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Disparity in Race-Specific Comorbidities Associated With Central Venous Catheter–Related Bloodstream Infection (AHRQ-PSI7)

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Abstract

Studies of racial disparities in hospital-level patient safety outcomes typically apply a race-common approach to risk adjustment. Risk factors specific to a minority population may not be identified in a race-common analysis if they represent only a small percentage of total cases. This study identified patient comorbidities and characteristics associated with the likelihood of a venous catheter–related bloodstream infection (Agency for Healthcare Research and Quality Patient Safety Indicator 7 [PSI7]) separately for blacks and whites using race-specific logistic regression models. Hospitals were ranked by the racial disparity in PSI7 and segmented into 4 groups. The analysis identified both black- and white-specific risk factors associated with PSI7. Age showed race-specific reverse association, with younger blacks and older whites more likely to have a PSI7 event. These findings suggest the need for race-specific covariate adjustments in patient outcomes and provide a new context for examining racial disparities.

Keywords

racial disparity; patient safety; comorbidities

Patient Safety Indicators (PSIs) were developed by the Agency for Healthcare Research and Quality (AHRQ) as a means to detect events that had a high likelihood of representing medical errors and could be identified using hospital administrative data.[1–3] Studies have applied the suite of PSIs to large samples of hospital discharges in order to address patient safety events and the quality of hospital care.[2–7] Studies examining health disparities have compared PSI7 (venous catheter–related bloodstream infection) rates and risks between race groups and often suggest unequal quality of care as the main reason for racial differences in

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adverse outcomes and safety events.[8,9] However, the causes of health disparities likely involve a complex relationship between demographic, socioeconomic, biological, and structural factors in addition to actual differences in quality of care.[10]

Adverse events from medical and surgical care do not result only from health care provider errors but also from acuity of patients' illnesses.[11] For example, comorbidities such as congestive heart failure (CHF), weight loss, diabetes, and electrolyte disorder are associated with increased likelihood of a patient safety event during hospitalization.[4] Some of these comorbidities occur earlier and more frequently in blacks than whites.[12,13] In a study of health disparities in sepsis, blacks had a 25% greater likelihood of having a sepsis diagnosis compared with whites and were more likely to have comorbid conditions (chronic renal failure, diabetes, and alcohol abuse) associated with sepsis.[14]

Therefore, blacks and whites may have different profiles and severity of comorbidities, which may explain some of the observed racial disparities in adverse outcomes and safety events. However, most studies of disparities in patient safety events typically have focused on hospital-level factors and concluded that racial disparities in patient outcomes result more from variation in quality between hospitals than from variation within hospitals.[8,15] As a consequence, studies of patient safety in US hospitals have evaluated differences in hospital characteristics, risk adjusting for demographic and clinical characteristics and comorbidities.[6,9,16,17] Racial disparities in the risk-adjusted rates of patient safety events in these studies, such as infection resulting from medical care, postoperative hemorrhage, and postoperative complications, were small and not significant for almost all the hospitals.[4,6,16] Because these studies did not adjust for the size and relative proportion of black/white discharges, Metersky et al used abstracted data on Medicare patients that included the percentage of black patient discharges in their analysis and concluded that adverse drug events and nosocomial infections among black patients are associated with a greater risk profile and a higher percentage of black patient discharges. Although these studies considered contextual effects and adjusted for between-hospital variance, lack of specific criteria for hospital sampling and risk adjustment that does not consider the variation in patient characteristics within hospitals may lead to biased estimates and conclusions on racial disparities.

It is important to note that the proportions of black and white patient discharges are not the same across hospitals, that the frequency of reported safety events varies across and within hospitals for both races, and that small hospitals in specific geographic locations may have substantially fewer discharges for a particular racial group. In addition, adverse outcomes such as the AHRQ PSIs are relatively rare events, and hospital inclusion criteria must be applied to ensure that there are sufficient cases in the appropriate denominator to compute valid rates and sufficient cases of race-specific outcomes to populate the numerators. If the inclusion criteria do not ensure sufficient representation of both races in the hospital sample, the outcomes for minority race groups may be underestimated.

In most studies, the additive model is used to evaluate racial disparities, with race included in the model as one of the explanatory variables, with the assumption that race has a "common effect" across other attributes in the model.[18] Failure to consider that patient characteristics may have different effects in blacks and whites may mask racial differences

in a safety event. When assessing patient safety events in general, studies have adjusted for patient baseline characteristics; some of these characteristics such as hypertension and diabetes affect blacks more than whites and may influence inpatient care for blacks and white differently. It is important to understand whether comorbidities used for risk adjustment affect a patient safety event equally for blacks and whites. Therefore, this study sought to identify patient comorbidities and characteristics associated with the likelihood of an AHRQ-PSI7 separately for blacks and whites using race-specific models, an approach that has not been used previously in PSI7 research.

Methods

Design and Data Source

A retrospective cross-sectional analysis was conducted of patients discharged from Florida acute hospitals from 2005 to 2009. Discharge data were obtained from the Florida Agency for Health Care Administration and derived from the Florida Inpatient Discharge Database. The data include diagnosis, procedure, and demographic information from 206 short-term acute hospitals.

Outcome Variable of Interest

The outcome variable of interest was defined as infection caused by medical care or venous catheter–related bloodstream infection, one of the PSIs developed by AHRQ. PSIs are used to screen for potential patient safety events in hospital discharge data and have been used to assess disparities in safety indicators.[9] The PSIs are reliable measures, with good construct validity and stability over time. PSI7 has been shown to be correlated with most of the other PSI indicators, and studies have suggested that it can be used as a quick index of general patient safety status.[19] For discharges before October 1, 2007, PSI7 was defined as infections related to hospital stay; from October 1, 2007, onward, it was defined as central venous catheter–related bloodstream infection.[20] Using the AHRQ PSI software,[21] PSI7 cases were identified accounting for these inclusion criteria: all discharges 18 years of age and older; pregnancy or childbirth discharges if younger than 18 years with *International Classification of Diseases, Ninth Revision, Clinical Modification* diagnostic codes 99662 and 9993; cases without diagnosis of infection present on admission; with a hospital stay longer than 1 day; and without immunocompromised state or cancer diagnoses. The data selection flow chart is shown in Figure 1.

Study Sample

Specific criteria were used to select hospitals for inclusion and to ensure that the hospitals had sufficient PSI7 cases to enable meaningful analysis and comparison of outcomes across hospitals and between white and black patients within hospitals. The criteria included having at least 10 black and white PSI7 discharges, or at least 25 white PSI7 and 5 black PSI7 discharges, or at least 30 PSI7 discharges total and 10 000 black discharges. Of the 206 hospitals, 103 hospitals met the criteria and were selected. For each hospital included, white and black patient discharges were aggregated to determine race-specific discharges and race-specific PSI7 rates. The hospitals were rank ordered and segmented into 4 groups based on

the black/white PSI7 rate ratio to provide a range of PSI7 rate gaps across Florida hospitals, which were used to describe the hospitals and patient characteristics.

The first group's black/white PSI7 rate ratio was 0.6, representing hospitals where black PSI7 rates were lower than white rates; the second group's black/white PSI7 rate ratio was 0.95, representing hospitals with nearly identical black/white PSI7 rates; the third group's black/white PSI7 rate ratio was 1.34 representing hospitals where black PSI7 rates were higher than white rates; the fourth group's black/white PSI7 rate ratio was 2.53, representing hospitals where black rates were much higher than white rates.

A total of 8 analytic samples were created: 4 for blacks and 4 for whites. The sizes of the black and white samples representing the 4 hospital groups are shown in Table 1. The total study population included 5 236 045 discharges.

Explanatory Variables of Interest

The explanatory variables of particular interest were the comorbidities. Comorbidities were identified using the Elixhauser Comorbidity Index.[22] The index includes 30 comorbidity measures for risk adjusting and predicting outcomes. In this study, 4 comorbidities—cancer (meta-static cancer, solid tumor, and lymphoma) and AIDS—were excluded because of their influence on PSI7. Also, 26 comorbid conditions were included in the analyses as a separate dichotomous variable. In addition to the comorbidities, other patient characteristics included were age as a continuous variable, sex, admission type (emergency, urgent, elective, and trauma), and pay source (Medicare, Medicaid, commercial insurance, Champus/Veterans Administration, and self-pay/underinsured). The reference groups were men for sex, elective admission for admission type, and commercial insurance for pay source.

Statistical Analysis

The PSI7 racial rate gap, represented by the 4 PSI7 rate ratios for the 4 hospital groups were used as the basis of describing the sample. All analyses were performed separately for the 8 race-specific analytic samples (ie, 4 separate analyses for black and white patients in each of the 4 hospital groups). Descriptive analyses by hospital groups included the following: total discharges, percentage of black and white discharges, PSI7 rates/10 000 discharges, the ratio of black/white PSI7 rate, average age, and average length of stay (LOS) for all patients and for patients with PSI7. Potential correlation between comorbidities within each hospital group was assessed using Spearman correlation and variance inflation factor. There was no significant correlation between the comorbidities, and all 26 comorbidities were included in the adjusted analyses. Hospital-level effects within groups were checked with multilevel analyses. There was no significant hospital-level effect because hospitals in each group have similar PSI7 rates; hence, logistic regression was applied. Logistic regression was used to assess the association of comorbidities with PSI7, adjusting for age, sex, health insurance, and admission type. LOS was not included in the model because it is an endogenous explanatory variable that is both a cause and effect of PSI7 and its inclusion in the model could bias the estimates.[23,24] In all, 8 separate logistic models were used to assess racial differences in PSI7 for blacks and whites in the 4 hospital groups. Comorbidities related to PSI7 were grouped to determine patterns that may explain racial differences in PSI7 risks

within hospital groups. The discriminating strength of the models was assessed with C statistics, which ranged between 0.65 and 0.73. For descriptive statistics, we used Excel (Microsoft Corporation, Redmond, WA). Logistic regression analyses were performed using SAS version 9.2 (SAS Institute Inc, Cary, NC).

Results

Characteristics of Hospital Groups

The black PSI7 rates increase consistently across the 4 groups, whereas the white rates decrease, though not in a perfectly linear fashion. Group 4 had the highest black rate and the lowest white rate, thus reflecting the largest racial disparity (Table 1).

The 5-year average of hospital discharges decreased linearly with the largest 5-year average in group 1 and the lowest in group 4. The percentage of total discharges represented by black patients increased across the groups, whereas the percentage of white discharges decreased steadily across the groups. No significant racial differences were apparent in LOS either for discharges with a PSI7 or all discharges. However, the LOS for patients who had PSI7 was nearly 3 times longer than the average LOS for all patients across all groups. On average, white patients were approximately 10 to 11 years older than blacks. However, the age gap for white and black PSI7 patients was highest in group 3 (15.9 years) and group 4 (17.5 years), where the infection rates for blacks were highest compared with whites. On average, these 2 groups have the youngest black patients and the oldest white patients.

Adjusted Results of Risk Factors for PSI7

The logistic regression models revealed 3 groups of comorbidities and characteristics associated with the likelihood of a PSI7 event (Tables 2 and 3). A primary cluster of significant factors common to both black and white patients was found in most of the hospital groups. Comorbid weight loss and electrolyte disorder are significant in all 8 groups, coagulopathy in 7 of 8 groups, and paralysis in 5 of 8 groups. Paralysis is significant for blacks in hospital groups with the lowest PSI7 rate gap (groups 1 and 2) and for whites in groups with the highest PSI7 rate gap (groups 1, 2, and 3). The primary cluster also includes emergency admission as a significant factor for all 8 groups and Medicare insurance for 7 of 8 groups.

A secondary cluster of risk factors that are race specific was identified. For whites, these included chronic blood loss/anemia, peptic ulcer/bleeding, diabetes with complications, and trauma admission. Notably, these secondary factors are found only in white groups 1 and 2, where PSI7 rates are highest. The secondary cluster for blacks includes perivascular disease, neurological disorders, and renal failure. Medicaid insurance was significant in 3 of 4 black groups.

A secondary cluster of race-common factors was identified; unlike the primary cluster, these factors typically were significant in only 1 or 2 groups. Drug abuse was significant for whites in groups 1 and 2 and for blacks in group 4, and therefore, it is an important risk factor for both races in groups where the PSI7 rates were highest. CHF was significant for whites in groups 1, 2, and 3 and for blacks in group 2. This suggests that, although not

completely race specific, CHF is more often associated with PSI7 for white patients than black patients. Age shows an inverse racial relationship (ie, high PSI7 rates are associated with increasing age for whites but decreasing age for blacks).

Discussion

In this study of racial disparity for PSI7 in Florida hospitals, it was found that racial disparity in PSI7 rates was highest in hospitals with high proportions of black discharges and lowest average total discharges. In addition, both common and race-specific risk factors of PSI7 were identified in hospital groups with a substantial black/white PSI7 rate gap. Numerous studies have examined racial disparities in hospital patient safety events using the AHRQ PSIs. These studies found that blacks had higher rates of nosocomial infections and some adverse surgical outcomes than whites, after risk adjusting for patient- and hospital-level factors.[6,9,25] The findings from these prior studies suggest that independent of hospital-level variations, blacks may have specific risk factors that may explain their increased risk for a patient safety event. Because these factors may be race specific, the “common effect” risk-adjustment method used in prior research will fail to identify race-specific factors and may not detect racial disparities.[18]

The present study’s findings indicate that there is a different set of patient characteristics that influence the likelihood of PSI7 events for black and white patients. In hospital groups 3 and 4, wherein the PSI7 rates are higher for blacks than whites, renal failure, perivascular disease, Medicaid insurance, and younger age were risk factors specific to black patients. The white race-specific risk factors identified in hospital group 1, wherein the PSI7 rate is higher for whites than blacks, include diabetes with chronic complications, chronic blood loss anemia, older age, and peptic ulcer/bleeding. The comorbidity profile associated with PSI7 in black and white patients is different, and their clinical needs may be different. These findings suggest the need for race-specific examination of patient safety events and provide a new context for examining racial disparities.

Studies have shown that for certain conditions (eg hypertension, heart failure, CHF), black and white patients show differences in pathophysiological and clinical characteristics and respond differently to some therapies.[26,27] There is documented evidence of a higher burden of cardiovascular disease in black Americans.[26] Furthermore, although multiple studies have suggested that the total mortality related to CHF as well as hospitalization for worsening CHF was higher in blacks compared with whites,[28–30] it is important to recognize that there are striking population differences with respect to this disease in almost every aspect.[29] For example, the cause of CHF is primarily ischemic disease in nonblack patients, but it has a predominantly hypertensive nature in blacks.[29] Risk adjustment in racial disparity studies that does not consider these differences between the race groups may miss important characteristics that may help explain racial disparities in health outcomes and help segment subpopulations at risk of patient safety events.

The present study also identified a cluster of common PSI7 risk factors, comorbid conditions, and characteristics that are consistent across the 4 hospital groups. Although it is beyond the scope of this research to explain the etiology and pathophysiology of all

conditions identified as common and/or race specific, previous studies provide support for some of them. For example, weight loss, which emerged as an important predictor of PSI7, has been suggested as a marker of many ongoing chronic diseases and associated with mortality in previous studies.[31] Although the list of potential causes of weight loss is extensive, for conditions such as gastrointestinal, hepatobiliary, hematologic, lung, breast, genitourinary, ovarian, and prostate malignancies, it may be a presenting feature before disease manifestation.[32] This is an important consideration for the present study, although confirmed cancer and AIDS cases were excluded from the analysis; there may be patients with undiagnosed cancerous diseases with comorbid weight loss included in the analysis who would be particularly susceptible to infections, including PSI7.

The results also showed that age has an inverse relationship with PSI7 for the race groups examined, with older whites and younger blacks at risk for PSI7. This relationship emerged for whites in hospital groups 1 and 2, wherein white PSI7 rates were high, and for blacks in groups 3 and 4, wherein black PSI7 rates were high. Considered together, these clusters of comorbid risk factors and demographic characteristics suggest that racial disparity in PSI7 across Florida hospitals is, in part, a result of differences in patient populations and race-specific risk factors.

This research has some limitations. Clinical details such as duration of catheterization, adequacy of using antimicrobial agents for prevention and treatment of bloodstream infections, site of catheter placement, type of catheter (single vs triple lumen), and the severity of the comorbid conditions were not available in the data and therefore were not accounted for. The data did not include a “present on admission” indicator for comorbidities. Certain conditions such as coagulopathy and electrolyte disorders may occur during hospitalization and should be considered complications rather than comorbid conditions. Furthermore, the logistic regression analysis did not allow the identification of the effects of reciprocal interactions between covariates.

Conclusions

This study showed that some comorbid conditions and patient characteristics that are associated with a PSI7 event differ by race. Race-specific differences in patterns of comorbid conditions are important determinants of hospital-level patient safety outcomes.

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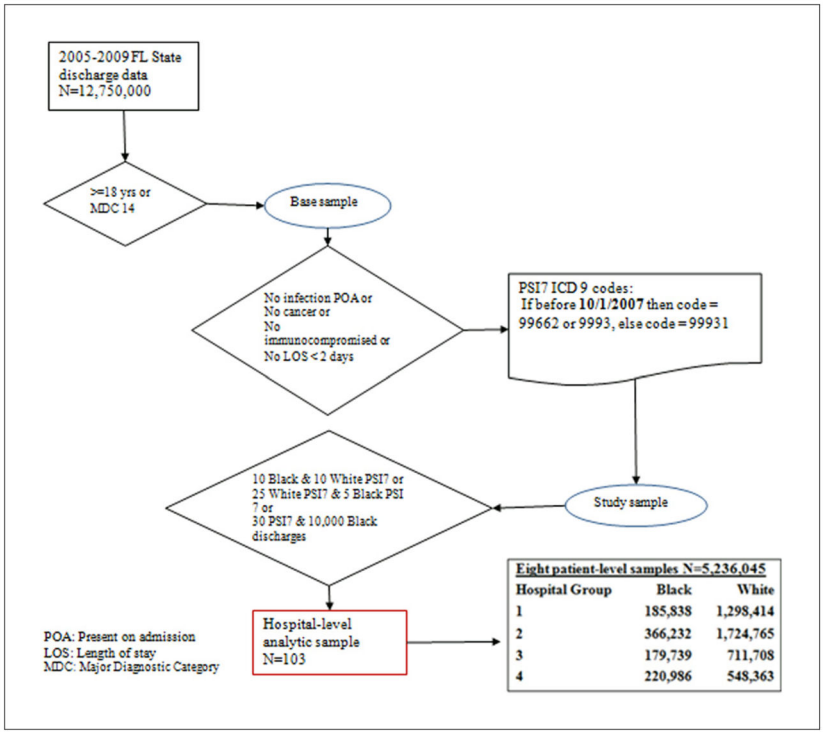

Figure 1.

Study data inclusion criteria.

Abbreviations: PSI, patient safety indicator; ICD 9, *International Classification of Diseases, Ninth Revision, Clinical Modification*.

Table 1

Patient Characteristics by Hospital Groups.

	Hospital Groups (N = 5 236 045)			
	Group 1 (n = 19)	**Group 2 (n = 33)**	**Group 3 (n = 22)**	**Group 4 (n = 29)**
Hospital discharges				
Total	1 484 252	2 090 997	891 447	769 349
Black	185 838	366 232	179 739	220 986
White	1 298 414	1 724 765	711 708	548 363
Average discharges (5 years)	78 118	63 364	40 520	26 529
Race (percentage of discharges)				
Black	0.13	0.18	0.20	0.29
White	0.87	0.82	0.80	0.71
PSI7 discharges				
Total	2614	4191	1480	1160
Black	209	705	375	586
White	2405	3486	1105	574
PSI7 (Rate/10 000)				
Black	11.24	19.25	20.86	26.52
White	18.52	20.21	15.52	10.46
Black/White PSI7 rate ratio[a]	0.60	0.95	1.34	2.53
Length of stay in days (mean, all patients)				
Black	4.84	4.80	5.18	4.81
White	4.94	4.90	5.00	4.86
Length of stay in days (mean, PSI7 patients)				
Black	14.70	14.98	14.80	15.28
White	14.30	14.19	13.96	14.05
Age (mean, all patients)				
Black	47.80	45.50	48.15	47.55
White	58.66	55.55	60.80	59.04
Age (mean, PSI7 patients)				
Black	50.69	49.70	47.60	46.26
White	62.18	59.70	63.50	63.80

Abbreviation: PSI, patient safety indicator.

[a]Black/White PSI7 refers to the ratio of black PSI7 rate to white PSI7 rate.

Table 2

Characteristics Associated With PSI7 Among Blacks, by Hospital Groups.

	Group 1		Group 2		Group 3		Group 4	
Characteristics	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Primary cluster[a]								
Weight loss	2.83	1.63–4.89	2.47	1.83–3.34	1.90	1.09–3.29	2.13	1.44–3.15
Fluid and electrolyte disorder	1.62	1.17–2.23	1.65	1.39–1.97	1.92	1.49–2.47	1.46	1.19–1.78
Emergency admission	3.52	2.05–6.07	1.93	1.50–2.49	2.30	1.52–3.48	4.77	3.31–6.85
Coagulopathy	2.07	1.11–3.88	2.28	1.67–3.13			2.31	1.63–3.28
Paralysis	2.00	1.18–3.39	1.88	1.38–2.55				
Medicare			2.00	1.56–2.58	2.50	1.74–3.59	2.83	2.18–3.67
Secondary cluster, race specific[b]								
Medicaid	1.60	1.05–2.45			1.43	1.02–2.01	2.04	1.60–2.61
Perivascular disease	2.00	1.10–3.67					1.64	1.04–2.57
Other neurological disorders	1.80	1.16–2.80						
Male	1.36	1.02–1.84						
Renal failure					1.66	1.08–2.54		
Secondary cluster, common[c]								
Age					0.97	0.98–0.99	0.96	0.98–0.99
Urgent admission							1.54	1.03–2.29
Drug abuse							1.42	1.02–1.98
Congestive heart failure			1.62	1.25–2.11				

Abbreviations: PSI, patient safety indicator; OR, odds ratio; CI, confidence interval.

[a]Primary cluster refers to the risk factors common to black and white patients and significant in most hospital groups.

[b]Secondary cluster, race specific refers to the risk factors specific to blacks and not consistently significant across hospital groups.

[c]Secondary cluster, common refers to the risk factors common to black and white patients but significant in only 1 or 2 groups.

Table 3

Characteristics Associated With PSI7 Among Whites, by Hospital Groups.

	Group 1		Group 2		Group 3		Group 4	
Characteristics	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Primary cluster[a]								
Weight loss	2.73	2.33–3.19	2.97	2.62–3.37	3.34	2.70–4.13	3.15	2.39–4.15
Fluid and electrolyte disorder	1.56	1.43–1.72	1.79	1.66–1.94	1.40	1.21–1.61	1.47	1.22–1.77
Coagulopathy	1.58	1.34–1.86	2.20	1.95–2.48	1.46	1.11–1.93	1.69	1.20–2.36
Emergency admission	2.00	1.76–2.28	1.26	1.16–1.38	1.71	1.41–2.07	1.71	1.31–2.24
Medicare	1.43	1.25–1.64	1.30	1.17–1.45	1.51	1.23–1.84	2.38	1.78–3.20
Paralysis	1.63	1.30–2.06	1.82	1.52–2.17	1.72	1.24–2.39		
Congestive heart failure	1.46	1.29–1.65	1.25	1.11–1.40	1.45	1.19–1.78		
Secondary cluster, race specific[b]								
Blood loss	1.44	1.17–1.77	1.26	1.04–1.53				
Ulcer	3.57	1.14–11.21	3.30	1.23–8.88				
Diabetes with chronic complications	1.40	1.13–1.73						
Trauma admission			1.57	1.19–2.08				
Secondary cluster, common[c]								
Drug abuse	1.37	1.10–1.71	1.24	1.03–1.48				
Age	1.01	1.01–1.02	1.01	1.01–1.02				
Urgent admission	1.62	1.40–1.88			2.02	1.64–2.48		

Abbreviations: PSI, patient safety indicator; OR, odds ratio; CI, confidence interval.

[a]Primary cluster refers to the risk factors common to black and white patients and significant in most hospital groups.

[b]Secondary cluster, race specific refers to the risk factors specific to whites and not consistently significant across hospital groups.

[c]Secondary cluster, common refers to the risk factors common to black and white patients but significant in only 1 or 2 groups.