ORIGINAL RESEARCH

Use of Percutaneous Coronary Intervention Among Black and White Patients With End-Stage Renal Disease in the United States

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***Background*—**Racial disparities in invasive cardiac procedures such as percutaneous coronary intervention (PCI) in the general population are well documented; however, national-level data on such disparities in the end-stage renal disease (ESRD) population are lacking. We assessed racial differences in PCI between black and white patients with ESRD on maintenance dialysis.

***Methods and Results*—**Using the US Renal Data System database, we abstracted Medicare inpatient procedure claims for PCI in a cohort of 268 575 Medicare-primary patients who initiated treatment on maintenance dialysis from January 1, 2009, through June 1, 2013. We conducted Cox regression analyses with PCI being the event, adjusted for demographic characteristics, Hispanic ethnicity, cause of ESRD, comorbidities, and socioeconomic factors. We also assessed the probability of PCI, accounting for death or transplant in competing risk regression models. The crude incidence rate of PCI among white patients was 25.8 per 1000 patient-years versus 15.5 per 1000 patient-years among black patients. Cox regression analyses demonstrated that black patients were significantly less likely to undergo PCI compared with white patients (adjusted hazard ratio: 0.64; 95% CI, 0.62–0.67; $P<0.001$). In the competing risk models, the racial gap for PCI among black and white patients remained significant with death (subdistribution hazard ratio: 0.81; 95% CI, 0.76–0.85; $P<0.001$) or transplant as a competing event (subdistribution hazard ratio: 0.67; 95% CI, 0.64–0.70; $P<0.001$).

***Conclusions*—**A racial gap exists in PCI use among dialysis patients despite having comprehensive coverage with Medicare. These findings persisted despite accounting for demographic, clinical, socioeconomic factors, and death or transplant as competing events. **(*J Am Heart Assoc*. 2019;8:e012101. DOI: 10.1161/JAHA.119.012101.)**

Key Words: angioplasty and stenting • end-stage renal disease • percutaneous coronary intervention • race and ethnicity

Patients with end-stage renal disease (ESRD) are among the highest risk populations for premature cardiovascular disease (CVD).[1] Mechanisms by which ESRD increases CVD risk include metastatic calcification, alterations in sodium and fluid balance, and exacerbation of inflammatory processes including atherosclerosis. Based on the recent US Renal Data System (USRDS) annual data report, stable coronary artery disease (CAD) and heart failure were the 2 most common CVDs present in adult ESRD patients in 2016.[1] However, acute myocardial infarction, valvular heart disease, cerebrovascular accident/transient ischemic attack, peripheral arterial disease, atrial fibrillation, sudden cardiac arrest and ventricular arrhythmias, and venous thromboembolism and pulmonary embolism were also common. Even relatively young ESRD patients—those aged 22 to 44 and 45 to 64 years—were likely to have CVD. The presence of CVD significantly decreases short- and long-term survival among ESRD patients. Herzog et al[2] reported that among ESRD patients receiving maintenance dialysis, mortality rates after acute myocardial infarction were 59% at 1 year, 73% at 2 years, and 90% at 5 years. Coronary reperfusion therapy from percutaneous coronary intervention (PCI) has been shown to improve the outcomes of dialysis-dependent patients with CAD.[3,4]

Similar survival benefits of PCI are seen in the general population with CAD.[5] Nonetheless, population-wide inequities in cardiovascular care among racial and ethnic minority groups have been reported in the literature for the past 3 decades.[6,7] Studies have demonstrated that black patients

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Clinical Perspective

What Is New?

- We examined racial differences in rates of percutaneous coronary intervention in a large national cohort of Medicare-primary end-stage renal disease patients on maintenance dialysis.
- Black race was associated with a 36% lower likelihood of undergoing percutaneous coronary intervention relative to white race among these patients after accounting for demographic, clinical, and socioeconomic factors.
- Racial disparities in percutaneous coronary intervention narrowed but remained significant after further accounting for death and kidney transplant as competing events.

What Are the Clinical Implications?

- A racial gap exists in the receipt of percutaneous coronary intervention among dialysis patients despite having comprehensive coverage with Medicare insurance, highlighting the crucial need for effective implementation of local and national strategies to promote racial equity in cardiovascular health.

with CAD were less likely to undergo coronary revascularization, with subsequent higher rates of morbidity and mortality.[8–13] More recent studies have documented persistent racial inequalities in evidence-based therapies for CAD, particular those that are costly or use newer technology.[14–16] These differences persist even after accounting for multiple factors including sociodemographics, insurance status, comorbidity, illness severity, and hospital characteristics and location.

In contrast to the well-documented race-associated disparities in cardiovascular care in the general population, there is a surprising lack of published reports assessing whether such a racial gap exists in the ESRD population. Given the paucity of data on disparities in PCI in the dialysis population, we assessed racial differences in the receipt of PCI in a diverse cohort of ESRD patients on maintenance dialysis, using the USRDS, a large, well-established, national-level database.

Methods

The authors declare that all supporting data are available within the article. We conducted a retrospective cohort study using the USRDS, which incorporates baseline and follow-up demographic and clinical data on nearly all patients accessing the Medicare ESRD program in the United States.[17] We identified Medicare primary patients aged >18 years who initiated on maintenance dialysis from January 1, 2009, through June 1, 2013, and were followed until December 31, 2013, from the 50 US states, the District of Columbia, and Puerto Rico. From this larger cohort, we identified 268 575 patients who were hospitalized and thus had documented Medicare claims through the *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) and Current Procedural Terminology codes. We used the following procedural codes for PCI: 00.66, 36.01, 36.02, 36.05, 36.06, 36.07, and 36.09 (Table S1). Codes 36.01–36.05 resulted in no cases because these codes were deleted from the Centers for Medicare and Medicaid Services (CMS) procedure list in 2005.[18] We used the following *ICD-9* codes for acute myocardial infarction (410.xx) and coronary atherosclerosis (414.00, 414.01, 414.0, 414.8) as primary discharge diagnoses (Table S2). We merged the USRDS data set with the 2010 US Census to obtain zip code–level median household income (MHI) data. The primary outcome was time to receipt of PCI among dialysis-dependent patients. This study was approved as exempt from review by the Walter Reed National Military Medical Center institutional review board.

Patients and Sources

The demographics of the dialysis population in this study have been described in the USRDS annual data reports for the years studied.[19] Variables included in the USRDS standard analysis files (*SAF* prefix), and in data collection methods and validation studies, are listed on the USRDS website (https://www.usrds.org/). The SAF.PATIENTS file was used as the primary data set, and SAF.MEDEVID was used for additional information coded in CMS Medical Evidence Form 2728. We used hospitalization inpatient data to identify those patients who had procedure codes for PCI and the respective dates of service. Study eligibility was restricted to patients with complete identifying and demographic information and evidence of Medicare as the primary payer from the date of dialysis initiation, as indicated from the SAF.PAYHIST file. This restriction was necessary to ensure accurate ascertainment of Medicare claims, which might not be reported for patients covered by alternative insurance or Medicare as a secondary payer. Files from the 2010 US Census (http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml) were used to merge by zip code with USRDS files. Because such data are area-based and thus ecological, we also assessed Medicare-Medicaid dual eligibility status from the USRDS files as an indicator of individual-level poverty.[20–22] Although eligibility varies by state, means testing is stricter than for either Medicare or Medicaid alone and usually includes the poorest patients receiving care, at most <135% poverty and generally <100% of poverty.[23]

Predictor Variables

The primary predictor variable was self-reported race (white/black). The covariates in our analysis included age at initiation

Table 1. Baseline Demographic and Comorbidity Characteristics of Medicare-Primary ESRD Patients on Dialysis, 2009–2013, Black Versus White

Variable	Black Patients (n=73 209)	White Patients (n=182 772)	*P* Value
Age (y) at start of dialysis	60.12±15.04	66.48±14.34	<0.001
Sex			<0.001
Male	36 967 (50.50)	105 572 (57.76)	
Female	36 242 (49.50)	77 200 (42.24)	
Hispanic ethnicity	1044 (1.43)	34 133 (18.70)	<0.001
Dialysis modality			<0.001
Hemodialysis	69 013 (94.27)	169 052 (92.49)	
Peritoneal dialysis	4196 (5.73)	13 720 (7.51)	
Cause of ESRD			<0.001
Diabetes mellitus	33 457 (47.10)	85 909 (49.55)	
Hypertension	27 345 (38.49)	49 893 (28.78)	
Glomerulonephritis	4814 (6.78)	13 246 (7.64)	
Cystic kidney disease	663 (0.93)	3619 (2.09)	
Other renal disorders	4757 (6.70)	20 713 (11.95)	
Comorbid conditions			
COPD	5455 (7.45)	22 698 (12.42)	<0.001
Diabetes mellitus	42 051 (57.44)	103 297 (56.52)	<0.001
Hypertension	66 270 (90.52)	156 784 (85.78)	<0.001
Atherosclerotic heart disease	10 532 (14.39)	44 698 (24.46)	<0.001
Congestive heart failure	23 286 (31.81)	64 755 (35.43)	<0.001
Peripheral vascular disease	7803 (10.66)	29 053 (15.90)	<0.001
Cerebrovascular disease (CVA, TIA)	8166 (11.15)	17 786 (9.73)	<0.001
Cancer	4231 (5.78)	16 178 (8.85)	<0.001
Tobacco use	5352 (7.31)	11 577 (6.33)	<0.001
BMI, kg/m^2	30.10±8.56	29.50±7.92	<0.001
Serum albumin, g/dL	3.17±4.03	3.22±4.87	0.04
Socioeconomic indicators			
Dual eligibility for Medicare and Medicaid*	28 554 (39.00)	44 214 (24.19)	<0.001
Zip code–level MHI ($/y)†	35 666±13 262	42 158±15 508	<0.001
Unemployed	20 716 (28.30)	30 877 (16.89)	<0.001

Data are n (%) or mean±SD. Univariate analyses were performed with χ^2 testing for categorical variables and the Student *t* test for continuous variables (Mann–Whitney test used for nonnormally distributed variables). BMI indicates body mass index; COPD, chronic obstructive pulmonary disease; CVA, cerebrovascular accident; ESRD, end-stage renal disease; MHI, median household income; TIA, transient ischemic attack.

*Dual-eligible status as defined in the Methods section.

†Based on zip code from the 2010 US Census.

of dialysis, sex, self-reported Hispanic ethnicity (a non–mutually exclusive category that could overlap with race), dialysis modality, primary cause of ESRD, diabetes mellitus, hypertension, other comorbid conditions related to CVD from CMS Medical Evidence Form 2728 (Table 1), tobacco use, body mass index, serum albumin, and socioeconomic factors (zip code–level MHI, individual employment status, and dual eligibility status for Medicare and Medicaid as a surrogate for individual-level poverty). Data on education level are not available and thus represent an unmeasured confounding variable.

Statistical Analysis

Analyses were performed using Stata 14 SE (StataCorp). Univariate analyses were performed with χ^2 testing for categorical variables. The Student's *t*-test was used for continuous variables and nonparametric tests (Mann–

Whitney) were used for nonnormal distributions. $P<0.05$ were considered statistically significant for univariate comparisons. We calculated crude incidence rates of PCI for black and white races and for 4 racial/sex subgroups: white male, white female, black female, and black male. The probability of receiving PCI by a certain time point was estimated using the Kaplan–Meier method and log-rank test to assess the significant difference between the groups.

We also conducted Cox proportional hazards regression analyses to model factors associated with the receipt of PCI, adjusted for demographic characteristics, Hispanic ethnicity, cause of ESRD, comorbidities, and socioeconomic factors, as noted earlier. As a sensitivity analysis, we developed Cox models to evaluate hazard ratios (HRs) for PCI among black and white patients for those who had primary discharge diagnoses of acute myocardial infarction and coronary atherosclerosis. We also conducted Cox models, stratified by race and sex (white male, white female, black female, and black male), age categories (18–39, 40–59, 60–79, ≥80 years of age), and MHI quintile levels. Proportional hazards assumptions were examined by graphing log (−log [survival function]) versus log (time) for the comparison groups. The follow-up period for both incidence rate calculation and survival analyses were censored at transplant, death, or end of study (December 31, 2013).

Given well-established racial differences in survival in the ESRD population[24,25] (ie, black patients survive longer than their non-Hispanic white counterparts), we also assessed the probability of PCI, accounting for death as a competing event in competing risk regression using the Fine and Gray method[26] (PCI is a nonfatal outcome and could be precluded by the occurrence of death). In a separate competing risk regression, we modeled transplant as the competing event (transplant would, by definition, preclude the occurrence of PCI in an ESRD patient on chronic dialysis). The competing risk analyses were adjusted for the same covariables as the Cox regression models.

Results

We identified a cohort of 268 575 patients with Medicare as the primary payer who were hospitalized and thus had documented Medicare inpatient claims. Table 1 shows the baseline demographics and characteristics of the study cohort, of whom 73 209 (27.3%) were black and 182 772 (68.0%) were white (12 594 [4.7%] were of other races). Compared with white patients, black patients were younger at dialysis initiation and were more likely to be female and to have hypertension as the primary cause of ESRD. Furthermore, black patients had indications of lower socioeconomic status compared with white patients. Specifically, a higher proportion of black patients were unemployed and had dual

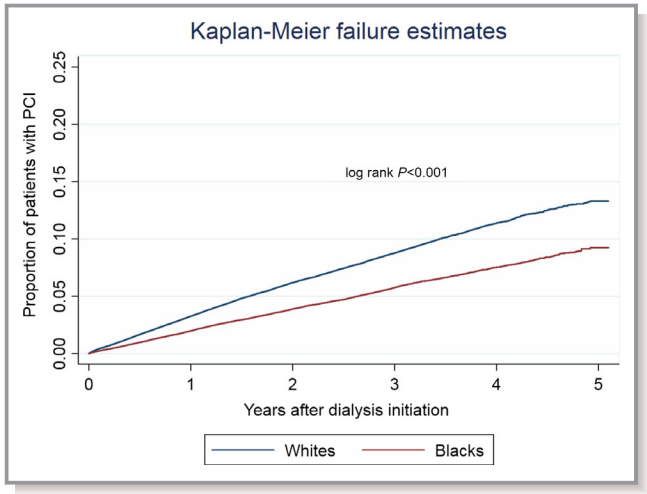

Figure 1. Kaplan–Meier estimates of percutaneous coronary intervention (PCI) among Medicare-primary end-stage renal disease patients on dialysis, black vs white.

eligibility status for both Medicare and Medicaid; they also had lower zip code–level MHIs than white patients. Conversely, white patients were older and more likely to be male and Hispanic. White patients also had indications of greater cardiovascular burden, as suggested by higher prevalence of comorbid conditions including chronic obstructive pulmonary disease, atherosclerotic heart disease, congestive heart failure, and peripheral vascular disease. However, white patients were less likely to be dual-eligible or unemployed and had higher area-level MHI than black patients.

Overall, 6.4% (n=17 261) of the ESRD cohort had at least 1 PCI procedure, and the crude incidence rate was 22.3 per 1000 patient-years (PY). White patients were more likely to have undergone PCI than black patients. The overall prevalence of PCI among white and black patients was 6.9% versus 5.0%, respectively ($P<0.001$; Figure 1). The unadjusted incidence rates for white and black patients were 25.8 and 15.5 per 1000 PY, respectively ($P<0.001$). Furthermore, as shown in Table 2 and Figure 2, white male patients had the highest crude incidence rates (26.7 per 1000 PY) compared with the other groups by race and sex.

In adjusted Cox regression models, black patients were significantly less likely to undergo PCI compared with white patients (adjusted HR [aHR]: 0.64; 95% CI, 0.62–0.67; $P<0.001$). The aHR was similar in non-Hispanic black patients versus non-Hispanic white patients (aHR: 0.64; 95% CI, 0.61–0.67; $P<0.001$). For the subgroup of patients who had a primary discharge diagnosis of acute myocardial infarction, the aHR among black versus white patients was 0.87 (95% CI, 0.81–0.93; $P<0.001$). For those who had a primary discharge diagnosis of coronary atherosclerosis, the aHR among black versus white patients was 0.92 (95% CI, 0.86–0.99; $P=0.019$). Compared with white males as the reference group, white

Table 2. Crude Incidence Rates and Adjusted HRs for PCI by Race and Sex

Group	Unadjusted Incidence Rate, per 1000 Patient-Years (95% CI)	Adjusted HR (95% CI)*	*P* Value
White male	26.7 (26.1–27.3)	1.0 (Reference)	
White female	24.5 (23.8–25.2)	0.87 (0.84–0.91)	<0.001
Black female	17.1 (16.4–17.9)	0.63 (0.59–0.66)	<0.001
Black male	14.1 (13.5–14.8)	0.58 (0.55–0.62)	<0.001

HR indicates hazard ratio; PCI, percutaneous coronary intervention.
*Covariables in the Cox proportional hazards regression model included age at initiation of dialysis, Hispanic ethnicity, dialysis modality, cause of end-stage renal disease, diabetes mellitus, hypertension, chronic obstructive pulmonary disease, tobacco use, atherosclerotic heart disease, cerebrovascular disease, congestive heart failure, peripheral vascular disease, cancer, body mass index, serum albumin, individual employment status, zip code–level median household income, and dual-eligible status for Medicare and Medicaid as a surrogate for individual-level poverty.

females, black females, and black males were significantly less likely to undergo PCI (aHR: 0.87, 0.63, 0.58, respectively; Table 2). Consequently, the widest differential was between white and black males in adjusted analyses, accounting for age, Hispanic ethnicity, dialysis modality, primary cause of ESRD, comorbid conditions, body mass index, serum albumin, and socioeconomic factors (employment status, individual- and zip code–level measures of poverty). In addition to analyses of groups by race and sex, we conducted adjusted Cox models stratified by age groups to evaluate racial disparities in PCI across the age spectrum. As shown in Table 3, black patients were significantly less likely to undergo PCI compared with white patients across all age categories, with the lowest likelihood among the youngest age group (ie, aHR of 0.44 in the 18–39 age group).

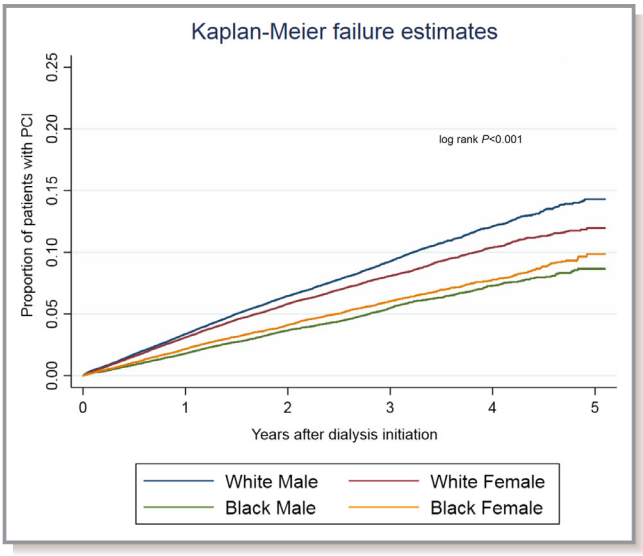

Figure 2. Kaplan–Meier estimates of percutaneous coronary intervention (PCI) among Medicare-primary end-stage renal disease patients on dialysis, stratified by race and sex.

Table 3. Adjusted HRs for PCI of Black Versus White Patients by Age*

Age Group	Sample Size, n (%)	Adjusted HR (Black vs White)	95% CI	*P* Value
18–39 y	17 545 (6.53)	0.44	0.34–0.58	<0.001
40–59 y	72 033 (26.82)	0.59	0.54–0.64	<0.001
60–79 y	134 703 (50.15)	0.69	0.65–0.73	<0.001
≥80 y	44 294 (16.49)	0.66	0.56–0.78	<0.001

HR indicates hazard ratio; PCI, percutaneous coronary intervention.
*Covariables in the Cox proportional hazards regression model included sex, Hispanic ethnicity, dialysis modality, cause of end-stage renal disease, diabetes mellitus, hypertension, chronic obstructive pulmonary disease, tobacco use, atherosclerotic heart disease, cerebrovascular disease, congestive heart failure, peripheral vascular disease, cancer, body mass index, serum albumin, individual employment status, zip code–level median household income, and dual-eligible status for Medicare and Medicaid as a surrogate for individual-level poverty.

Given that traditional methods for survival analyses (ie Kaplan–Meier, Cox regression) ignore competing events, we conducted adjusted competing risk regression to account for death as a precluding event for PCI and found that the racial gap for PCI among black and white patients narrowed but remained significant (subdistribution HR: 0.81; 95% CI, 0.76–0.85; $P<0.001$). In a separate model that accounted for transplant as a competing event, the likelihood of PCI among black patients remained lower than among white patients on dialysis (subdistribution HR: 0.67; 95% CI, 0.64–0.70; $P<0.001$).

From a socioeconomic standpoint, adjusted Cox regression models stratified by dual eligibility status for Medicare and

Table 4. Adjusted HRs for PCI of Black Versus White Patients by MHI Quintiles*

MHI Quintile Level	Mean MHI ($)	Adjusted HR (Black vs White)	95% CI	*P* Value
Bottom fifth	23 594	0.59	0.54–0.64	<0.001
Lower middle	31 588	0.64	0.58–0.70	<0.001
Middle	37 488	0.64	0.58–0.71	<0.001
Upper middle	45 330	0.66	0.60–0.73	<0.001
Top fifth	64 490	0.70	0.62–0.78	<0.001

HR indicates hazard ratio; MHI, median household income; PCI, percutaneous coronary intervention.
*Covariables in the Cox proportional hazards regression model included age at initiation of dialysis, sex, Hispanic ethnicity, dialysis modality, cause of end-stage renal disease, diabetes mellitus, hypertension, chronic obstructive pulmonary disease, tobacco use, atherosclerotic heart disease, cerebrovascular disease, congestive heart failure, peripheral vascular disease, cancer, body mass index, serum albumin, individual employment status, and dual-eligible status for Medicare and Medicaid as a surrogate for individual-level poverty.

Medicaid showed similar likelihood of PCI among black and white patients (dual eligible, aHR: 0.62; 95% CI, 0.58–0.67; $P<0.001$; non–dual eligible, aHR: 0.65; 95% CI 0.62–0.69; $P<0.001$). When stratified by MHI quintile levels (Table 4), black patients were also significantly less likely to undergo PCI compared with white patients, with a racial gap that was attenuated by those patients in the highest area-level income bracket (aHR of 0.70 in the top fifth quintile versus 0.59 in the bottom fifth quintile).

Discussion

We found in a large national cohort of Medicare-primary ESRD patients on maintenance dialysis that black patients were less likely to undergo PCI compared with white patients in both unadjusted and adjusted analyses (aHR: 0.64). Similarly, non-Hispanic black patients were less likely to undergo PCI than non-Hispanic white patients (aHR: 0.64). For the subgroups that had primary discharge diagnoses of acute myocardial infarction or coronary atherosclerosis, the racial disparities for PCI remained significant (aHR: 0.87 and 0.92, respectively). We further stratified our analyses by age groups to examine the impact of age on racial differences in PCI and found that black patients were significantly less likely to undergo PCI than white patients regardless of age. These findings persisted even after accounting for clinical and sociodemographic factors. This racial gap narrowed but remained significant in a competing risk model with death as a competing event (subdistribution HR: 0.81). Attenuation of the racial difference could be caused by lower mortality rates among black ESRD patients compared with their white counterparts, thus increasing the chance of having a PCI—an important factor that is accounted for in the competing risk regression. The racial difference in the receipt of PCI remained significant in a similar analysis that accounted for transplant as a competing event (subdistribution HR: 0.67). Our findings are consistent with a large body of evidence documenting racial and ethnic disparities in the treatment of CAD and acute myocardial infarction in the general population, highlighted by the seminal 2003 Institute of Medicine report, *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care.*[27] Based on this report, black patients with CAD or acute myocardial infarction were significantly less likely to receive appropriate medical therapies including β-blockers and thrombolytic or antiplatelet agents. Black patients were also 20% to 50% less likely to undergo a revascularization procedure compared with white patients. In a review of studies published from 1966 to 2000, Kressin et al[6] reported that black patients had odds ratios ranging from 0.32 to 0.80 for PCI compared with white patients in the general population. Using data from the ARIC (Atherosclerosis Risk in Communities) community surveillance study from 2000 to 2014, Arora et al[28] demonstrated that black patients had a 45% lower probability of receiving revascularization therapy than white patients hospitalized with non–ST-segment–elevation myocardial infarction. These investigators also found that black patients in this cohort had more comorbidities but were less likely to be discharged on evidence-based medications. Thus, despite efforts to standardize therapy for non–ST-segment–elevation myocardial infarction, differences between black and white patients have persisted during this 15-year period.

Our findings demonstrate that racial differences in PCI in the ESRD population have persisted since Daumit et al[29] first reported their results of an analysis of 4987 ESRD patients initiated on dialysis in 1986–1987. These investigators found that white patients on dialysis were 40% more likely than their black counterparts to receive a cardiac procedure (cardiac catheterization, angioplasty, or coronary artery bypass grafting; adjusted relative risk: 1.41; 95% CI, 1.13–1.77). Using the same study cohort, the investigators subsequently examined the intersection of race and sex in those undergoing invasive cardiac procedures (cardiac catheterization, angioplasty, or coronary artery bypass grafting)[30] and found that, among white males, white females, black females, and black males, the crude incidence rates for cardiac procedures were 37.2, 33.3, 28.4, and 24.2 per 1000 PY, respectively. This trend is consistent with our unadjusted analyses (Table 2). On adjusted analyses, we found that white females, black females, and black males were significantly less likely to receive PCI compared with white males. In particular, black males were least likely to undergo PCI compared with white males (aHR: 0.58). Nearly 2 decades ago, Daumit et al[30] also reported lower odds of cardiac procedures among black males on dialysis compared with white males (adjusted odds ratio: 0.66; 95% CI, 0.47–0.92).

From a socioeconomic standpoint, we found that black patients were less likely to undergo PCI compared with white patients in every MHI quintile. Although the racial gap was attenuated by those patients in the highest area-level income, the difference remained significant. Given that zip code–level MHI data are area based and thus ecological, we also assessed Medicare-Medicaid dual eligibility status as an indicator of individual-level poverty. We found racial disparities in the receipt of PCI regardless of dual eligible status. Dual-eligible beneficiaries represent a disadvantaged subgroup of older Americans who are generally impoverished and have higher prevalence of physical and cognitive impairments, less education, and lower levels of social support than their Medicare-only counterparts.[31,32] The lower likelihood of PCI among black dual-eligible patients compared with their white counterparts occurred despite being enrolled in an insurance program that was designed to supplement patients who have financial and other disadvantages to improve access to care in

the ESRD population.[33] This finding is consistent with the notion that the provision of health insurance by itself is an important but not sufficient intervention to improve health care in disadvantaged populations. Daumit et al[29] demonstrated that racial disparities in cardiac procedures were substantially attenuated after patients initiated treatment for ESRD on dialysis covered by Medicare insurance. Nonetheless, in their study, white patients on maintenance dialysis were still more likely to receive a cardiac procedure than black patients, with a relative risk of 1.4. We demonstrated, in a large cohort, that the racial gap in PCI persists despite patients having comprehensive coverage with Medicare as the primary insurance payer. It has been shown that minority patients with health insurance still experience substantial barriers to accessing quality care.[9] We also demonstrated that the racial gap in PCI persists regardless of income status, as measured by zip code–level MHI and dual eligibility status.

The underlying mechanisms of racial disparities in cardiovascular procedures are complex and likely include biological, sociocultural, and environmental factors.[34] An American Heart Association (AHA) Scientific Statement highlighted the importance of social determinants of health in effecting CVD outcomes among disadvantaged groups.[35] The Institute of Medicine report described components of health disparities including patient-, provider-, and healthcare system–level factors.[27] Patient-level variables include sociodemographics, clinical characteristics (disease burden and severity), health-related beliefs and attitudes, and trust in the healthcare system.[6,36] Provider-level variables include attitudes, bias, patient–provider relationship, and level of diversity in the physician workforce. Healthcare system–level variables include availability of cardiac procedure technology, reimbursement, and financing issues. Furthermore, racial disparities in cardiac procedures may arise from "overuse" (higher rate of revascularization for clinically inappropriate indications) among white patients, or "underuse" (lower rate of revascularization for appropriate indications) among black patients.[11,37,38]

Our study has certain limitations. First, the USRDS is largely an administrative database with inherent shortcomings. Its data collection is not specifically designed for research purposes. Unlike clinical databases, the USRDS does not provide granular clinical information about the severity of CAD, the clinical appropriateness of revascularization, patient preferences (refusal of procedure), and adherence to treatment regimen (eg, cardiac medications) and physician attitudes. Second, for sensitivity analysis, we developed Cox models to evaluate hazard ratios for PCI among black and white patients among those who had primary discharge diagnoses of acute myocardial infarction or coronary atherosclerosis. However, these diagnoses are broadly encompassing and do not provide more detailed information on the severity of disease, the types of acute coronary syndrome such as ST-segment–elevation myocardial infarction versus non–ST-segment–elevation myocardial infarction or whether the patients with coronary atherosclerosis had multi- versus single-vessel disease. These clinical factors may determine the decision to pursue PCI at an individual level. Third, there could be ascertainment bias related to providers' responses on CMS Medical Evidence Form 2728. A validation study by Longenecker et al[39] demonstrated significant underreporting of comorbid conditions on the CMS Form 2728 that may result in lower estimates of disease burden and differential bias when comparing 2 groups. Fourth, it is possible that black patients in our study cohort had lower rates of PCI than white patients because they were younger and had lower cardiovascular burden based on their baseline comorbid conditions. In contrast to the general population, black patients with ESRD on dialysis have lower prevalence of CVD than their white counterparts.[40–42] However, on stratified analyses, we found that the aHRs for black versus white patients were low across all age groups. We also adjusted the regression models for comorbidities related to CVD (Table 1). In sum, we acknowledge the possibility of selection bias to the extent that black patients in our ESRD cohort may have better cardiovascular health than white patients, resulting in lower rates of PCI, due to unobserved, residual confounders. Fifth, in the absence of individual-level income data, we used zip code–based MHI as a surrogate for patient income. We acknowledge potential biases associated with zip code as a proxy measure of individual-level socioeconomic status. Nevertheless, the concordance of our findings for both area-based and individual-level poverty complement each other and provide more robust findings because an association observed with income on an aggregate level may not represent the association that exists at an individual income level.[43] Furthermore, dual eligibility is binary by definition and provides no additional information for income above poverty level. Last, we cannot draw conclusions about causality given the retrospective nature of our study.

In conclusion, a racial gap exists in PCI use among dialysis patients despite having comprehensive coverage with Medicare. These findings persisted despite accounting for demographic, clinical, and socioeconomic factors and death or transplant as competing events. Recently, the AHA released a scientific statement highlighting persistent racial disparities in CVD burden, disease management, and outcomes and recommended a broad set of strategies to promote racial equity in cardiovascular health.[44] Narrowing the racial gap in cardiac intervention will require efforts in ameliorating patient, provider, and healthcare system factors. These efforts would lead to progress in achieving the AHA 2020 Impact Goals.

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Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table S1. ICD-9 CM Procedure Codes for percutaneous coronary intervention.

ICD-9 CM Procedure Code	Description
00.66	Percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy
36.01*	Single vessel percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy without mention of thrombolytic agent
36.02*	Single vessel percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy with mention of thrombolytic agent
36.05*	Multiple vessel percutaneous transluminal coronary angioplasty [PTCA] or coronary atherectomy performed during the same operation, with or without mention of thrombolytic agent
36.06	Insertion of non-drug-eluting coronary artery stent(s)
36.07	Insertion of drug-eluting coronary artery stent(s)
36.09	Other removal of coronary artery obstruction

*Codes deleted from the Centers for Medicare and Medicaid Services (CMS) procedure list in 2005

Table S2. ICD-9 CM Codes as primary discharge diagnoses.

ICD-9 CM Codes	Description
410.xx	Acute myocardial infarction
414.00	Coronary atherosclerosis of unspecified type of vessel, native or graft
414.01	Coronary atherosclerosis of native coronary artery
414.0	Coronary atherosclerosis
414.8	Other specified forms of chronic ischemic heart disease