the study (17). All patients were admitted to non-federal hospitals in the 50 states or the District of Columbia. We excluded patients who were enrolled in a health maintenance organization or who had a previous ICD implantation recorded in the MEDPAR database, and we limited our cohort to patients admitted between January 1, 1990, and October 2, 2000, as insufficient follow-up records were available to determine if ICD implantation had occurred within 90 days of hospitalization among those admitted after this period. All patients were black or white and between the ages of 65 and 94 years of age. After forming the initial cohort, we excluded patients who had no demographic information recorded in the Medicare enrollment database, or who had ambiguous or conflicting entries for date of death, discharge destination, or hospitalization in the MEDPAR record.

Patient characteristics. Demographic information was abstracted from the Medicare enrollment database, in which age and gender were determined from birth record documentation used in Social Security applications, and race was self-reported. We estimated Zoning Improvement Plan (ZIP) code-specific median income and educational attainment using data from the 1990 and 2000 U.S. Census. To adjust for differences in comorbidities between patients, we used a validated method of risk-adjusting administrative data using diagnosis codes recorded in the index hospitalization record. A vector of 29 dummy variables was constructed for each patient, with values dependent on the presence or absence of diagnostic codes for each clinical category (18). This method has been demonstrated to be superior in several cases for predicting short-term mortality when compared with the Charlson comorbidity index (19), even when a "look-back" to previous medical encounters has been incorporated into the Charlson calculation (20). We also determined whether there was coding for acute myocardial infarction (410) or cardiac ischemia without infarction (411). As our previous work suggested that a diagnosis of anoxic brain injury was an independent, negative predictor for receipt of an ICD (7), we recorded the presence of this code (34.81) in the MEDPAR record as well.

Because socioeconomic factors can influence the relationship between quality of health care and outcomes (8), we estimated educational attainment and income by matching the subject's race and ZIP code to race-specific, median education and per-capita income as reported, by ZIP code, in the 1990 and 2000 U.S. Census. We used simple linear extrapolation to estimate ZIP code level income and education for years of admission between 1990 and 2000. "Hot deck" imputation was used to substitute for absent income and education data in the census (<5% of patients lived in such areas) (21). Income levels were adjusted for regional variation in cost-of-living using indices for 1990 (22), and all incomes were adjusted to year 2000 dollars using the consumer price index (23). Although ZIP code data cannot accurately estimate the socioeconomic status of individuals, such data have been used effectively in health care utilization studies to control for socioeconomic variation among communities (24–26).

Hospital characteristics. We used linked data from the American Hospital Association to identify each patient's admitting hospital and to ascertain the institution's academic status. We classified a hospital as an academic medical center if it was a member of the council of teaching hospitals, comprising approximately 500 medical centers in the U.S. (27). To determine whether patients were receiving care in an urban hospital, we first identified the health service area (i.e., locality sharing tertiary referral centers and health services infrastructure [28]) in which the patient was hospitalized. We assigned "urban" status to those patients hospitalized in health service areas with greater than one million inhabitants in the 2000 U.S. Census—61 of the nation's 802 health service areas met this definition (10,28).

Outcomes. The primary outcome of interest was receipt of an ICD within 90 days of hospital admission, as many patients hospitalized with ventricular arrhythmias have a compelling clinical indication for prompt defibrillator implantation. The dates of defibrillator implantation (International Classification of Diseases-Clinical Modification procedure codes 37.94 or 37.96) were determined from the index and all subsequent MEDPAR records for each patient in our cohort through the year 2000. As patients who may have otherwise received a defibrillator within 90 days of discharge may have died before having the opportunity, we also determined the date of the patient's death from the annual Medicare enrollment database, which was cross-referenced to the Social Security Death Master File.

Multivariate analyses. We modeled defibrillator utilization using multinomial logistic regression, a method of linear modeling in which the dependent variable has more than two discrete outcomes. The three potential outcomes for our models were: 1) survival to 90 days after index admission without receiving a procedure; 2) death before 90 days without a procedure; or 3) receipt of procedure within 90 days of admission. All regression models included gender, age, income, education, year of admission, the Elixhauser comorbidity vector, coding for ventricular fibrillation or ventricular tachycardia on admission, coding for anoxic brain injury or coronary ischemia during hospitalization, and whether the qualifying diagnosis was the admitting and/or primary diagnosis.

In the first regression model, we included an interaction term between the year of hospital admission and race to ascertain whether there was a significant temporal change in the relationship between race and procedure receipt. The second model included all the variables in the first model plus an additional variable indicating the percentage of black inhabitants in the county where the patient was hospitalized (10), as well as an additional interaction between this variable and year of admission. By adding this second time-trend, we could measure the effect on the slope estimate of the original race-year trend—a reduction in slope would indicate that changes over time in the effect of race could be explained by increased procedural availability over time in areas with higher black populations. We hypothesized that technology diffusion and racial disparity may be materially different at academic compared with non-academic hospitals, thus we applied our models to the entire cohort as well as to sub-cohorts comprising patients admitted to academic and non-academic centers.

We used *t* tests to compare continuous variables except when data were skewed, in which case the Wilcoxon rank-sum statistic was used. We used chi-square tests to compare categorical variables. Comparisons between the values of coefficients in nested multivariate models followed the method of Clogg et al. (29). We used Bonferroni's correction for multiple pair-wise comparisons. All analyses were performed using SAS version 8.2 (SAS Institute, Cary, North Carolina), except for the regression procedures, which were performed using STATA version 7.0 (Stata Corp., College Station, Texas). All regression models were adjusted for data being clustered, and all significance tests were two-sided. We assumed a p value of <0.05 was statistically significant.

RESULTS

We identified 570,575 white or black elderly patients hospitalized with cardiac arrest or ventricular arrhythmia between 1990 and 2000 (Table 1). The proportion of black patients closely approximated the fraction of elderly Medicare beneficiaries who are black (30). As compared with white patients, black patients were slightly younger, more likely to be female, and from communities with lower race-specific levels of income and education. Black patients were more likely to have been admitted to academic hospitals or hospitals in major urban centers. Clinically, white patients were more likely to have ischemic heart disease, ventricular fibrillation/tachycardia, valvular heart disease, peripheral vascular disease, chronic pulmonary disease, hypothyroidism, early-stage cancer, rheumatologic disease, and depression. Conversely, black patients were more likely to be diagnosed with anoxic brain injury, congestive heart failure, pulmonary circulatory disease, hypertension, paralysis, neurologic disease, diabetes, renal insufficiency, metastatic cancer, weight loss, fluid/electrolyte imbalance, anemia, and alcohol abuse.

Defibrillators were implanted within 90 days of hospital admission for 5.3% of the cohort. Among all patients who underwent ICD implantation within the first year after hospitalization, 91% of whites and 89% of blacks received the device within the first 90 days ($p = 0.003$ for the difference). In academic centers, the ICD implantation rate among elderly patients increased from 2% to 13% from 1990 to 2000, whereas in non-academic centers the implantation rate increased from 2% to 10% (Fig. 1). Substantial differences in ICD implantation rates among white and black patients were apparent at both academic and non-academic medical centers throughout these 11 years. In the final year of the study (2000), approximately twice as many elderly white patients (11%) received ICDs compared with black patients (6%).

Geographic differences in ICD utilization decreased over time. When the ICD implantation rate was compared between counties with >10% black population and those counties with <10% black population, a "geographic gap" was noted for non-academic hospitals early in the 1990s (Fig. 2). By the end of the 1990s this gap had closed. For academic hospitals, initial geographic near-parity in 1990 to 1992 was followed by higher ICD rates in academic hospitals in counties with smaller black populations in the mid-1990s, but by 1999 to 2000 this difference disappeared. Increases over time in the relative ICD implantation rate for blacks compared with whites were observed in most areas, but most markedly in localities with large black populations. Geographically, there were initially higher rates of ICD implantation in the Northeast, Great Lakes area, and Pacific Coast in 1990, but by the year 2000 procedure rates were more geographically uniform.

Multivariate analyses indicated significant time trends in both racial disparity and geographic variation (Table 2). Racial disparity for ICD use was present in both academic and non-academic hospitals throughout the 1990s. However, there was also a significant time-trend for improvement in racial disparity, with the odds ratio for blacks receiving ICDs rising from 0.52 in the years 1990 to 1992 to 0.69 in 1999 to 2000 ($p = 0.01$ for trend). Subgroup analyses indicated that this improvement was entirely due to decreasing disparity in non-academic hospitals ($p = 0.002$ for time trend), whereas we observed no significant time trend in the ICD racial disparity rate at academic institutions. When additional interaction terms that measured the

Table 1. Characteristics of the Ventricular Arrhythmia Cohort*

	Whites (n = 519,604)	Blacks (n = 50,971)	p Value
Demographic characteristics			
Age, mean (SD), yrs	76 (7)	75 (7)	<0.0001
Female gender	217,312 (42)	25,456 (50)	<0.0001
Per-capita income, median (IQR), $	20,000 (16,800–25,000)	11,700 (9,600–14,600)	<0.0001
Education, mean (SD), yrs	13.8 (1.2)	12.6 (1.1)	<0.0001
Region			<0.0001†
Northeast	131,145 (25)	9399 (19)	
Midwest	134,387 (26)	10,839 (21)	
South	187,937 (36)	27,616 (54)	
West	66,135 (13)	3117 (6)	
Hospitalization characteristics			
Academic hospital‡	68,874 (13)	13,369 (26)	<0.0001
Urban hospital§	232,237 (45)	28,970 (57)	<0.0001
Qualifying diagnosis was admitting diagnosis	68,085 (13)	5,804 (11)	<0.0001
Qualifying diagnosis was primary diagnosis	76,787 (15)	6,198 (12)	<0.0001
Year of admission			<0.0001†
1990–1992	149,505 (29)	13,336 (26)	
1993–1995	152,618 (29)	14,549 (29)	
1996–1998	139,997 (27)	14,367 (28)	
1999–2000	77,484 (15)	8,719 (17)	
Clinical characteristics			
Anoxic brain injury	12,516 (2)	1,462 (3)	<0.0001
Ischemic heart disease	193,496 (37)	12,918 (25)	<0.0001
Ventricular fibrillation or ventricular tachycardia	475,288 (91)	45,459 (89)	<0.0001
Congestive heart failure‖	203,349 (39)	23,603 (46)	<0.0001
Valvular heart disease‖	61,903 (12)	4,991 (10)	<0.0001
Pulmonary circulatory disease‖	6,509 (1)	838 (2)	<0.0001
Peripheral vascular disease‖	19,700 (4)	1,760 (3)	0.0001
Hypertension‖	108,095 (21)	12,566 (25)	<0.0001
Paralysis‖	5,281 (1)	884 (2)	<0.0001
Neurologic disease‖	25,581 (5)	2,908 (6)	<0.0001
Chronic pulmonary disease‖	97,541 (19)	7,909 (16)	<0.0001
Diabetes without complications‖	51,349 (10)	6,520 (13)	<0.0001
Diabetes with complications‖	11,957 (2)	1,875 (4)	<0.0001
Hypothyroidism‖	15,501 (3)	735 (1)	<0.0001
Renal disease‖	12,668 (2)	3,275 (6)	<0.0001
Tumor without metastases‖	22,647 (4.4)	2,021 (4.0)	<0.0001
Metastatic cancer‖	3,492 (0.7)	488 (1.0)	<0.0001
Rheumatologic disease‖	4,616 (0.9)	368 (0.7)	0.0001
Weight loss‖	5,097 (1)	835 (2)	<0.0001
Fluid/electrolyte disturbance‖	76,461 (15)	9,725 (19)	<0.0001
Blood-loss anemia‖	5,522 (1.1)	706 (1.4)	<0.0001
Deficiency anemia‖	18,802 (4)	2,990 (6)	<0.0001
Alcohol abuse‖	4,535 (1)	828 (2)	<0.0001
Depression‖¶	5,583 (1.1)	258 (0.5)	<0.0001

*Unless otherwise indicated, data appear as number (percentage). †P value for chi-square of distribution among categories. ‡Member of the Council of Teaching Hospitals. §Located in a Health Service Area with population exceeding one million. ‖Elixhauser comorbidity category. ¶All other Elixhauser categories showed no significant differences between black and white patients.

IQR = interquartile range.

time trend of ICD utilization in counties with larger black populations were added to the multivariate models, the slope of the time trend in non-academic hospitals decreased significantly, from 1.045 to 1.036 ($p = 0.002$ for the difference). By the year 2000, there was no significant difference in the ICD utilization rate between areas with higher (>10%) and lower (<10%) black populations.

Modifying the definition of the primary outcome to include receipt of an ICD within 365 days rather than 90 days after hospital admission produced no substantive changes in the magnitude or significance of the multivariate analysis results.

DISCUSSION

Substantial racial disparity in ICD utilization persisted throughout the 1990s, but utilization progressively equalized in non-academic hospitals. Geographic differences in ICD utilization were present early in the decade, with elderly ventricular arrhythmia patients living in counties

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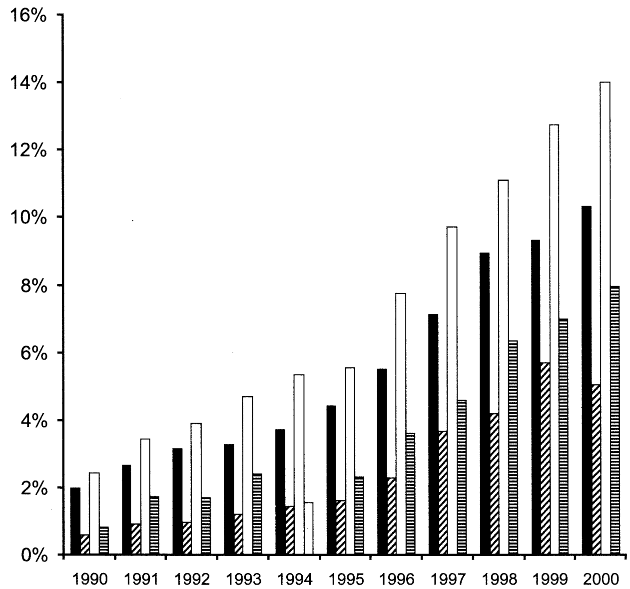

Figure 1. Implantable cardioverter-defibrillators (ICDs) implanted among elderly ventricular arrhythmia patients, by year. The **y-axis** represents the percentage of the target population receiving ICDs for each year indicated on the **x-axis**. **Black bars** = ICD implants among white patients admitted to non-academic hospitals; **diagonally cross-hatched bars** = ICD implants among black patients admitted to non-academic hospitals; **white bars** = implants among white patients admitted to academic hospitals; **horizontally cross-hatched bars** = ICD implants among black patients admitted to academic hospitals.

with >10% black population having a 19% to 23% lower likelihood of receiving an ICD in 1990 compared with patients living in counties with smaller black populations. However, by the year 2000, ICD implantation rates in communities with larger black populations essentially equaled procedure rates in communities with smaller black populations. These two phenomena appear to be correlated,

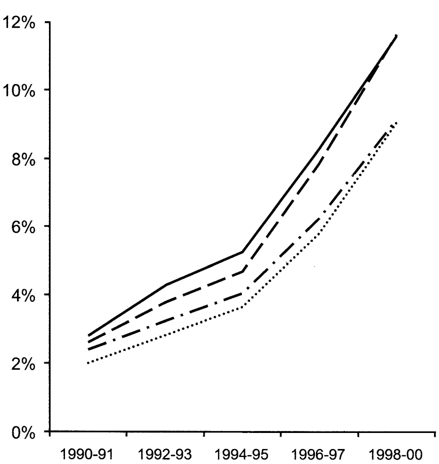

Figure 2. Time trends in geographic disparity. The **y-axis** represents the percentage of the target population receiving implantable cardioverter-defibrillators (ICDs) for each time period listed on the **x-axis**. **Solid line** = ICDs implanted in academic medical centers in counties with <10% black population; **dashed line** = ICDs implanted in academic medical centers in counties with >10% black population; **dot-dashed line** = ICDs implanted in non-academic medical centers in counties with <10% black population; **dotted line** = ICDs implanted in non-academic medical centers in counties with >10% black population.

with the reduction in geographic variation explaining approximately 20% of the improvement in racial disparity over the 11-year time period.

The administrative records on which this study was based lacked sufficient detail to determine if patients met established clinical criteria for ICD utilization (3). In fact, given the broadly defined denominator, undoubtedly many patients in our cohort had absolute contraindications to ICD use, such as transient arrhythmias provoked by reversible causes (e.g., coronary ischemia or electrolyte disturbances) or extremely limited life expectancy. It was therefore not possible to identify the "correct" rate of ICD implantation that would have represented the highest quality care (31,32). However, our previous work has suggested that the disparity in ICD utilization measured in administrative databases represents under-use among blacks, rather than over-use among whites, and the receipt of an ICD was a strong, independent predictor of long-term survival among both blacks and whites (7).

The persistence of racial disparity in implantable defibrillators during the decade of the 1990s, despite numerous reports documenting the presence of racial disparities in cardiac care and emphasizing the importance of their amelioration (33–36), is troubling. The Institute of Medicine's health disparities report described the pervasiveness of health care disparities (8). Our results suggest that such disparities may also be difficult to change—even as late as 1999 to 2000, elderly black patients with ventricular arrhythmias continued to have approximately two-thirds the likelihood of receiving an implantable defibrillator. This disparity persisted despite adjustment for numerous demographic and clinical differences between black and white patients. Substantial increases in the rate of ICD utilization among blacks may still be necessary in order to achieve racial equity in the care of patients with ventricular arrhythmias.

This study also suggests that geographic factors significantly contributed to national levels of racial disparity in defibrillator utilization. Specifically, implantable defibrillators may have insufficiently "penetrated" the health care systems where black patients were more likely to receive care. As a relatively new technology in the 1990s, ICDs were utilized at different rates in different localities, with delays in growth more likely in areas with larger black populations. Our results are in accordance with previous preliminary evidence suggesting a racial "innovation gap" in health care (13).

This finding poses an important implication for policymakers attempting to eliminate racial disparities in health care, a prominent goal of the U.S. Department of Health and Human Services' "Healthy People 2010" initiative (37): geographic differences in health care matter. The importance of this relationship between geography and race in health care disparity was highlighted by Skinner et al. (9), who found that 95% of the observed disparity in the rate of knee replacement surgery among Hispanic women, but only 16% of the disparity observed in black men, was attributable

Table 2. Results of Multivariate Analyses*

Time Trend(s) Included in Model	1990–1992	1993–1994	1995–1996	1997–1998	1999–2000	p Value, Linear Trend	p Value, Difference in Race Time-Trend†
All hospitals							
Race‡	0.51 (0.42–0.63)	0.57 (0.47–0.68)	0.57 (0.49–0.66)	0.64 (0.57–0.73)	0.71 (0.63–0.80)	0.003	n/a
Race and geography§	0.52 (0.42–0.64)	0.56 (0.46–0.67)	0.57 (0.49–0.67)	0.62 (0.54–0.70)	0.69 (0.61–0.78)	0.01	0.001
Academic hospitals							
Race‡	0.56 (0.38–0.81)	0.49 (0.35–0.68)	0.56 (0.42–0.75)	0.56 (0.44–0.72)	0.59 (0.48–0.73)	0.57	n/a
Race and geography§	0.53 (0.37–0.76)	0.49 (0.35–0.68)	0.60 (0.46–0.79)	0.55 (0.43–0.70)	0.61 (0.50–0.75)	0.39	0.12
Non-academic hospitals							
Race‡	0.46 (0.37–0.58)	0.54 (0.44–0.67)	0.52 (0.43–0.63)	0.63 (0.55–0.72)	0.70 (0.61–0.81)	0.002	n/a
Race and geography§	0.48 (0.38–0.61)	0.54 (0.44–0.68)	0.53 (0.44–0.63)	0.61 (0.52–0.70)	0.68 (0.59–0.79)	0.009	0.002

*Unless otherwise indicated, data appear as the adjusted odds ratio (95% confidence interval) for blacks receiving an implantable cardioverter-defibrillator compared with whites admitted to similar hospitals during the same time period. †Test for whether the time-trend slope for race differs between models. ‡Multivariate model with all clinical, demographic, and hospital covariates, time trend only for race. §Multivariate model with all clinical, demographic, and hospital covariates, time trends for both race and racial composition of county.
n/a = not applicable.

to geographic differences in procedure. Our results extend these findings by demonstrating that for one potentially life-saving cardiac procedure, reductions in racial disparity during the 1990s occurred simultaneously with decreases in geographic variability.

Our research suggests that policies designed to reduce geographic variation in health care by rewarding high-quality care and discouraging low-quality care may have the added benefit of reducing racial disparities. Quality-based financial incentives by federal and state health care payers that encourage the appropriate use of lifesaving procedures such as ICD implantation may consequentially diminish or eliminate both geographic and racial disparities in health care. Future research initiatives should be focused on delineating the key factors influencing technology adoption by physicians and hospitals that care for large numbers of minority patients. The role of institutional economic barriers to innovation deserves special emphasis.

Study limitations. Limitations of this study include issues related to both the observational design and nature of administrative data. Observational studies cannot prove causality, thus the correlation we observed between improvement in geographic disparity and reduction in racial disparity does not guarantee that geographic equalization of procedure rates actually promotes health care equity. Furthermore, administrative data lacks the rich detail of medical records—it is possible that systematic differences exist between the accuracy and/or detail of records for white and black beneficiaries, or between records produced by hospitals in areas with large black populations and hospitals in predominantly white areas. Also, we arbitrarily defined our outcome as ICD receipt within 90 days of hospitalization, and a disproportionate percentage of blacks underwent implantation after 90 days. Nevertheless, our results did not substantially change even if the window for ICD implantation was extended to a full year after hospital admission. In addition, the recent changes in clinical indications for ICD implantation may have changed the national pattern of ICD utilization and diffusion such that our observations are no longer applicable to current practice; however, there is little evidence to support this. Finally, as all patients in our study were older than age 65 years, the results that we observed may not apply to younger populations.

Summary. Utilization of the ICD was lower among black compared with white elderly Medicare beneficiaries throughout the 1990s, although there was more equal utilization by the end of the decade. Improvement in racial disparity was associated with reductions in geographic differences in ICD utilization. Policies designed to enhance the delivery of effective new technologies to localities with large minority populations may be essential to eliminate racial disparities in health care quality.

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