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Do hospitals provide lower quality of care to black patients for pneumonia?*

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Abstract

Objectives—Recent studies reported lower quality of care for black vs. white patients with community-acquired pneumonia and suggested that disparities persist at the individual hospital level. We examined racial differences in emergency department and intensive care unit care processes to determine whether differences persist after adjusting for case-mix and variation in care across hospitals.

Design—Prospective, observational cohort study.

Setting—Twenty-eight U.S. hospitals.

Patients—Patients with community-acquired pneumonia: 1738 white and 352 black patients.

Interventions—None.

Measurements—We compared care quality based on antibiotic receipt within 4 hrs and adherence to American Thoracic Society antibiotic guidelines, and intensity based on intensive care unit admission and mechanical ventilation use. Using random effects and generalized estimating equations models, we adjusted for case-mix and clustering of racial groups within hospitals and estimated odds ratios for differences in care within and across hospitals.

Main Results—Black patients were less likely to receive antibiotics within 4 hrs (odds ratio, 0.55; 95% confidence interval, 0.43–0.70; $p < .001$) and less likely to receive guideline-adherent antibiotics (odds ratio, 0.72; 95% confidence interval, 0.57–0.91; $p = .006$). These differences were attenuated after adjusting for casemix (odds ratio, 0.59; 95% confidence interval, 0.46–0.76 and 0.84; 95% confidence interval, 0.66–1.09). Within hospitals, black and white patients received similar care quality (odds ratio, 1; 95% confidence interval, 0.97–1.04 and 1; 95% confidence interval, 0.97–1.03). However, hospitals that served a greater proportion of black patients were less likely to provide timely antibiotics (odds ratio, 0.84; 95% confidence interval, 0.78–0.90). Black patients were more likely to receive mechanical ventilation (odds ratio, 1.57;

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95% confidence interval, 1.02–2.42; $p = .042$). Again, within hospitals, black and white subjects were equally likely to receive mechanical ventilation (odds ratio, 1; 95% confidence interval, .94–1.06) and hospitals that served a greater proportion of black patients were more likely to institute mechanical ventilation (odds ratio, 1.13; 95% confidence interval, 1.02–1.25).

Conclusions—Black patients appear to receive lower quality and higher intensity of care in crude analyses. However, these differences were explained by different case-mix and variation in care across hospitals. Within the same hospital, no racial differences in care were observed.

Keywords

race; disparities; quality of care; community-acquired pneumonia

Previous studies report that black patients compared to white patients receive lower quality of care for severe infections, such as community-acquired pneumonia (CAP) and sepsis (1–5), and that these disparities may persist at individual hospitals (3). Despite these recent efforts to understand racial disparities in pneumonia care, several issues remain unsolved.

First, there is no standard definition of quality of care. Examining only evidence-based processes of care as quality indicators does not necessarily capture “true” treatment quality, because other factors such as patient preferences may influence treatment (6). Depending on the process measure, we might draw different conclusions about treatment quality. For example, black patients with CAP are less likely to receive timely and guideline adherent antibiotics in the emergency department (ED) (1–3) but may be treated more intensely, as evidenced by a higher likelihood of receiving intensive care unit (ICU) services during hospitalization (7).

Second, black subjects reside in different neighborhoods and seek care at different hospitals (3). As suggested by disparity research in other fields (8, 9), racial disparities may be explained by variation in care among hospitals. Black patients often receive care at hospitals that provide lower quality of care, whereas within the same hospital, black and white patients are treated similarly. Statistical methods to account for within-center correlation and confounding attributable to variation in care across centers have been described (10, 11). Most previous studies examining care differences for pneumonia did not account for either of these effects (2–4), and a single study showed that black patients received lower quality of care despite accounting for these effects (5).

Third, it is unclear whether reported racial differences in process of care for CAP lead to disparities in outcomes, such as incidence of severe sepsis. Understanding the reasons for disparities is critical to direct quality-improvement initiatives and to control for differences when exploring mechanisms of disease and effects of treatment interventions. We therefore sought to examine racial differences in CAP treatment by evaluating processes of care in the ED and utilization of different therapeutic interventions in the ICU. We used a large observational cohort of CAP patients recruited from four geographic regions in the US with detailed individual-level measures of illness severity and used robust statistical methods to adjust for differences in case-mix, the confounding effect of variation in care among hospitals, and clustering of black and white patients within hospitals.

MATERIALS AND METHODS

Subjects and Study Design

We analyzed data from the Genetic and Inflammatory Markers of Sepsis (GenIMS) study (12). GenIMS is an inception cohort study of patients with CAP recruited from ED of 28 US academic and community hospitals in southwestern Pennsylvania, Connecticut,

southern Michigan, and western Tennessee. Eligible subjects were at least 18 yrs old with a clinical and radiologic diagnosis of CAP using the criteria of Fine et al (13). Exclusion criteria included transfer from another hospital, discharge from a hospital within the previous 10 days, diagnosis of pneumonia within the past 30 days, chronic dependency on mechanical ventilation, cystic fibrosis, active pulmonary tuberculosis, admission for palliative care, previous enrollment in the study, imprisonment, and pregnancy. Institutional Review Boards of all participating centers approved the study, and written informed consent was obtained from all subjects or their legal proxies. Of the 2320 subjects recruited, we limited our analyses to a subset of 2090 white and black subjects, excluding the remaining small number of subjects in other racial groups.

Clinical Characteristics and Outcomes

We prospectively collected detailed baseline and sequential clinical information by structured subject or proxy interviews, bedside assessment by study nurses, and from medical records. Patients or proxies chose race from among the categories used by U.S. Census Bureau (14). We classified subjects as insured if they had commercial health insurance, Medicare, or Medicaid coverage. We compared racial differences in quality of care in ED by assessing if initial antibiotic therapy was administered within 4 hrs based on Medicare quality-monitoring system criteria and if antibiotics were adherent to American Thoracic Society guidelines for the management of adults with CAP (15). To assess guideline adherence, we examined antibiotic use in the first 24 hrs of hospital admission and used the 2001 guidelines in place at the time of the study. We used strict criteria for guideline adherence, similar to a previous study (16).

We compared care processes in the ICU by examining racial differences in ICU admission and utilization of ICU therapies, such as mechanical ventilation and pulmonary artery catheterization. In addition, we also compared frequency of “do not resuscitate” directives before and during hospital admission. To adjust for case-mix, we assessed comorbidity with the Charlson comorbidity score (17) and severity of illness on presentation using the Pneumonia Severity Index (PSI) (13). For outcomes, we compared risk for severe sepsis and 1-yr mortality. We defined severe sepsis as pneumonia with acute organ dysfunction following the 2001 International Consensus Criteria (18). We ascertained mortality over 1 yr by National Death Index search. GenIMS was conducted from 2001 to 2003, data collection was completed by 2004, and 1-yr survival data for all subjects were available in 2006.

Statistical Analyses

We conducted univariate comparisons using Fisher's exact, Wilcoxon rank-sum, or Kruskal-Wallis tests as appropriate. To compare processes of care in the ED, we adjusted for case-mix, including age, sex, insurance status, and Charlson and PSI scores.

We accounted for hospital effect (confounding because of variation in care among hospitals) and clustering (correlation within hospital) using generalized estimating equation and random effects logistic regression models. We used both models because generalized estimating equation accounts for clustering of racial groups within hospitals, whereas random effects models also allow for the inclusion of a random component related to the hospital. We used the decomposition approach for each model, as described previously (10, 11), and assessed the association between race and quality and intensity of care within and among hospitals. The within-center odds ratio (OR) measures the association between race and treatment quality conditional on center. The among-center OR reflects the impact of proportion of black patients at a hospital on treatment quality. Unless otherwise stated, we calculated among-center OR for every 10% increase in proportion of black patients. We used an exchangeable correlation structure and jackknife for covariance estimation in the

generalized estimating equation model and variance components covariance structure in the random effects model.

We used similar models for intensity of care and adjusted for age, sex, Charlson score, insurance, and differences in severity of illness using PSI scores. Because of racial differences in recruitment from different geographic regions, we repeated the analyses stratified by geographic region.

We used a logistic regression model to compare risk of severe sepsis and a Cox proportional hazards model to compare survival. We constructed these models by adjusting for age, sex, insurance, and Charlson score for susceptibility to severe sepsis and age, sex, insurance, PSI, and Charlson scores for 1-yr survival. All analyses were performed using SAS 9.1 (SAS Institute, Cary, NC) or Stata 10.0 (StataCorp, College Station, TX), defining statistical significance at $p < .05$. OR and hazard ratios are presented with 95% confidence intervals (CIs).

RESULTS

Clinical Characteristics

Of the 2090 subjects included in our analyses, 1738 (83.2%) were white and 352 (16.8%) were black (Table 1). White subjects were older than black subjects (mean age, 68 vs. 53 yrs; $p < .001$) and had a higher burden of comorbid conditions (69.2% of white subjects had a Charlson score of ≥ 1 compared to 63.1% of black subjects; $p = .028$). In particular, respiratory disease and cardiovascular disease were more prevalent among white subjects, whereas chronic kidney disease and acquired immune deficiency syndrome were more frequent among black subjects. White subjects were approximately twice as likely as black subjects to have had previous influenza (53.7% vs. 27.5%; $p < .001$) or pneumococcal (52.3% vs. 23.1%; $p < .001$) vaccinations. Most subjects had health insurance, although black patients were less likely to be insured than white patients (85.5% vs. 96.5%; $p < .001$). Although few subjects had a do not resuscitate directive before hospitalization, they were more common among white subjects (white 6.7% vs. black subjects, 1.1%; $p < .001$). Symptoms were present for a shorter duration in white subjects than in black subjects before presentation to ED (4.8 vs. 5.4 days; $p = .002$), but both groups were equally likely to have been treated with antibiotics before presentation (17.6% white vs. 14.5% black subjects; $p = .163$).

On ED presentation, white subjects had higher PSI (97.7 vs. 78.6; $p < .001$) and Acute Physiology and Chronic Health Evaluation III scores (53.9 vs. 47.4; $p < .001$) compared to black subjects. This was mainly because white subjects were older and had a higher burden of comorbid conditions. After evaluation in the ED, 262 (12.5%) subjects were discharged home and 1828 (87.5%) were admitted. There were no racial differences in the frequency of hospital admission (84.9% vs. 88.0% for black and white subjects; $p = .133$).

Approximately half of all subjects were recruited from large (bed size ≥ 250) hospitals and teaching hospitals. Black subjects were mainly recruited from ED of large teaching hospitals (87.5% of black vs. 46.4% of white subjects; $p < .001$), and nearly two-thirds of all black subjects were enrolled in Michigan, Tennessee, and Connecticut. The average proportion of black subjects per hospital was 24% (range, 0%–89%). In contrast, white subjects were more likely to be recruited from small (bed size < 250) nonteaching hospitals, and the majority of white subjects were enrolled in Pennsylvania.

Quality of Care

Black subjects were less likely to receive antibiotics within 4 hrs (OR, 0.55; 95% CI, 0.43–0.70; $p < .001$) and to receive guideline concordant antimicrobial therapy (OR, 0.72; 95% CI, .57–.91; $p = .006$) (Tables 2 and 3, Fig. 1). The difference in antibiotic timing remained unchanged when adjusted for case-mix (adjusted OR, 0.59; 95% CI, 0.46–0.76; $p < .001$). Within hospitals, black and white patients received similar care in both random effects and generalized estimating equation models (OR, 1.00; 95% CI, 0.97–1.04 and 1.00; 95% CI, 0.98–1.03) (Table 3). Differences in care were largely explained by variation in care among hospitals. Hospitals that provided care for a greater proportion of black subjects were less likely to provide timely antibiotics in both models (OR, 0.84; 95% CI, 0.78–0.90; $p < .001$ and OR, 0.84; 95% CI, 0.80–0.88; $p < .001$ for every 10% increase in proportion of black patients) (Table 3). Furthermore, these differences were striking when hospitals that had the largest proportion of black patients (>80%) were compared to hospitals without any black patients (OR, 0.21; 95% CI, 0.11–0.41; Fig. 1).

Racial differences in guideline-adherent use of antibiotics were largely explained by case-mix (OR, 0.84; 95% CI, 0.66–1.09; $p = .188$), although accounting for differences in clustering using generalized estimating equation or random effects models further attenuated the OR (among-center OR, 0.98; 95% CI, 0.91–1.06; $p = .610$ and OR, 0.98; 95% CI, 0.90–1.07; $p = .685$; among-center OR, 0.85; 95% CI, 0.39–1.86 for comparing hospitals with the highest proportion of black patients to hospitals without any black patients) (Table 3, Fig. 1).

Among hospitalized subjects, 16.2% ($n = 296$) were admitted to the ICU and 6.9% ($n = 118$) received mechanical ventilation. One-fourth of those admitted to the ICU were admitted from the ED. In contrast to processes of care in the ED, treatment intensity was similar or higher in black subjects. Although no difference was seen in overall frequency of ICU admission between hospitalized black and white subjects (17.1% vs. 16.0%; $p = .66$), black patients with PSI classes IV and V were more frequently admitted to the ICU compared to white patients with similar PSI scores (37.2% vs. 20.9%; $p < .001$). Black and white subjects were equally likely to be admitted to the ICU (unadjusted OR, 1.08; 95% CI, 0.77–1.50; $p = .657$ and case-mix adjusted OR, 1.09; 9% CI, 0.76–1.58; $p = .637$). These ORs were further attenuated after additionally adjusting for racial clustering among hospitals (among-center OR, 1.07; 95% CI, 0.95–1.20; $p = .246$ in random effects model). Mechanical ventilation use was slightly higher in black compared to white subjects among all hospitalized subjects (9.7% vs. 6.4%; $p = .04$), subjects admitted to the ICU (52.9% vs. 37.1%; $p = .042$), and subjects with severe pneumonia (PSI class IV and V; 21.6% vs. 8.7%; $p = .001$). Among all hospitalized, a trend toward higher use of mechanical ventilation among black subjects persisted when adjusted for casemix (adjusted OR, 1.58; 95% CI, 0.97–2.57; $p = .067$). After additional adjusting for confounding attributable to center and clustering within center, hospitals that provided care to a greater proportion of black patients were more likely to initiate mechanical ventilation, but no differences were seen within the same hospital (among-center OR, 1.13; 95% CI, 1.02–1.25; $p = .017$ using random effects model; among-center OR, 2.97; 95% CI, 1.22–7.27 for comparing hospitals with the highest proportion of black patients to hospitals without any black patients) (Table 3, Fig. 1).

For patients in the ICU, pulmonary artery catheter use was infrequent (7.8%; $n = 23$). Black subjects were more likely to receive pulmonary artery catheters, but results were not statistically significant (11.8% vs. 6.9%; $p = .25$). Finally, the frequencies of a do not resuscitate directive (2.0% vs. 4.0%; $p = .10$) and initiation of comfort measures (1.7% vs. 2.9%; $p = .28$) were similar between all hospitalized black and white subjects.

Additional analyses of a subset of the five hospitals that recruited the highest numbers of black subjects from Michigan, Tennessee, and Connecticut confirmed our overall finding of

similar quality of care in the ED for black and white subjects within hospitals, but lower quality of care (antibiotic timing) in hospitals treating a higher proportion of black patients (among-center OR using random effects models after adjusting for case-mix and clustering within hospitals were 0.73; 95% CI, 0.56–0.95; $p = .019$ and 0.74, 95% CI, 0.49–1.12; $p = .155$ for antibiotic timing and guideline-adherence, respectively). Stratified analyses by states (Pennsylvania, Connecticut, and Michigan) did not change the overall OR (data not shown).

Results did not change after we added cluster characteristics like hospital bed size or excluded three hospitals that recruited 35% of all black subjects and had well below average performance scores on antibiotic timing and adherence (among center OR using random effects models, 0.83; 95% CI, 0.73–0.94; $p = .003$ and 0.97; 95% CI, 0.84–1.11; $p = .628$ for antibiotic timing and adherence).

Severe Sepsis and Survival

Severe sepsis occurred in 573 (27.4%) subjects. Black subjects had a lower risk of severe sepsis compared to white subjects (21.6% vs. 28.6%; unadjusted OR, 0.69; 95% CI, 0.52–0.90; $p = .007$) (Table 4). When adjusted for age, sex, insurance, and Charlson score, results were no longer statistically significant (adjusted OR, 1.02; $p = .89$). Furthermore, the incidence of respiratory, cardiac, neurologic, coagulation, and liver dysfunction did not differ between groups. Black subjects were less likely to have renal dysfunction compared to white subjects (Table 3), but again this difference disappeared adjusting for case-mix (adjusted OR, 1.05; 95% CI, 0.71–1.56; $p = .80$). The risk of death was lower for black compared to white subjects over 1 yr (hazard ratio, .66; 95% CI, .49–.89; $p = .007$), but no difference was observed in adjusted analysis (adjusted hazard ratio, 1.22; 95% CI, 0.89–1.70; $p = .22$).

DISCUSSION

In crude comparisons, black subjects in our cohort received lower quality of CAP care than white subjects. These differences were attributable to differences in case-mix and variation in the quality of care among hospitals. In general, black patients were more likely to receive care at hospitals that provided lower quality of care, regardless of race. In contrast, hospitals that served a higher proportion of black patients in general provided higher intensity of care regardless of race, illustrated by higher use of mechanical ventilation. Our findings underscore the importance to carefully understand differences in case-mix, control for within-hospital vs. among-hospital differences, and to consider multiple dimensions of care processes when examining racial differences in quality of care for CAP.

The attenuation of differences in administration of guideline-adherent antibiotics between black and white subjects after adjusting for case-mix is consistent with other studies assessing quality of care after surgery (8) and for acute myocardial infarction (9). Although antibiotic administration should adhere to guidelines irrespective of CAP severity, care decisions are often based on clinical appearance (19).

We found that different clustering of black and white subjects among hospitals is likely to confound racial differences in processes of care, and black subjects were more likely to receive care at hospitals that provided overall lower quality of care. This is in contrast with a recent study suggesting that disparities are likely to persist at the individual hospital level (3). We cannot exclude that socioeconomic variables, other than insurance status, such as income and educational status, may account for this residual association. Furthermore, among-center ORs were fairly wide, and further studies of hospitals treating greater proportions of black patients may be necessary. Specific interventions targeted to overall

low-performance hospitals, such as improving nurse staffing, reducing triage time in the ED, and educational efforts, may reduce these disparities (20–22).

There is ongoing debate about the best quality of care indicators for CAP (23–25). We chose timing of initial antibiotics and adherence to American Thoracic Society guidelines because they are widely used, currently recommended by different organizations, including the Centers for Medicare and Medicaid Services (26), and associated with survival in observational studies (27, 28). In addition to ED care processes, we also compared treatment intensity because these care processes may better-capture overall treatment quality. Examining only antibiotic timing and guideline adherence in the ED suggests that hospitals that treat higher proportions of black subjects provide poorer quality of care to black and white patients with similar case-mix. In contrast, these hospitals tend to provide higher intensity of care to black and white patients with similar case-mix and illness severity. Thus, a comprehensive evaluation of different dimensions of care provides a broader understanding of racial differences in overall treatment quality.

Several reasons could explain lack of effect on short-term and long-term outcomes despite differences in care processes. First, care processes in the ED and ICU examined in our study could have a small or no effect on outcomes, as previously suggested (21). Second, any adverse effect on outcomes caused by delayed administration of antibiotics or nonadherence to guidelines could dissipate with higher treatment intensity in other facets of care.

We observed differences in case-mix between black and white subjects presenting to the ED. White subjects had higher PSI and Acute Physiology and Chronic Health Evaluation III scores mainly because they were older and had a higher burden of chronic conditions. This finding could have occurred because of selection bias at initial study enrollment. We did not have racial information of patients who refused to participate in the study. However, recent data suggest racial minorities and non-Hispanic whites in the United States are equally willing to participate in health research (29). In addition, higher illness severity among white subjects presenting to the ED with infection and sepsis has also been reported in a previous population-based study of severe sepsis (1). Black patients presented slightly later to the ED than white patients after symptom onset, but antibiotic therapy before ED presentation was similar in both groups. Thus, biological differences in the host response to infection may exist between racial groups and warrant further investigation.

In summary, previously described racial differences in quality of care for CAP in the ED were largely explained by differences in case-mix and the fact that black subjects seek care at hospitals that are less likely to comply with initial treatment guidelines. After accounting for these among-hospital differences, black and white subjects with similar illness severity received similar care in the ED. In contrast, hospitals serving higher proportions of black subjects provide higher intensity of care, but within the same hospital black and white subjects receive similar intensity of care. Hence, racial disparities occur at the hospital level, but within individual institutions black and white patients are treated equally. Policy interventions directed at hospitals that provide care to large number of black patients seem most promising to reduce racial disparities for CAP. In addition, assessing different dimensions of care quality and accounting for differences in case-mix and variation in care among hospitals may improve understanding of racial differences in care for CAP.

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Figure 1.

Odds ratios (OR) and 95% confidence intervals of different care processes in the (A) emergency department and (B) intensive care unit (ICU) in black compared to white subjects. The OR are estimated in three models: an unadjusted model, a model adjusting for case-mix, and a model adjusting for case-mix and different clustering of black and white subjects among hospitals using random effects. For case-mix adjustment for all quality and intensity measures, we adjusted for age, sex, insurance status, and Charlson and pneumonia severity score scores. The among-center OR reflects differences in treatment among hospitals serving the lowest and highest proportion of black patients (hospitals with >80% black patients compared to those with no black patients).

Table 1Patient and hospital characteristics for all subjects and stratified by race^a

Variable	All Subjects, n = 2090	White Subjects, n = 1738	Black Subjects, n = 352	<i>p</i>
Demographics				
Age, mean (sd)	65 (18)	68 (17)	53 (16)	<.001
Sex, male, n (%)	1085 (51.9)	919 (52.9)	166 (47.2)	.054
Health insurance ^b , n (%)	1978 (94.6)	1677 (96.5)	301 (85.5)	<.001
Health behaviors				
Ever smoked, n (%)	1365 (65.3)	1135 (65.3)	230 (65.3)	1.000
Years smoked, mean (sd)	13.0 (23.1)	13.7 (23.6)	9.8 (19.7)	.020
Chronic health conditions ^c				
Charlson comorbidity score >0, n (%)	1425 (68.2)	1203 (69.2)	222 (63.1)	.28
Respiratory disease, n (%)	734 (35.1)	623 (35.9)	111 (31.5)	.126
Cardiac disease, n (%)	503 (27.3)	453 (29.8)	50 (15.6)	<.001
Chronic kidney disease, n (%)	49 (2.3)	27 (1.6)	22 (6.3)	<.001
Diabetes, n (%)	396 (19.0)	332 (19.1)	64 (18.2)	.765
Neoplastic disease, n (%)	125 (7.2)	111 (7.7)	14 (4.6)	.066
Acquired immunodeficiency syndrome, n (%)	33 (1.6)	12 (0.7)	21 (6.0)	<.001
Do not resuscitate directive before admission, n (%)	120 (5.7)	116 (6.7)	4 (1.1)	<.001
Vaccination status				
Influenza vaccine in preceding 8 mos, n (%)	787 (48.8)	705 (53.7)	8 (27.5)	<.001
Pneumococcal vaccine, n (%)	748 (46.9)	680 (52.3)	68 (23.1)	<.001
Symptoms and therapy before hospitalization				
Duration, mean (sd)	4.9 (7.3)	4.8 (7.2)	5.4 (7.4)	.002
Received antibiotics within seven days of hospital admission, n (%)	357 (17.1)	306 (17.6)	51 (14.5)	.163
Hospital characteristics				
Teaching hospital	1113 (53.3)	806 (46.4)	307 (87.5)	<.001
Bed size n (%)				
<100 beds	52 (2.5)	52 (3.0)	0 (0.0)	<.001 ^d
100–249 beds	916 (43.8)	791 (45.5)	125 (35.5)	
250–499 beds	808 (38.7)	713 (41.0)	95 (27.0)	
>500 beds	314 (15.0)	182 (10.5)	132 (37.5)	

^aData were missing for <5% of the cohort for most variables;^bincludes subjects with Medicare, Medicaid, or commercial health insurance;^cchronic health conditions based on subject or proxy report and review of medication inventory. Cardiac disease was defined as a history of coronary artery disease, myocardial infarction, coronary artery bypass graft surgery, or coronary artery stent placement. Chronic kidney disease was defined as need for dialysis, glomerular filtration rate <60 mL/min/m², based on the modification of diet in renal disease equation and the last available creatinine (30);^d*p* value compares bedsize <250 and >250.

Table 2

Racial differences in emergency department processes of care and intensive care unit treatment intensity

Care Processes	White Subjects, n = 1738	Black Subjects, n = 352	p
Emergency department			
Antibiotics adherent to American Thoracic Society guidelines, n (%)	1150 (66.2)	206 (58.5)	.006
Received antibiotics within 4 hrs, n (%)	1297 (74.6)	217 (61.7)	<.001
Treatment intensity ^a			
Admitted to ICU, n (%)	245 (16.0)	51 (17.1)	.657
Interventions in ICU, n (%)			
Mechanical ventilation	91 (37.1)	27 (52.9)	.042
Pulmonary artery catheter	17 (6.9%)	6 (11.8%)	.252

ICU, intensive care unit.

^a Comparing admission to ICU among hospitalized patients and includes 1529 white and 299 black subjects.

Table 3

Racial differences in risk of severe sepsis and organ dysfunction

Variable	White Subjects	Black Subjects	<i>p</i>
Risk of severe sepsis, n (%)	497 (28.6)	76 (21.6)	.007
Organ dysfunction			
Respiratory	270 (15.5)	53 (15.1)	.872
Cardiac	60 (3.5)	15 (4.3)	.434
Renal	285 (16.4)	40 (11.4)	.019
Liver	9 (0.5)	3 (0.9)	.437
Neurologic	91 (5.2)	20 (5.7)	.697
Coagulation	23 (1.3)	1 (0.3)	.106

Data presented as unadjusted odds ratios (OR) and OR after adjusting for case-mix, and case-mix and center effect. Adjusting for center effect yielded two separate OR, a within-center and among-center component.

Table 4

Black and white subjects receiving equal quality and intensity of care

Variable	Unadjusted	Adjusted for Case-Mix	Adjusted for Case-Mix and Center Effect Using RE Model		Adjusting for Case-Mix and Center Effect Using GEE Model	
			Within-Center	Among-Center ^b	Within-Center	Among-Center ^b
Antibiotic receipt within 4 hrs	.55 (.43–.70) ^e	.59 (.46–.76) ^e	1.00 (.97–1.04)	.84 (.78–.90) ^e	1.00 (.98–1.03)	.84 (.80–.88) ^e
Guideline-adherent antibiotics	.72 (.57–.91) ^d	.84 (.66–1.09)	1.00 (.97–1.03)	.98 (.90–1.07)	1.00 (.97–1.03)	.98 (.91–1.06)
ICU admission ^a	1.08 (.77–1.50)	1.09 (.76–1.58)	1.01 (.97–1.06)	1.07 (.95–1.20)	1.01 (.95–1.07)	1.08 (.95–1.22)
Mechanical ventilation ^a	1.57 (1.02–2.42) ^c	1.58 (.97–2.57)	1.00 (.94–1.06)	1.13 (1.02–1.25) ^c	1.00 (.90–1.10)	1.12 (.96–1.33)

RE, random effects; GEE, generalized estimating equation. ICU, intensive care unit; OR, odds ratio.

^aDetermined in a subset of 299 black and 1529 white patients admitted to hospital;^bthe among-center OR reflects the impact of an 10% increase in the proportion of black subjects at a hospital on treatment quality or intensity;^c $p < .05$;^d $p < .01$;^e $p < .001$.