Racial and Ethnic Disparities in Cardiac Catheterization for Acute Myocardial Infarction in the United States, 1995–2001

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Objective: To examine recent trends in racial and ethnic disparities in cardiac catheterization for acute myocardial infarction (AMI) to determine whether disparities documented from the 1980s through mid-1990s persist, and evaluate whether patient and hospital characteristics are associated with any observed disparities

Methods: Cross-sectional analyses of 585,710 white, 51,369 black and 31,923 Hispanic discharges from hospitals in the Nationwide Inpatient Sample (which includes data on all discharges from 951 representative hospitals in 23 states) that had performed cardiac catheterization from 1995–2001 with a primary diagnosis of AMI. Adjusted procedure rates and prevalence ratios (PR) were computed to compare catheterization rates by race and ethnicity.

Measurements and Main Results: Catheterization rates were higher for whites than blacks for all years examined; rates among Hispanics increased during this period and approached the rate among whites. After adjustment for age, demographics, comorbidity, year and hospital characteristics, rates (per 100 discharges) were 58.4 for whites, 50.1 for blacks (PR 0.87; 95% CI 0.84–0.91) and 55.2 for Hispanics (PR 0.95; 95% CI 0.90–0.99).

Conclusions: These nationwide data suggest blacks remain less likely than whites and Hispanics to undergo catheterization during a hospitalization for AMI. Whether this disparity stems from patient or provider factors remains to be determined.

Key words: acute myocardial infarction ■ race ■ black ■ Hispanic ■ cardiac catheterization

INTRODUCTION

Black–white disparities in the application of invasive cardiovascular procedures have been well-documented using administrative and clinical data from the 1980s through the mid-1990s.[1-18] Data on Hispanic–white differences in cardiac procedure rates have been sparse and less consistent.[1,19,20] Although it is unclear the extent to which disparities in procedure use is responsible for black Americans continued excess cardiovascular disease (CVD) mortality compared to whites, efforts to identify and address reasons for procedure disparities may yield insights into overall CVD disparities. We recently documented a narrowing of the gender gap between men and women for catheter-based procedures in the acute myocardial infarction (AMI) setting.[21] However, little is known about more recent trends in racial disparities and whether the magnitude of the disparity differs substantially by hospital or patient characteristics, such as teaching status or insurance coverage. Thus, we conducted a national cross-sectional study using data from the 1995–2001 Nationwide Inpatient Sample (NIS). We sought to discern whether racial disparities persist despite increasing procedure use and awareness of the race gap (as evidenced by papers from the 1980s and 1990s), and to determine which personal and hospital characteristics were associated with racial disparities. To accomplish these aims, we compared rates of cardiac catheterizations performed prior to discharge for AMI in blacks and Hispanics vs. whites. Because the definition of anatomy by catheterization is generally required before deciding on angioplasty or bypass grafting and this information is not available in the NIS, we focused our analyses on race differences in catheterization rates.

METHODS

Data Source

The NIS is a product of the Agency for Healthcare Research and Quality's Healthcare Cost and

Utilization Project. NIS is designed to approximate a 20% sample of all nonfederal, short-term, general and specialty hospitals serving adults in the United States. The sampling strategy employed selected hospitals within states that have state inpatient databases (SID) according to defined strata based on hospital ownership, size, teaching status, urban/rural location and region. All discharges from sampled hospitals for the calendar year are then selected for inclusion into NIS. From 1995–2001, NIS captured discharge level information on primary and secondary diagnoses and procedures, discharge vital status, and demographics on six-to-seven million discharges per year from approximately 1,000 hospitals in 32 states. Data elements that could directly or indirectly identify individuals are excluded; thus, we considered all discharges to be independent. The unit of analysis was the discharge rather than the individual. A unique hospital identifier allows for linkage of discharge data to a NIS dataset with hospital characteristics.[22] Racial categorization was obtained by NIS from the hospital discharge abstract and was systematically missing for some hospitals and these states: Georgia, Illinois, Kentucky, Maine, Minnesota, Nebraska, Oregon, Washington and West Virginia. As there were few Asian, Native American or other race AMI discharges, we elected to limit our analysis to white, black or Hispanic discharges from hospitals performing cardiac procedures in the 23 states reporting race data. These included Connecticut, Massachusetts, New Jersey, New York, Pennsylvania and Rhode Island in the northeast; Iowa, Kansas, Missouri, Michigan and Wisconsin in the midwest; Florida, Maryland, North

Table 1. Demographic and Medical Characteristics of 669,002 Discharges with a Primary Diagnosis of Acute Myocardial Infarction from Hospitals Performing Catheterization in the 1995–2001 Nationwide Inpatient Sample, by Race

Characteristic	White N= 585,710	Black N=51,369	Hispanic N=31,923
Age, years	68.2 (13.6)	63.6 (14.1)	65.1 (13.6)
Aged ≥65 years	62.8	48.7	53.7
Female	38.7	48.1	37.4
Region: Northeast	25.8	18.6	17.8
South	41.9	59.6	44.3
Midwest	17.8	11.8	1.4
West	14.5	10.0	36.4
Insurance: Private	32.3	30.4	27.9
Medicare	59.4	50.9	47.6
Medicaid	2.9	9.8	12.6
Self Pay/ Other	5.4	9.0	12.6
Household median income <$25,000‡	12.5	32.4	23.0
Nontransmural infarction	49.7	57.4	51.4
Involved in transfer	32.6	23.5	29.0
Previous myocardial infarction	7.4	6.7	5.9
Diabetes Mellitus	24.4	35.9	29.0
Congestive Heart Failure	29.4	30.5	29.1
Charlson Comorbidity Score	2.0 (1.0)	2.1 (1.0)	2.0 (1.0)
In-Hospital Death	8.8	8.4	7.7
Admitted to urban teaching hospital	40.9	56.6	45.1

Data are mean (standard deviation) or percent. All differences across race categories significant at p<0.001. ‡ Median household income by postal code of residence

Carolina, South Carolina, Tennessee and Texas in the south; and Arizona, California, Hawaii, and Utah in the west.

Population Selection and Variable Definition

We identified all discharges with a first-listed (primary) diagnosis of AMI (ICD9 code 410.xx) in each year. Patients younger than 18, and discharges missing race, age or gender data were excluded. We also excluded those with ICD9 code 410.x2, as this indicates admission for an episode of care subsequent to the infarction. Among those with AMI, we identified patients who underwent cardiac catheterization (ICD9 codes 88.52–88.58 and 37.21–37.23), percutaneous transluminal coronary angioplasty (PTCA) (36.01–36.05) and stent implantation (36.06). Discharges reporting only PTCA or stent placement were considered to have had catheterizations. Hospitals reporting no catheterizations for any discharge were classified as a noncatheterization hospital; discharges from these hospitals were excluded from further analysis.

Secondary diagnoses were used to create a comorbidity index according to the method of Charlson and Deyo.[23] We considered those with ICD9 codes 410.7 (subendocardial infarct) and 410.9 (unspecified infarct) to have had nontransmural myocardial infarctions, and all others to have had transmural infarcts. In-hospital death was ascertained via each patient's discharge vital status (alive or dead). We created indicator variables from data on race (white, black, Hispanic), primary insurance payer (private, Medicare, Medicaid, self-pay/other) and on three categories of median income in the discharged patient's postal code (<$25,000, $25–35,000 and >$35,000), and added a fourth category for the 5% of discharges missing these data. Discharges were defined as having been involved in a transfer if they were either admitted from or discharged to another short-term hospital. Hospital characteristics utilized in the analyses were hospital size (based on beds), location and teaching status (rural, urban nonteaching, urban teaching) and region (northeast, midwest, south, west).

Statistical Analysis

Although NIS includes sampling weights to enable calculation of national estimates, because race was missing for many discharges, the weights cannot be utilized. Exploratory data analysis was performed by comparing the characteristics of black, white and Hispanic discharges using summary statistics (anova, Chi-square) and graphs. Multivariable linear regression was used to calculate yearly procedure rates by race, adjusted for demographics, comorbidities, vital status and hospital characteristics. All rates are presented as procedures per 100 AMI discharges. To compare procedure rates by race, we calculated prevalence rate ratios, since odds ratios deviate significantly from rate ratios when the proportion experi-

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Table 2. Catheterization Rates per 100 Discharges for Discharges with Acute Myocardial Infarction from Hospitals Reporting Race Data and Performing Catheterization Included in the 1995–2001 Nationwide Inpatient Sample and Prevalence Ratios for Comparison of Black and Hispanic rates to White Rate

Characteristic	White	Black	PR; 95% CI	Hispanic	PR; 95% CI
All Discharges					
Unadjusted	58.1	54.5***	0.94; 0.90–0.98	59.1^NS	1.02; 0.96–1.08
Adjusted	58.4	50.1***	0.87; 0.84–0.91	55.2*	0.95; 0.90–0.99
Gender					
Female	57.2	49.0***	0.86; 0.83–0.90	53.5*	0.93; 0.88–0.99
Male	59.6	51.2***	0.88; 0.84–0.92	56.8^NS	0.96; 0.92–1.0
Region					
Northeast	51.0	40.8***	0.85; 0.78–0.92	41.3*	0.84; 0.75–0.98
Midwest	65.1	56.4**	0.88; 0.82–0.96	63.7^NS	0.98; 0.92–1.04
South	57.5	51.2***	0.90; 0.85–0.96	58.1^NS	1.01; 0.93–1.07
West	57.2	44.1***	0.79; 0.73–0.85	52.5***	0.92; 0.88–0.96
Type of AMI					
Transmural	62.8	54.6***	0.88; 0.85–0.92	58.4**	0.93; 0.89–0.98
Nontransmural	54.9	46.8***	0.86; 0.83–0.90	53.0^NS	0.96;0.92–1.01

AMI = acute myocardial infarction; PR = prevalence ratio; CI = confidence interval. Analyses (except unadjusted) adjusted for age, gender, comorbidity, discharge vital status, insurance status, zip-code median income category, transfer status, region, year, and hospital characteristics. Black–white and Hispanic/white comparisons significantly different at: * p<0.05, ** p<0.01, *** p<0.001 or not significantly different (NS)

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encing the event of interest (in this case, receiving a catheterization) is high.[24,25] These are defined numerically as the adjusted procedure rate for blacks (or Hispanics) divided by the adjusted procedure rate for whites. We estimated adjusted rate ratios and confidence limits with multivariate Poisson regression. To address the similarity of catheterization rates between groups discharged from the same hospital, robust standard errors were obtained by assuming clustering by hospital. Stratified analyses were performed to explore the effect of year, region and type of AMI on the relationship between catheterization and race. Wald tests were used to determine the significance of interaction terms in linear regression models and likelihood ratio tests to determine the significance of interaction terms in the Poisson models. All significance tests were two-tailed. All analyses were carried out utilizing Stata (Stata 7.0, College Station, TX).

RESULTS

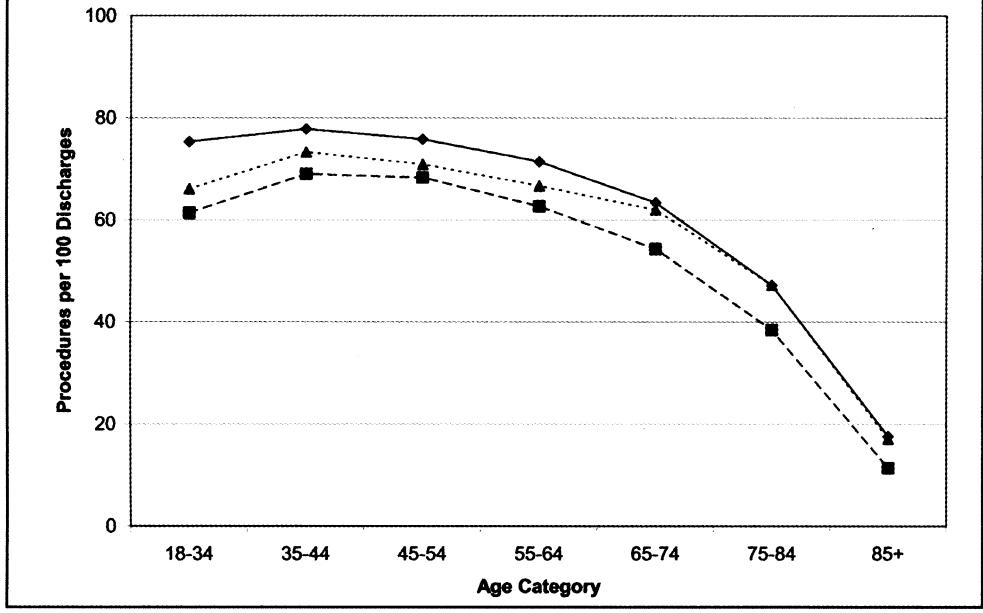## Composition of the Sample and Discharge Characteristics

We identified 1,032,697 discharges with a first-listed diagnosis of AMI [International Classification of Diseases, Ninth Revision, (ICD-9) code 410] between 1995 and 2001. Of these, we excluded 257 due to age <18 or missing age or gender. We excluded from analysis 220,706 discharges due to missing race data; 26,861 reporting another race; 110,527 discharges from hospitals not performing catheteriza-

tions; and 5,344 with diagnosis code 410.x2. After these exclusions, our sample included 669,002 adult AMI discharges (87.5% white, 7.7% black, 4.8% Hispanic) from 951 hospitals. In comparison to white discharges, nonwhite AMI discharges were more likely to be younger, have diabetes, to have Medicaid or no insurance, reside in lower income areas and be admitted to urban teaching hospitals (Table 1).

Catheterization Analyses

The unadjusted catheterization rate was similar among whites and Hispanics and only slightly lower among blacks (Table 2). Catheterization rates decreased as age increased in all ethnic groups after ages 35–44 (Figure 1). In every age category, black catheterization rates were significantly lower than for whites (p<0.001 each comparison). In contrast, Hispanic catheterization rates below age 65 were substantially lower than among whites (p<0.05 each comparison). Hispanic and white catheterization rates were similar above age 65. Age adjustment revealed the disparity between blacks and whites with an adjusted catheterization rate of 58.7% in whites and 50.2% in blacks (PR 0.86; 95% CI 0.83–0.90). The age-adjusted Hispanic catheterization rate (56.0%) was nonsignificantly lower than that of whites (PR 0.96; 95% CI 0.90–1.02). Additional adjustment for gender, comorbidities, discharge vital status, zip code, median income, insurance status, region, year, transfer status and hospital characteristics did not appreciably change the black–white difference estimate but resulted in a small but significant disparity between Hispanics and whites (Table 2). Adjusted catheterization rates fluctuated between 1995 and 2001 (Figure 2). Rates among Hispanics increased significantly (p<0.05 for trend) and approached the catheterization rate of whites after 1999. The gap between blacks and whites remained substantial in all years.

Stratified Analyses

Adjusted catheterization rates were lower among women than men in all three ethnic groups (Table 2). There was little difference, however, in the likeli-

Figure 1. Catheterization rates per 100 discharges with acute myocardial infarction in the 1995-2001 Nationwide Inpatient Sample by race and age category. Diamonds and solid line indicate rates in whites; squares and long-dashed line represent rates in blacks, and triangles and short-dashed line rate in Hispanics.

hood of black men or women to receive catheterization compared to their white counterparts. Although a small disparity was found for Hispanic compared to white women, the difference between Hispanic and white men was not significant (p for race-gender interaction=0.4). There was considerable variation in catheterization rates by region (p for race-region interaction=0.01). Rates were generally highest in the midwest and lowest in the northeast (Table 2). The black–white disparity was smallest in the south and greatest in the west. The Hispanic catheterization rate in the northeast was similar to the rate among blacks and was significantly lower than among whites. In contrast, there was no disparity between Hispanics and whites in the midwest and south. A small but significant Hispanic disparity was present in the west. Catheterization rates were higher among those discharged with a transmural AMI. Although there was little effect of type of AMI on the black–white difference, Hispanics with transmural AMIs were somewhat less likely to undergo catheterization (p for race-AMI type interaction 0.01).

DISCUSSION

These results support several conclusions. First, black–white differences in cardiac catheterization during hospitalization for AMI continued to persist through the late 1990s to 2001, despite higher rates of cardiac catheterization than reported in earlier years. Second, these disparities were not explained by differences in age, comorbidity, in-hospital mortality, type of AMI, hospital characteristics or insurance status. Third, Hispanic–white disparities in catheterization overall were smaller than the black–white disparities and appeared to have narrowed nationally between 1995 and 2001. Finally, the northeastern and western regions of the country demonstrated greater disparities than the southern and midwestern regions.

Strengths of our study are the inclusion of all ages and insurance payers, multiple years of recent hospital data from a nationally representative sample of U.S. community hospitals, and the ability to characterize procedure use by hospital allowing elimination of hospitals that do not offer cardiac catheterization. In addition, the relatively large numbers of black and Hispanic discharges with AMI allowed for sufficient power to perform multivariable and stratified analyses. Many of these strengths are due to our use of NIS, which surveys over 10 times as many discharges as the National Hospital Discharge Survey (NHDS). Although one might suspect the rates of procedures estimated in this study might differ systematically from prior NHDS-based reports due to data source differences rather than to temporal changes, a comparison of NIS and NHDS for 1995 concluded that for AMI, the estimates of the total number of discharges, average length of stay and in-hospital mortality were not statistically different.[26]

Several limitations deserve mention. First, as with all administrative data sources, there may be misclassification of both predictors and outcomes. The specificity of a primary discharge diagnosis of AMI is likely to be higher than its sensitivity; thus, we may not have captured all AMI cases, but most discharges in our analyses are likely to have had an AMI.[27,28] Although Hispanic ethnicity in this data source is listed as race, Hispanics may identify themselves as white race. This may contribute to misclassification of race. Any

Figure 2. Catheterization rates per 100 discharges with acute myocardial infarction in the 1995-2001 Nationwide Inpatient Sample adjusted for age, demographics, insurance type, comorbidities, vital status, and hospital characteristics by race and year. Diamonds and solid line indicate rates in whites; squares and long-dashed line represent rates in blacks, and triangles and short-dashed line rate in Hispanics.
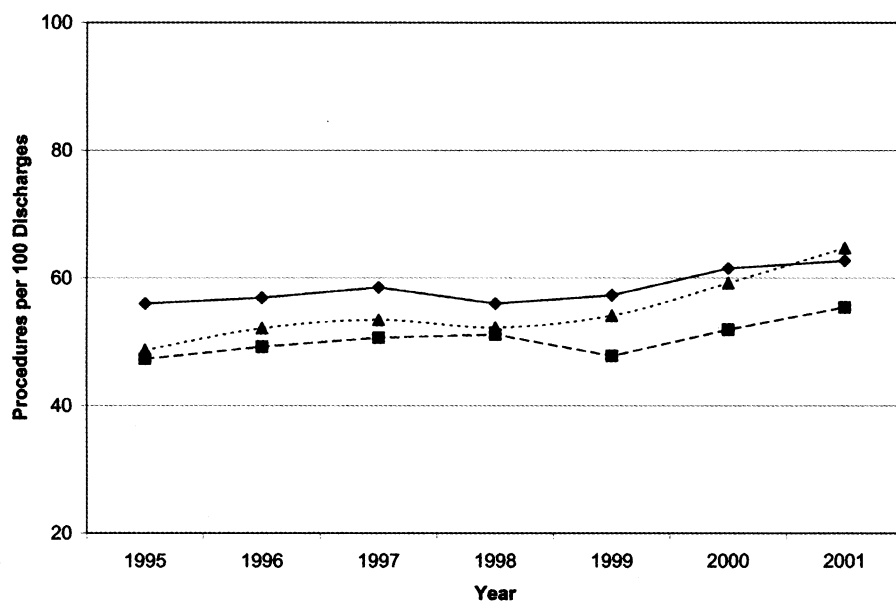
misclassification is likely to be nondifferential with respect to outcomes and, thus, would bias our risk estimates towards the null. Second, as NIS records discharges rather than individuals, it is possible that transfers between NIS hospitals would lead us to count an individual twice. Persons with more than one AMI in a calendar year presenting to the same hospital may also be overcounted. These latter limitations may alter the rate estimates but should not affect the rate ratio estimates.

The most significant limitation is that these records lack important clinical data, including timing of and symptoms at presentation, severity of infarction and prior medical history. Use of the Charlson comorbidity index only partially mitigates this limitation, as comorbid diagnoses may not have been recorded. This may result in important unmeasured clinical differences between minorities and whites. In particular, we were unable to identify receipt of thrombolytic therapy or previous revascularization history, presence and degree of renal insufficiency, occurrence of postinfarction angina, or results of non-invasive cardiac testing, all of which may be important factors in the decision to perform catheterizations. A recent study has found that gender differences observed in coronary revascularization after angiography using administrative data in Alberta, Canada were eliminated when clinical variables, such as ejection fraction and extent of coronary disease, were included in analyses.[29] However, most prior reports utilizing clinical data and having sufficient power to detect differences have consistently found black–white differences in cardiac procedure use.[1] Furthermore, cardiac catheterization for AMI may be the diagnostic tool initiating a "clinical cascade" in that it is a requisite step in defining the coronary anatomy prior to the consideration of either angioplasty or coronary artery bypass graft (CABG).[30] A related limitation is that administrative data do not provide any information on refusal of procedures, patient preferences or physician attitudes. Because of these limitations, although we can conclude that a black–white disparity continues to exist, we are unable to discern the causes of the disparities.

The catheterization rate disparity between blacks and whites in our study is narrower compared to most earlier studies.[31] An analysis of the 1988–1990 NHDS found an adjusted odds ratio of catheterization for black women of 0.48 and 0.61 for black vs. white men, which compares to a black–white OR of 0.71 in our study (using the formula of Zochetti et al. to transform PR to OR).[16,25] An analysis from a sample of discharges from hospitals participating in the Second National Registry of Myocardial Infarction (NRMI-2) from 1994–1996 reported an adjusted OR for black vs. white coronary catheterization

of 0.85; crude catheterization rates by race were not reported.[32] This is a smaller disparity than found in our study when expressing the results as odds (OR 0.71). This difference may be due to additional adjustment for the clinical variables available in NRMI-2 or to differences between hospitals participating in NRMI compared to NIS. The apparent narrowing of the disparity between 1995 and 1998, only to widen again after 1999, may be due to differences in the hospitals sampled by NIS by year, rather than any true shift in the likelihood of offering blacks catheterization after 1999.

Compared to black–white cardiac care disparities, there is comparatively less literature with mixed findings for Hispanic–white disparities.[1] Our findings of a small, barely significant difference in catheterization between Hispanics and whites overall is consistent with findings from the 1980s in Texas[19] as well as national data from the National Registry of Myocardial Infarction for 1994–1996.[20] However, the small disparity observed in western states is consistent with the finding of a significant Hispanic–white disparity in Medicare AMI patients in California in the early 1990s.[33] Demographic variation in Hispanic populations (country of origin, socioeconomic status, immigration status) may account for some of the discrepancy noted between regional and national analyses.

Patient race and gender have been shown to influence physicians' decisions to refer patients for catheterization.[34] Although we sought to address the impact of hospital transfers, patients may have been transferred to non-NIS hospitals for their procedure. However, our findings are unlikely to be different if we could completely account for all transfers—a recent analysis found that black patients ≥65 years were generally less likely to receive catheterization and revascularization than whites regardless of the facilities available at the initial facility.[11] Coronary artery procedures may be overutilized in the United States; physicians may be overutilizing procedures in whites rather than underutilizing them in blacks.[35,36] However, an analysis applying RAND angiography appropriateness criteria to Medicare beneficiaries with AMI found that catheterization was more likely to be underused among blacks compared to whites.[37]

In light of the high incidence of myocardial infarction, even small relative differences in catheterization rates between minorities and whites may be important, particularly if they reflect wider differences in care known to have significant benefit. As our society ages and becomes more ethnically diverse, a better understanding of what drives racial differences in cardiac procedure use is clearly needed, as are studies revealing the clinical impact (in terms of differences in mortality or quality of life) of

racial disparities and trials of novel strategies to reduce racial disparities.

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