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DO RACE-SPECIFIC MODELS EXPLAIN DISPARITIES IN TREATMENTS AFTER ACUTE MYOCARDIAL INFARCTION?

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Abstract

Context—A large literature establishes the presence of racial differences in healthcare using methods which assume that the covariates used for risk-adjustment affect whites and blacks equally. If incorrect, this assumption may overstate (or understate) the racial gap in treatment disparities.

Objective—We sought to determine whether models that allow for separate coefficients for whites and blacks (i.e. race-specific models) altered the measurement of racial disparities in treatments.

Design, Setting, and Participants—We used data from the Cardiovascular Cooperative Project, which has data on 130,709 white and 8,286 black patients admitted with an acute myocardial infarction during 1994 and 1995.

Main Outcome Measures—We examined rates of six treatments using two models: the conventional “common-effects” model which assumes that all covariates affect whites and black equally, and a race-specific model that allowed the effect of each covariate to vary by race.

Results—Using the conventional common-effects models, we found that blacks were less likely to receive five of the six treatments (odds ratios 0.90 to 1.64). When we used race-specific models, we found nearly identical racial disparities in treatments (odds ratios 0.93 to 1.75) We were unable to identify any interaction effect which systematically suggested the presence of race specific effects.

Conclusions—The use race-specific models to perform risk-adjustment yields estimates of the racial disparity in treatment that are identical to those obtained from them conventionally used common-effect model. Racial disparities in care are not the artifact of mis-specified models.

Introduction

Racial differences in healthcare are widely known, although the reasons behind these differences are not as well understood. While clinicians and policy makers worry that these differences might reflect provider decisions to treat blacks and whites differently, others question whether the studies have adequately demonstrated that the differences are significant and meaningful. Some have suggested that inadequate accounting for confounders, or inappropriate statistical approaches might over-estimate the gaps in care between black and white Americans^{1,2}

Much of the research in the last two decades has focused on trying to account for potential confounders, such as patient choice^{3,4}, economic differences^{5,6}, or differences in access to

care⁷. Less attention has been paid to whether previous work has applied appropriate statistical techniques to assess differences based on race or ethnicity. Most studies use multivariate modeling techniques to account for baseline differences between blacks and whites, and these models generally assume that the covariates, whose values often differ strikingly between blacks and whites, affect blacks and whites equally. For example, in evaluating racial differences in cardiovascular outcomes, most investigators have adjusted for baseline differences in hypertension rates; a risk factor that blacks are more likely to have. However, we are not aware of studies that have tried to systematically account for the fact that physicians may weight the presence of hypertension differently in blacks and whites, and therefore, simply including this covariate in a multivariable model would be inadequate.

Given the tremendous focus on the issue of racial differences in healthcare, the substantial resources dedicated to this topic, and the priority that it has received, it is critically important the measured racial gap in care is not the partial consequence of inadequate statistical techniques. Specifically, we wanted to ensure that the assumption of “common effects”, that covariates such as hypertension or diabetes affect blacks and whites equally, is reasonable. Therefore, we sought to determine how well common effects models performed and whether previous findings of racial disparities would change meaningfully if we used race-specific models that allowed for covariates to have differential effects based on race.

Methods

Data Collection

We used data from the Cooperative Cardiovascular Project (CCP), which collected detailed chart-based clinical data on Medicare patients admitted to a hospital for acute myocardial infarction. The details of the data collection process in the CCP have been detailed elsewhere^{8,9} but we describe it briefly. The CCP used administrative data to identify patients admitted with acute myocardial infarction (International Classification of Diseases, Ninth Revision, Clinical Modification [ICD-9-CM] principal diagnosis of 410.xx). After identification of patients with an Acute MI, a consecutive sample of all Medicare beneficiaries admitted during a 4- to 8-month window between 1994 and 1995⁹ was obtained. For this sample of beneficiaries, the CCP collected detailed clinical data from patient’s charts using a chart abstraction protocol. For our analysis, we chose to include only whites or blacks and we further excluded all patients who were transferred from another emergency room or acute care facility¹⁰.

Variables

For each admission, we categorized each patient into 1 of 5 age categories, which were designed to represent beneficiaries, aged 65–69, 70–74, 75–79, 80–84, and 85–99. We converted many other continuous variables into categorical ones using cut-offs previously chosen by others¹¹. Specifically, we defined hypotension as blood pressure less than 100 mm Hg, renal function in three categories (<1.5 mg/dL, 1.5 to 1.9 mg/dL, or $\geq$ 2.0 mg/dL), anemia as hematocrit level less than 30 percent, low albumin as level less than 3.0 mg/dL low ejection fraction as that less than 40 percent and finally, high creatine kinase (CK) as a level greater than 1000¹¹.

Outcomes

We examined six treatments for blacks and whites as our outcomes. They were the receipt of reperfusion (defined as thrombolysis or percutaneous coronary interventions [PCI]) within six hours, aspirin during the hospitalization, beta-blocker during hospitalization, cardiac catheterization within 30 days of admission, PCI within 30 days of admission and coronary artery bypass graft (CABG) surgery within 30 days. We then examined rates of coronary angiography

for white and black patients. Next, because both PCI and CABG are dependent on a prior coronary angiography, we excluded patients who were class III for angiography in our analysis of rates of these two procedures.

Statistical Analysis

For each of the six treatments outlined above, we estimated two alternative models to understand whether different clinical factors, such as hypertension or diabetes, might affect blacks and whites differently. The first model is the conventionally used “common-effects model”, and the second is the more general “race-specific” model. In the first “common-effects” approach, the effect of each covariate on the receipt of treatment was constrained to be the same by race. Using the coefficients and associated standard-errors from these models, we calculated the adjusted rate of use of each of the treatments by race. We adjusted for baseline differences between blacks and whites using age, gender, and each of the covariates available in the CCP that might have been plausibly associated either with the predictor (race) or with the outcome (receiving therapy for Acute MI). The full list of covariates in our model is presented in Table 1. In our second approach, we estimated race-specific models where we used all of the covariates listed in Table 1 to estimate separate models for blacks and whites. Once again, we adjusted for baseline differences and used these coefficients to create a predicted rate of receiving these therapies. Because the “common-effects” model is nested within the “race-specific” model, we examined whether predicted values from these two models, and odds ratios on race, were substantively different.

To formally evaluate whether the two models yielded predictions that were statistically different we estimated a third model that is statistically equivalent to the “race-specific” model: we reran a “common-effects” model where we added a race interaction term for every covariate in Table 1. We then performed a Wald test to see if the interactions effects were jointly equal to zero¹². We also computed likelihood-ratio tests and noted that these were indistinguishable from the Wald tests.

Using clinical criteria, we a priori chose to focus on 12 covariates as likely being most likely to have a differential affect on whites and black. These include gender, age (in 5-year increments), and prior history of each of the following: acute MI, congestive heart failure (CHF), diabetes mellitus (DM), hypertension, low ejection fraction, peripheral vascular disease. Other covariates included current tobacco use, CHF at admission, shock at admission, renal dysfunction at admission, and the presence of an order to not resuscitate the patient. However, because we were concerned that our selection of covariates where we anticipated a racial different may be subject to our own biases, we report all the interactions in two Appendix tables. All analyses were conducted using STATA 9.0, College Station, TX.

Results

There were 138,995 Medicare beneficiaries who were hospitalized for Acute MI in the CCP database. Of these, 8,286 (6.0%) were blacks. Black Americans were younger, more likely to be female, admitted from a nursing home, have limited mobility, but less likely to have a Do Not Resuscitate on file at the time of admission (table 1). Blacks also had higher rates of hypertension, diabetes, tobacco use and other comorbidities associated with higher cardiovascular risk. Finally, there were important racial differences in clinical presentation that are outlined further in Table 1.

Blacks had lower unadjusted rates reperfusion within six hours of admission and beta-blocker use, although the rates of aspirin use were comparable between the two groups. By 30 days after admission, black patients had significantly lower rates of cardiac catheterization, PCI and CABG surgery (Table 2).

When we used the “common effects” model to adjust for baseline covariates, we found that blacks received fewer of five of the six therapies (all but aspirin during hospitalization, rows 2 to 5, table 3) with odds ratios (comparing whites to blacks) that varied from 0.90 (95% CI 0.86 to 0.94) for aspirin use to 1.64 (95% CI 1.53 to 1.70) for CABG within 30 days. We then examined prediction models for whites and blacks using race-specific co-efficients and when we compared them to common-effects models, we found nearly identical results (rows 6 to 9, table 3). The predicted rates for whites using race-specific models differed by less than 0.2% for each of the six outcomes. The predicted rates for blacks using black-specific models were also comparable: differing between 0.2% for PCI to as much as 1.0% for beta-blocker use (table 3). Finally, the odds ratios for the common-effects models were nearly identical to those from the race-specific models (rows 5 and 9, table 3).

Our examination of the interaction terms revealed little consistent effects: of the 12 variables we identified a priori as clinically most relevant, only a previous history of diabetes had interactions that were significant ($p < 0.05$) for two of the three treatments we examined. Four other co-variables (female gender, prior MI, history of low EF, and elevated creatinine) had one interaction that was statistically significant (table 4). The odds ratios for each of these 12 covariates were relatively similar for blacks and whites across all three treatment measures (Table 4). We present the data on the covariates for the other three outcomes in Appendix A and for all the covariates for all six outcomes in Appendix B.

Discussion

We used race-specific coefficients in risk-adjustment models to determine whether they affect the degree of disparities observed for cardiac care and found that race-specific coefficients lead to nearly identical results as common-effects models that did not derive race-specific effects. For each of the six outcomes examined, the common-effects models understated rates of treatment for blacks (that is, the racial disparity in treatment was overstated), although these differences were small and statistically insignificant. We could identify no interactions that consistently modified the relationship between race and any of the six treatments.

Our study has important limitations. First, we examined data from the CCP, which are now more than 10 years old, and it is possible that the relationship between race and procedure use may have changed. However, there is substantial evidence that treatment disparities, even for patients with AMI, have not changed over this time period.^{13,14} Changes in the prevalence of underlying comorbidities are accounted for in our analysis, but *changes* in the effect of these comorbidities on the receipt of treatments are not. Second, we examined treatment differences only and not outcomes. While it may be the case the presence of certain comorbidities does not differentially affect the receipt of treatment for whites and blacks, the same comorbidities may affect downstream survival and other outcomes differently by race. We did not explore this possibility in our analysis because our ability to risk-adjust for survival (as opposed to risk-adjustment for treatment) remains limited with datasets such as the CCP.

While there is little doubt that blacks and whites have different levels of comorbid conditions (i.e. diabetes or hypertension) and important differences in socioeconomic factors, most previous investigations, by “adjusting for baseline differences” have made the assumption that clinicians treat whites and blacks with a given co-morbidity the same. Whether or not it is clinically accurate (i.e. whether blacks and whites with diabetes should be treated the same), the assumption has only modest effects on the relationship between race and treatment outcomes. Its use should not distract clinicians and policy-makers from the fact that measured racial disparities in care are not a statistical artifact.

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Table 1
Characteristics of patients in the Cooperative Cardiovascular Project

	Whites N= 130,709 Mean (95% CI)	Blacks N=8,286 Mean (95% CI)	P-value for test of racial difference
Demographics			
Age	76.7	75.6	<0.0001
Female Sex (%)	48.9	58.8	<0.0001
Admitted from a Nursing Home (%)	5.8	6.1	0.07
Limited Mobility (%)	18.7	26.2	<0.0001
Had DNR on file at admission (%)	9.7	6.2	<0.0001
Clinical History			
Previous Revascularization (%)	17.5	9.9	<0.0001
Previous Myocardial Infarction (%)	29.5	29.0	0.40
History of CHF (%)	21.5	27.2	<0.0001
Diabetes (%)	29.6	42.1	<0.0001
Hypertension (%)	60.5	79.5	<0.0001
Current tobacco smoker	14.4	17.8	<0.0001
History of a Low EF (%)	3.7	4.5	0.001
Metastatic cancer (%)	0.8	0.9	0.36
History of PVD (%)	10.3	12.6	<0.0001
History of COPD (%)	20.7	17.8	<0.0001
Dementia (%)	6.1	8.3	<0.0001
Clinical Features at Presentation			
History of Atrial Fibrillation	9.8	6.8	<0.0001
Received CPR (%)	3.4	4.2	0.0005
Anterior location of MI	30.7	30.9	0.71
Inferior location of MI	19.6	15.9	<0.0001
Other location of MI	9.4	10.5	0.001
Heart Block (%)	15.9	14.1	<0.0001
Congestive Heart Failure (%)	28.5	33.2	<0.0001
Hypotension (%)	3.8	3.6	0.32
Cardiogenic Shock (%)	2.3	2.0	0.05
Elevated creatine kinase (%)	30.2	33.4	<0.0001
Albumin < 3.0 mg/dL (%)	4.4	6.9	<0.0001
Creatinine > 2.0 mg/dL (%)	15.4	17.8	<0.0001
Hematocrit < 30% (%)	4.5	9.1	<0.0001

Table 2

Treatments of patients in the Cooperative Cardiovascular Project

	Whites N= 130, 709	Mean (95% CI)	Blacks N=8286	Mean (95% CI)	P-value for test of racial difference
	Treatments in the hospital				
Reperfusion within 6 hours	18.4%	18.2-18.6	11.9%	11.2-12.6	<0.0001
Aspirin	78.3%	78.1-78.5	77.6%	76.7-78.5	0.14
Beta-blocker	45.6%	45.4-45.9	42.4%	41.4-43.5	<0.0001
	Treatment at 30-days				
Cardiac catheterization	46.6%	46.3-46.8	39.2%	38.1-40.2	<0.0001
Percutaneous Coronary Intervention	18.1%	17.9-18.3	12.3%	11.6-13.0	<0.0001
CABG Surgery	13.7%	13.5-13.9	8.9%	8.3-9.5	<0.0001

Table 3

Predicted rates of treatments (and 95% CI) using race-specific versus common-effect coefficients to adjust[†] for baseline differences.

	Reperfusion within 6 hours	Aspirin	Beta-blocker	Cardiac Catheterization	PCI	30 d. CABG
	Models using common-effects co-efficients					
Predicted rate for whites	10.5% (10.3–10.7)	80.5% (80.3–80.7)	44.3% (44.0–44.6)	39.8% (39.5–40.2)	12.3% (12.1–12.6)	8.1% (7.9–8.3)
Predicted rate for blacks	6.8% (6.3–7.3)	82.1% (81.2–82.9)	41.9% (40.8–43.0)	34.0% (32.9–35.3)	9.2% (8.6–9.8)	5.1% (4.8–5.6)
Odds ratio *	1.61 (1.52, 1.71)	0.90 (0.86, 0.94)	1.10 (1.07, 1.14)	1.28 (1.23, 1.33)	1.38 (1.33, 1.46)	1.64 (1.53, 1.70)
	Models using race-specific co-efficients					
Predicted rate for whites	10.5% (10.3–10.8)	80.6% (80.3–80.8)	44.2% (43.9–44.5)	40.0% (39.6–40.4)	12.2% (12.0–12.5)	8.1% (7.9–8.3)
Predicted rate for blacks	6.4% (5.7–7.3)	81.7% (80.6–82.8)	40.9% (39.5–42.4)	33.6% (31.9–35.4)	9.0% (8.1–10.0)	4.8% (4.0–5.7)
Odds ratio *	1.72 (1.54, 1.90)	0.93 (0.87, 0.98)	1.15 (1.09, 1.20)	1.32 (1.20, 1.45)	1.40 (1.29, 1.55)	1.75 (1.50, 2.06)

* Odds ratio, whites compared with blacks.

[†] Adjusted for: age, gender, source of admission (nursing home, other facility), level of mobility, the presence of a do not resuscitate at admission, previous revascularization, prior myocardial infarction (MI), history of any of the following: congestive heart failure (CHF), diabetes, hypertension, low ejection fraction, metastatic cancer, peripheral vascular disease, chronic obstructive pulmonary disease, or dementia. Also adjusted for the presence of any of the following at admission: atrial fibrillation, location of MI, heart block, CHF, hypotension, cardiogenic shock, elevated creatine kinase, low albumin, elevated creatinine, or low hematocrit.

Table 4

Effect of selected patient characteristics on likelihood of receiving three selected treatments.

	Cardiac Catheterization			Reperfusion			Beta-blocker		
	OR Blacks	OR Whites	P-value*	OR Blacks	OR Whites	P-value*	OR Blacks	OR Whites	P-value*
Female	0.91	0.75	<0.01	0.93	0.93	0.97	1.00	0.99	0.84
Age									
70-74 years	0.75	0.81	0.25	0.94	0.85	0.28	0.91	0.96	0.44
75-79 years	0.57	0.59	0.67	0.82	0.70	0.16	0.81	0.89	0.22
80-84 years	0.33	0.27	0.03	0.57	0.48	0.18	0.87	0.83	0.61
>85 years	0.09	0.09	0.86	0.31	0.28	0.65	0.62	0.70	0.21
Previous MI	0.83	0.78	0.36	1.06	0.87	0.04	1.12	1.02	0.09
History of CHF	0.61	0.59	0.61	0.58	0.61	0.65	0.62	0.62	0.90
History of Diabetes Mellitus	0.99	0.81	<0.01	1.02	0.78	0.00	0.93	0.86	0.12
History of hypertension	1.18	1.15	0.70	1.17	0.96	0.04	1.46	1.39	0.46
History of low ejection fraction	1.02	0.71	0.01	0.81	0.75	0.76	0.90	0.80	0.37
History of peripheral vascular disease	1.00	0.94	0.44	0.86	0.81	0.69	1.01	1.07	0.46
Current Tobacco Smoker	0.94	0.91	0.64						
CHF at admission	0.70	0.69	0.86	0.63	0.63	0.97	0.63	0.62	0.72
Shock at admission	1.28	1.12	0.58	1.36	1.64	0.50	0.52	0.49	0.75
DNR at admission	0.27	0.25	0.73	0.67	0.71	0.84	0.69	0.67	0.83
Renal Dysfunction									
Creatinine 1.5-2.4 mg/dL	0.85	0.70	0.01	0.81	0.81	1.00	0.87	0.80	0.28
Creatinine ≥2.5 mg/dL	0.43	0.37	0.14	0.48	0.52	0.65	0.70	0.72	0.76

* P-value to determine if the effect estimate is different for whites compared with blacks.

Appendix A

	PCI			CABG			Aspirin	
	OR Blacks	OR Whites	P-value*	OR Blacks	OR Whites	P-value*	OR Blacks	OR Whites
Female	0.97	1.02	0.51	0.77	0.64	0.03	0.86	0.83
Age 70-74 years	0.83	0.87	0.54	0.89	0.97	0.34	0.97	0.93
Age 75-79 years	0.77	0.71	0.39	0.77	0.80	0.74	0.89	0.87
Age 80-84 years	0.57	0.49	0.25	0.38	0.40	0.69	0.93	0.86
Age ≥ 85 years	0.19	0.23	0.35	0.06	0.11	0.17	0.82	0.80
Previous MI	0.82	0.71	0.10	1.01	1.02	0.87	1.11	0.97
History of CHF	0.54	0.67	0.07	0.62	0.63	0.89	0.78	0.74
History of Diabetes Mellitus	0.96	0.83	0.06	1.09	1.03	0.49	1.03	0.89
History of hypertension	1.05	1.00	0.54	1.14	1.21	0.56	1.14	1.16
History of low ejection fraction	0.74	0.82	0.64	1.10	0.76	0.09	1.38	1.03
History of peripheral vascular disease	0.97	0.83	0.19	1.31	1.13	0.24	1.11	0.99
Current Tobacco Smoker	1.01	0.95	0.54	0.91	0.88	0.73	1.12	1.13
CHF at admission	0.56	0.54	0.77	1.06	1.05	0.89	0.78	0.77
Shock at admission	1.63	1.53	0.82	2.61	1.07	0.01	0.42	0.54
DNR at admission			0.71	0.28	0.26	0.84	0.69	0.65
Renal Dysfunction								
Creatinine 1.5-2.4 mg/dL	0.83	0.72	0.17	0.79	0.86	0.45	0.73	0.75
Creatinine ≥ 2.5 mg/dL	0.47	0.44	0.69	0.53	0.51	0.79	0.56	0.58

* results in red represent statistically significant differences at $p < 0.05$.

Appendix B

	Cardiac Catheterization		PCI		Reperfusion		CABG		ASA		Beta-blocker	
	OR Blacks	OR Whites	OR Blacks	OR Whites	OR Blacks	OR Whites	OR Blacks	OR Whites	OR Blacks	OR Whites	OR Blacks	OR Whites
Previous Revascularization	1.40	1.24	1.66	1.52	1.20	0.97	0.98	0.53	1.14	0.95	1.04	1.01
Dementia	0.35	0.28	0.47	0.38	0.30	0.52	0.34	0.31	1.14	0.91	0.99	0.89
Metastatic Cancer	0.19	0.23	0.15	0.40	0.62	0.26			1.00	0.71	0.99	0.97
History of Peripheral Vascular Disease	1.00	0.94			0.86	0.81	1.31	1.13	1.11	0.99	1.01	1.07
History of Chronic Obstructive Pulmonary Disease	0.84	0.71	0.71	0.83	0.82	0.78	0.93	0.72	0.79	0.77	0.55	0.53
History of previous angiogram	1.37	1.32	1.18	1.12	1.00	1.09	1.75	1.40	1.22	1.59	1.62	1.81
Atrial Fibrillation at admission	0.73	0.71	0.70	0.74	0.82	0.82	0.42	0.72	0.78	0.66	0.85	0.79
CPR at admission	0.42	0.48	0.69	0.62	0.55	0.57	0.25	0.65	0.30	0.30	0.74	0.72
Anterior MI	0.99	0.94	1.27	1.24	4.50	4.09	0.94	0.82	0.93	0.99	1.04	1.03
Inferior MI	0.97	1.0	1.55	1.37	4.39	4.79	0.61	0.84	1.11	1.21	1.05	1.02
Other MI	0.66	0.69	0.95	0.77	0.81	0.68	0.58	0.75	0.57	0.64	0.64	0.75
Heart block at admission	0.85	0.84	0.87	0.85	0.74	0.75	0.77	0.87	0.80	0.87	0.68	0.78
Hypotension at admission	0.80	0.78	1.06	1.01	1.46	1.54	0.63	0.82	0.66	0.58	0.47	0.50
Elevated CK at admission	1.03	0.98	1.29	1.21	2.75	2.78	1.02	0.88	1.20	1.27	1.25	1.20
Admitted from a nursing home	0.32	0.33	0.63	0.35	0.56	0.46	0.26	0.26	0.73	0.78	0.73	0.72
Admitted from another institution	1.11	0.74	1.05	0.75	0.92	0.73	1.54	0.80	1.05	0.92	1.14	0.95
Unable to walk	0.22	0.35	0.24	0.59	0.37	0.51	0.25	0.42	0.58	0.63	0.57	0.69
Walk with assistance	0.58	0.56	0.79	0.70	0.61	0.61	0.54	0.59	0.38	0.51	0.88	0.84
Low albumin at admission	0.94	0.80	1.16	0.95	1.05	0.98	0.76	0.82	0.73	0.79	0.81	0.82
High bilirubin at admission	0.59	0.66	0.70	0.72	0.48	0.64	0.76	0.79	0.74	0.72	0.73	0.88
Low hematocrit at admission	0.65	0.56	0.87	0.66	0.61	0.56	0.82	0.66	0.75	0.45	0.87	0.81

* data missing if the models could not create a parameter estimate in a race-specific model.

* results in red represent statistically significant differences at $p < 0.05$.