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Burden of present-on-admission infections and healthcare-associated infections by race and ethnicity

Christie Y. Jeon, ScD,
Department of Medicine, Cedars-Sinai Medical Center, 8700 Beverly Blvd. Los Angeles, CA 90048 christie.jeon@cshs.org

Peter Muennig, PhD,
Department of Health Policy and Management, Mailman School of Public Health, Columbia University, 722 West 168th Street, New York, NY 10032. pm124@columbia.edu

E. Yoko Furuya, MD MS,
Department of Medicine, Division of Infectious Diseases, 630 West 168th Street, Box 82 New York, NY 10032. eyf2002@columbia.edu

Bevin Cohen, MS,
Columbia University School of Nursing, Georgian Building, 617 W. 168th St. New York 10032. bac2116@columbia.edu

Denis Nash, PhD, and
CUNY School of Public Health at Hunter College, Hunter College Campus 2180 Third Ave, New York, NY 10035 New York, NY. dnash@hunter.cuny.edu

Elaine L. Larson, RN, PhD
Columbia University School of Nursing, Georgian Building, 617 W. 168th St. New York 10032. ell23@columbia.edu

Abstract

Background—In the U.S., incidence of sepsis and pneumonia differ by race, but it is unclear whether this is due to intrinsic factors or healthcare factors.

Methods—We conducted a study of 52,006 patients hospitalized in 2006-2008 at a referral hospital in upper Manhattan. We examined how the prevalence of present-on-admission and healthcare-associated infection compared between non-Hispanic Blacks, Hispanics, and non-Hispanic Whites adjusting for socio-demographic factors, admission through the emergency room (ER), and co-morbid conditions.

Corresponding author: Christie Y. Jeon ScD Department of Medicine Cedars-Sinai Medical Center 8700 Beverly Blvd. Los Angeles, CA 90048 christie.jeon@cshs.org Phone: 310 423 6345.

Results—Non-Hispanic Blacks had 1.59 [95% confidence interval (CI): 1.29-1.96] and 1.55 [95%CI: 1.35-1.77]-fold risk of community-acquired BSIs and UTI as compared to non-Hispanic Whites. Hispanic patients had 1.31 [95%CI: 1.15-1.49]-fold risk of presenting with community-acquired UTIs compared to non-Hispanic Whites. Controlling for admission through the ER, comorbidity and neighborhood income attenuated the differences in prevalence of infections.

Conclusion—In conclusion, we found that health disparities in present-on-admission infections may be largely explained by potential lack of ambulatory care, socioeconomic factors and comorbidity.

Keywords

health inequality; present-on-admission factors; race and ethnicity; healthcare-associated infections; community-acquired infections

In the U.S., incidence of sepsis and pneumonia differ by race, with Blacks experiencing 1.25 to 2.4 times higher infection rates as compared to Whites (1-4). Understanding the multi-factorial causes of this disparity and its influence on the source and types of infections would better inform how to reduce the excess burden of infection. Part of the disparity in infections could be attributed to differences in the prevalence of pre-existing comorbidities (2, 5). For example, Blacks are more likely to develop sepsis because of underlying infection burden as well as organ dysfunction (4). Vulnerability to chronic conditions are affected by repeated exposure to stressors (6), as well as quality and access to care for these comorbidities (7) that are influenced the larger socioeconomic context. However, socioeconomic factors are only partly to be blamed as racial disparities in bacteremic pneumonia persisted even after adjustment for socio-demographic factors, including poverty level (1). Still others point to genetic differences in immune function for variability in predisposition to infections (8).

While previous studies have reported high rates of sepsis in Blacks, and highlight a few important mechanisms by which the disparity may occur, they did not simultaneously consider the influence of socio-demographic, co-morbid and healthcare-associated factors. Furthermore, there has been no attempt to distinguish whether the infections occurred in the community or in the healthcare-setting. Differences in present-on-admission infection rates would call for better community-based prevention efforts, prevention through ambulatory care, culturally sensitive interventions and lifestyle modifications, while differences in healthcare-associated infections would call for better management of inpatients in hospital settings. Previous studies on infection rates by race and ethnicity also lacked data on Hispanics (1, 2, 4), who now comprise the largest minority ethnic group in the U.S.

In this study we compared rates of present-on-admission and healthcare-associated infections and described related demographic, clinical and procedural factors by race and ethnicity, including Hispanics. Then we assessed if any apparent disparities in community-acquired infections are explained by referral through the emergency room, and other factors present-on-admission. Further, we examined if any apparent disparity in healthcare-associated infections are explained by present-on-admission and in-hospital factors.

Methods

Study setting and patient population

We conducted a retrospective study of patients who were discharged from January 2006 to December 2008 from a tertiary referral hospital in upper Manhattan. We extracted data from: the Clinical Data Warehouse that integrates information from over 20 clinical electronic sources; the admission, discharge, transfer system; and the computerized physician and nursing order entry system. Detailed description of the methods for integration of data have previously been published (9).

Case definition

We examined racial and ethnic differences in three common types of infections: bloodstream infections (BSI), urinary tract infections (UTI) and pneumonia. Patients who develop an infection within 48 hours of admission are considered to have acquired it prior to admission (10). As 48 hours could span over 3 days, we defined an infection for which the culture was collected within the first 3 days of admission as community-acquired, while infections that occurred thereafter were defined as healthcare-associated. We excluded people who had been hospitalized within 7 days prior to admission and those who transferred from other medical facilities, as they likely would not have community-acquired infection and the timing of infection from admission to a medical facility to infection onset could not be established. We followed infection algorithms recommended by CDC's National Healthcare Safety Network (NHSN) (10) and modified the definitions where clinical symptoms were indicated, as data on symptoms were not systematically collected in the electronic medical record system.

BSI was defined as infections that were: 1) confirmed with a positive blood culture for any bacterial pathogen; and 2) that had no positive culture with the same organism at other body sites within 14 days prior to positive blood culture. An infection with a common skin contaminant (e.g., coagulase negative staphylococci) was counted as a case if 2 or more blood cultures drawn on separate occasions within 2 days of each other were positive.

UTI was defined as infections presenting with a positive urine culture as follows either: 1) $>10^5$ colony forming units per milliliter of urine and no more than one other species of microorganism; *or* 2) 10^3-10^5 colony forming units per milliliter of urine and no more than one other species of microorganism, accompanied by pyuria within two days of positive culture.

We defined pneumonia as cases with one or more positive respiratory cultures and a discharge diagnosis of pneumonia, which includes a set of 62 ICD-9 codes indicative of pneumonia. Time to infection was determined by the day of culture collection for each type of infection.

Demographic, clinical and procedural data

We obtained information on potential confounders including age, sex, race/ethnicity, ICD-9-CM diagnoses, ICD-9-CM procedures, ICU stay, admission through the ER, primary payer

status, month and year of discharge, length of stay and mortality from the ADT system. Race and ethnicity was categorized as non-Hispanic White, non-Hispanic Black, Hispanic, 'Other' or missing. Patients categorized as 'other' included those who were identified in the system as 'other (not specified)', 'Asian', 'Pacific Islander' 'Indian', 'Native Indian' or 'Multi-racial'. ICD-9-CM diagnoses of interest included diabetes, renal failure, malignancy, transplant history, substance abuse, and chronic dermatitis that were present on admission. We computed the Charlson index of comorbidity, which has been validated to predict 10-year mortality with each unit of increase in score, using ICD-9-CM codes to determine the extent of illness evident at admission (11). Procedures associated with infections included mechanical ventilation, vascular procedures (cardiac catheterization, angiography, angioplasty, stent), central venous catheterization and urinary catheterization. Duration of central venous and urinary catheterization was determined from information available in the physicians' order sheets. Primary payers of hospital charges were categorized as Medicaid or non-Medicaid among those who were less than 65 years of age, and categorized as 'Medicare only', 'Medicare and supplemental insurance', or 'no Medicare' among those 65 years or older. Socioeconomic status was determined by neighborhood median household income based on zip-code level data from the 2000 U.S. Census.

Statistical analysis

We described the characteristics of non-Hispanic White, non-Hispanic Black, and Hispanic patients, as well as those of 'other' race and those missing racial identity by summarizing the frequencies and percentage of categorical variables and the mean and standard deviation of continuous variables. Differences in continuous variables by race and ethnicity categories were tested by Kruskal-Wallis test and differences in categorical variables were tested by Chi-squared tests. We examined the association between race and ethnicity, and community-acquired infections via logistic regression, adjusting for age, sex, distance to the hospital, year and month of discharge. Age, sex, distance to the hospital and year and month of discharge were specified as confounders *a priori* as we were interested in contributors to disparity present, independent of these factors. Odds ratios were interpreted as relative risks as the occurrence of the outcomes was less than 5%. Where a statistically significant difference in infection prevalence by race/ethnicity was detected, we examined potential contributors to the disparity by evaluating the association between race and ethnicity and community-acquired infections further adjusting for 1) median neighborhood household income, 2) primary payer, 3) present-on-admission comorbid factors, and 4) admission through the ER. Present-on-admission comorbid factors included diabetes, renal failure, malignancy, transplant history, substance abuse, chronic dermatitis and Charlson score. The change in regression coefficients (log of odds ratio) were used to determine how much variability in community-acquired infection by race/ethnicity could be explained by the above-mentioned factors.

We examined the association of race and ethnicity with healthcare-associated infections independent of age, sex, distance to the hospital and year and month of discharge by Cox proportional hazard model, using days since admission as the scale of time. Where a statistically significant difference in hazard of infection was detected, we examined potential contributors to the disparity by evaluating the association between race and ethnicity and

healthcare-associated infections adjusting for 1) median household income, 2) primary payer, 3) comorbid factors, 4) admission through the ER, and 5) indwelling devices (i.e. central venous line, vascular catheter, urinary catheter, and mechanical ventilation). To test for proportionality of hazards, we tested for interaction of log-transformed time with race/ethnicity and all other potential confounders and included significant interaction terms in the multivariate model. The percent change in regression coefficients (log of hazard ratio (HR)) was used to determine how much variability in community-acquired infection by race/ethnicity could be explained by the above-mentioned factors. Statistically significant associations were evaluated at a P-value of ≤0.05 and all analyses were conducted in SAS Version 9.2 (SAS Institute, Cary, NC).

Results

Study Population

There were 60,994 patients seen in the adult tertiary care hospital from January 2006 to December of 2008. After excluding 748 patients lacking neighborhood household income data and 8,345 patients who had transferred from other medical facilities or were previously hospitalized within 7 days, the final analytic sample was 52,006 patients. Of these, non-Hispanic Whites, non-Hispanic Blacks, Hispanics, 'other' and those with unspecified race comprised 42%, 18%, 25%, 5.9% and 9.4% of the study population, respectively. The electronic medical records lacked data on the specific ethnicities of Hispanics; in 2007, Puerto Ricans and Dominican Republicans comprised the largest ethnic groups among Hispanics in New York City (12). The non-Hispanic Whites were older than all other categories of race/ethnicity (mean age: 60 vs. 55 vs. 55 vs. 56 vs. 55 years, $p<0.0001$). Half of the study population was male, but this sex distribution varied by race-ethnic status, with a higher proportion of males among non-Hispanic Whites compared to all others ($p<0.0001$).

Non-Hispanic Blacks and Hispanics (relative to non-Hispanic Whites) lived closer to the hospital ($p<0.0001$), came from a lower median neighborhood household income ($p<0.0001$), were more likely to have Medicaid membership and ($p<0.0001$), were more likely to be seen in the emergency room first ($p<0.0001$), have higher prevalence of diabetes and renal failure ($p<0.0001$), lower prevalence of transplant history and malignancy ($p<0.0001$ for both), fewer operations ($p<0.0001$) and lower rates of certain invasive procedures ($p<0.0001$ for central venous line, urinary catheter and vascular catheter). See Table 1.

Associations of race and ethnicity with community-acquired infections

In our study population, 816, 2235, and 280 patients presented with community-acquired BSIs, UTIs and pneumonia respectively at admission. Adjusting for age, sex, distance to the hospital and month and year of discharge Non-Hispanic Blacks had 1.59-fold higher risk of presenting with community-acquired BSIs and 1.55-fold higher risk of presenting with community-acquired UTI as compared to non-Hispanic Whites. Hispanic patients had 1.31-fold risk of presenting with community-acquired UTIs compared to non-Hispanic Whites. There was no statistically significant difference in prevalence of pneumonia by race and

ethnic categories. (Table 2) Other factors associated with a higher likelihood of community-acquired BSIs included median neighborhood income of ≤ $75,000, diabetes, renal failure, malignancy, transplant history, chronic dermatitis, higher Charlson score and admission through the ER. Similarly, factors associated with a higher likelihood of community-acquired UTIs included median neighborhood income of ≤75,000, membership in Medicaid or Medicare Part A only, diabetes, renal failure, transplant history, chronic dermatitis, higher Charlson score and admission through the ER. (Table 2)

Controlling for other present-on-admission factors attenuated the differences in prevalence of infections to varying degrees (Table 3). Of note, adjusting for admission through the ER led to the greatest attenuation in the relationship between race/ethnicity and community acquired BSIs and UTIs to null associations. The second highest contributing factor was comorbidity (including diabetes, renal failure, malignancy, transplant history, substance abuse, chronic dermatitis, and Charlson score), which collectively explained 26-42% of the disparity between non-Hispanic Blacks and non-Hispanic Whites and 19% of the disparity in between Hispanics and non-Hispanic Whites. Median neighborhood household income also contributed substantially accounting for 20-27% of the apparent disparity (Table 3).

Associations of race and ethnicity with healthcare-associated infections

Of those who were admitted to the hospital without community-acquired infection and stayed in the hospital for longer than 3 days, 506, 1026, and 4284 patients developed healthcare-associated BSIs, UTIs and pneumonia, respectively. Adjusting for age, sex, distance to the hospital and month and year of discharge, an elevated hazard of healthcare-associated BSI was apparent among non-Hispanic Blacks compared to non-Hispanic Whites (HR = 1.31 (1.02, 1.69)). When modeling the hazard of UTI, the interaction between time and race-ethnicity was significant. The estimated HR at baseline was significantly greater than 1, similar to trends observed in community-acquired UTI, Table 2. However, the ratio estimated for the interaction term with time was less than 1, which indicates that the difference in occurrence of UTI by race categories that was evident at admission (time = 0) decreased with increasing time. There was no statistically significant difference in hazard of pneumonia by race and ethnic categories. (Table 4) Other factors associated with healthcare-associated BSIs include Medicaid membership, renal failure, malignancy, higher Charlson index, admission through the ER, urinary catheterization and central venous line catheterization.

Controlling for admission through the ER, primary payer and comorbidity attenuated the differences in hazard of infections between non-Hispanic Blacks and Whites by 17%, 15%, and 13% respectively. (Table 5) Controlling for in-dwelling devices did not account for the difference, but rather further strengthened the relationship between non-Hispanic black ethnicity and healthcare-associated infection (increased the magnitude of coefficient). When all variables were adjusted for, non-Hispanic Blacks patients were not at significantly higher risk for healthcare-associated BSIs (HR = 1.14 (exponent of 0.135), (0.87, 1.51)) (Table 5).

Associations of race and ethnicity with admission through the ER

In order to determine factors that influenced racially disparate patterns of admission through the ER, we investigated how controlling for primary payer, median neighborhood household income, and comorbid factors changed the coefficient of association between race/ethnicity and admission through the ER. Adjusting for age, sex, distance to the hospital and month and year of discharge, non-Hispanic Blacks and Hispanics were more likely to be hospitalized through the emergency room compared to non-Hispanic Whites, (OR = 3.92 (3.67, 4.18); and OR = 3.28 (3.09, 3.49)). Collectively, neighborhood household income, primary payer and comorbidity explained 35% of the excess emergency room visits among non-Hispanic Blacks and 31% that of Hispanics; of these, neighborhood household income accounted for 23% of the disparity in non-Hispanic Blacks and 22% in Hispanics. After adjustment for all present-on-admission factors, Hispanic Blacks and Hispanics were still more likely to be hospitalized through the emergency room compared to non-Hispanic Whites, (OR = 2.44 (2.27, 2.62) for non-Hispanic Blacks; and OR = 2.26 (2.11, 2.42) for Hispanics)

Discussion

In this population of over 50,000 inpatients, we found that non-Hispanic Blacks were at slightly elevated risk of developing BSI throughout the hospital stay compared to non-Hispanic Whites. Could this have been influenced by differential treatment of Blacks in the hospitals? The data indicate that while non-Hispanic Blacks were less likely to receive indwelling devices, this had no bearing on the difference in incidence of infections. This association was partially reduced by adjustment for admission through the ER, suggesting that the emergency room could be a source of healthcare-associated infection, as had been previously hypothesized (13). The data also suggest that the relative hazard of UTI by race and ethnicity decreased over time, indicating that differences apparent toward the beginning of the admission disappeared as patients spent more time in the hospital. This further suggests that in this hospital setting differences in infection rates are likely driven by factors present prior to admission.

In addition to our findings for healthcare-associated BSI, we found greater prevalence of community-acquired BSI and UTI in non-Hispanic Blacks and Hispanics, as compared to non-Hispanic Whites after accounting for demographic and temporal factors. On the other hand we found no differences in the presence of community-acquired or healthcare-associated pneumonia by race or ethnicity. Previous studies on race and infection reported a similarly higher crude or age-adjusted rate of sepsis (4, 5) and overall infection rates (4) in African Americans compared to Whites. Our study adds to the current literature by demonstrating that apparent disparities in community-associated BSI and UTI can be explained in part by multiple present-on-admission factors, including admission through the ER, comorbid factors, and socioeconomic context. We also contribute to the discussion of health inequity by including the Hispanic population, who comprise the fastest growing minority group in the U.S.

Of potentially contributing factors, controlling for admission through the ER led to the greatest reduction in disparity in present-on-admission infections. Presentation to the

emergency room could reflect 1) a higher acuity of illness, 2) lack of ambulatory or primary care options and health insurance, or 3) norms surrounding appropriate sources of care (e.g., distrust of the healthcare system or concerns about immigration status). These factors are intrinsically linked. Inadequate access to ambulatory care may result in hospitalizations with severe infections due to suboptimal management of underlying disease. Poorly managed chronic diseases, such as renal failure, increase the risk of infection, as well as delay diagnosis and treatment, during which infections progress to severe levels. Indeed, racial disparities in hospitalizations for ambulatory care-sensitive conditions (14), use emergency room services and time to filling prescription (15) have been reported in the literature. However, these studies show that the differences persisted even after controlling for socioeconomic measures and insurance status. Disparate patterns of admission through the ER by race/ethnicity also remained in our study after controlling for socioeconomic status, indicating that other cultural or community-level factors also influence racial disparity in use of emergency room services.

In models that did not include admission through the ER, we found that comorbidity and socioeconomic context explained a substantial burden of the disparity in community-acquired BSI and UTI. The specific comorbid conditions that were present to a greater extent in non-Hispanic Blacks and Hispanic populations in our study were diabetes, renal failure, substance abuse and chronic dermatitis, which are known risk factors of infections (16-19). Household income levels are correlated with measures of crowding (20) that could elevate the exposure to and transmission of infectious agents. Disparities unexplained by measured comorbidity and socioeconomic context may also be influenced by differences in allostatic load, which affects the neuroendocrine and immune systems (6, 21). Allostatic load leads to a “resetting” of the body’s natural feedback systems which may result in an increased risk of chronic disease as well as an altered response (and susceptibility to immunological threats.

The strengths of our study include a large sample size of hospitalized adult population, with sufficient representation of non-Hispanic Blacks and Hispanics to be able to have 80% power to detect >20% difference between the racial groups for the most common infection (i.e. community-acquired UTI). The collection of data from multiple sources of electronic records allowed for control of multiple potential confounders, including demographic characteristics, insurance status, comorbid conditions, and in-hospital variables. The database also allowed us to distinguish between community-acquired and healthcare-associated infections and establishing the temporal order of administration of invasive procedures and infection events.

The use of existing electronic data also posed some limitations. First, we did not have access to systematic data on symptoms of infections, which could have led to under-reporting of cases. However, the use of laboratory culture data allowed for identification of bacterial infections specifically and enabled us to determine when the infection was suspected. Furthermore, it is unlikely that culture collection would have been influenced by race or ethnicity. Secondly, we lacked data on health behaviors, housing conditions, and individual income levels that could collectively influence one’s risk of community-acquired infection. In this regard, the fact that blatant disparities in infection disappeared with the adjustment of

variables suggests that the measured confounding variables accounted for differences in unmeasured positive confounders. Thirdly, as we had access to data from only hospitalized patients, our findings on community-acquired infection may not be generalizable to community-acquired infection events that do not require hospitalization. The absence of data on individual's access to ambulatory care services also prevented us from determining whether the differential referral through the emergency was due to lack of ambulatory options. Finally, as mentioned earlier, data on other racial or ethnic groups were relatively sparse and the specific ethnic identities of patients in this category were unclear.

In conclusion, we found greater prevalence of community-acquired BSI, and UTI in hospitalized non-Hispanic Blacks and Hispanics, as compared to non-Hispanic Whites. The differences were largely explained by multiple present-on-admission factors, admission through the ER, neighborhood income levels, and comorbid conditions. We also found higher incidence of healthcare-associated BSI in Hispanics which was attenuated with control for admission through the ER. The greater usage of emergency room among non-Hispanic Blacks and Hispanics could only be partially explained by socioeconomic context, primary payer and comorbid conditions.

Future direction

Our study points to the research needs for determining how to prevent excess hospitalizations with infections among minorities through enhanced ambulatory care. This study also points to the need for community-level policies that might enhance health and reduce health disparities. Intervention studies to improve health outcomes in the community have examined a number of social goods, such as income tax reduction (22), enhanced education (23-25), housing vouchers (26, 27), and conditional cash transfers (28-34). However, these studies have not produced consistent results on what social interventions are effective in improving health outcomes. Therefore, not only are more intervention studies on the non-medical determinants of health needed, but also new ways of effectively addressing differences in access to social goods in different racial and ethnic contexts.

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Highlights

- Blacks are hospitalized with bloodstream infections more often than Whites.
- Hispanics are hospitalized with urinary tract infections more often than Whites.
- Enhanced ambulatory care can reduce racial/ethnic differences in infections.

Table 1

Description of demographic and clinical characteristics by race and ethnicity in a tertiary referral hospital for adults

		Non-Hispanic White (n=24045)	Non-Hispanic Black (n=9210)	Hispanic (n=12795)	Other (n=3070)	Missing (n=4886)
Categorical variables	**Subcategories**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Infections						
Community-Acquired Infections (within 3 days of admission)						
	BSI	235 (1.1%)	216 (2.4%)	241 (1.9%)	39 (1.3%)	85 (1.7%)
	UTI	611 (2.8%)	560 (6.1%)	711 (5.6%)	105 (3.4%)	248 (5.1%)
	pneumonia	98 (0.4%)	70 (0.8%)	72 (0.6%)	9 (0.3%)	31 (0.6%)
Healthcare-Associated Infections						
	BSI (case/1000 person-days)	193 (2.80)	122 (3.70)	123 (3.23)	24 (2.62)	44 (2.47)
	UTI (case/1000 person-days)	431 (6.57)	202 (6.63)	229 (6.38)	56 (6.68)	108 (6.39)
	Pneumonia (case/1000 person-days)	162 (2.35)	96 (2.78)	100 (2.56)	24 (2.64)	46 (2.55)
Factors present on admission						
Age (mean in years, SD)		60 (17)	55 (17)	55 (18)	56 (17)	55 (19)
Male		12094 (55%)	4167 (45%)	5661 (45%)	1590 (52%)	2519 (52%)
Admission through the ER		4929 (22%)	6651 (72%)	9587 (75%)	1185 (39%)	2961 (61%)
Distance to hospital						
	<2 miles	1936 (8.8%)	4439 (48%)	7352 (57%)	630 (21%)	1683 (34%)
	2-5 miles	2323 (11%)	2155 (23%)	3233 (25%)	438 (14%)	788 (16%)
	>5 miles	17786 (81%)	2616 (28%)	2210 (17%)	2002 (65%)	2415 (49%)
Neighborhood median household income (mean in $, SD)		60836 (26528)	30095 (13448)	30447 (12185)	47375 (24750)	43882 (25510)
Primary payer						
< 65 years of age	Medicaid	672 (3.1%)	2132 (23%)	3270 (26%)	366 (12%)	698 (14%)
	Private	11577 (53%)	4333 (47%)	5372 (42%)	1632 (53%)	2604 (53%)
>= 65 years of age	No Medicare	1108 (5.0%)	464 (5.0%)	847 (6.6%)	200 (6.5%)	263 (5.4%)
	Medicare Part A only	7723 (35%)	1661 (18%)	2581 (20%)	672 (22%)	1034 (21%)
	Medicare Part A + other	965 (4.4%)	620 (6.7%)	725 (5.9%)	200 (6.5%)	287 (5.9%)
Comorbidity present on admission						
	Diabetes	3314 (15%)	2150 (23%)	3318 (26%)	710 (23%)	833 (17%)
	Renal failure	2138 (10%)	1628 (18%)	1608 (13%)	375 (12%)	547 (11%)

		Non-Hispanic White (n=24045)	Non-Hispanic Black (n=9210)	Hispanic (n=12795)	Other (n=3070)	Missing (n=4886)
Categorical variables	**Subcategories**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
	Malignancy	3742 (17%)	914 (10%)	1150 (9.0%)	357 (12%)	494 (10%)
	Transplant history	550 (2.5%)	131 (1.4%)	213 (1.7%)	48 (1.6%)	35 (0.7%)
	Substance abuse	629 (2.9%)	1103 (12%)	828 (6.5%)	74 (2.4%)	377 (7.7%)
	Chronic dermatitis	587 (2.7%)	388 (4.2%)	4517 (4.0%)	81 (2.6%)	171 (3.5%)
Charlson score*	2+	7034 (32%)	3358 (36%)	3960 (31%)	990 (32%)	1349 (28%)
During the hospitalization						
ICU stay		2560 (12%)	752 (8.2%)	1033 (8.0%)	316 (10%)	448 (9.2%)
Operations > 30 min		10585 (48%)	1989 (22%)	2903 (23%)	947 (31%)	1281 (26%)
Mechanical ventilation		644 (2.9%)	335 (3.6%)	451 (3.5%)	76 (2.5%)	188 (3.9%)
Vascular catheters		4827 (22%)	1118 (12%)	1600 (13%)	941 (31%)	644 (13%)
Urinary catheter		11400 (52%)	2981 (32%)	3963 (31%)	1265 (41%)	1585 (32%)
Central venous line		2361 (11%)	598 (6.5%)	692 (5.4%)	282 (9.2%)	286 (5.9%)

BSI = bloodstream infection, UTI = urinary tract infection, SD = standard deviation, ICU = Intensive care unit,

* Greater Charlson index score indicates greater presence of illness that increase the 10-year predicted mortality

Table 2

Age, sex, distance to hospital, month and year adjusted associations with community-acquired infections

		Community-acquired bloodstream infection	Community-acquired urinary tract infection	Community-acquired pneumonia
Factors present on admission		**OR**	**OR**	**OR**
Race/Ethnicity (non-Hispanic White as reference)				
	Non-Hispanic Black	1.59 (1.29, 1.96)	1.55 (1.35, 1.77)	1.36 (0.96, 1.93)
	Hispanic	1.19 (0.96, 1.47)	1.31 (1.15, 1.49)	0.96 (0.67, 1.37)
	Other	1.10 (0.78, 1.55)	1.14 (0.92, 1.42)	0.62 (0.31, 1.23)
	Missing	1.35 (1.04, 1.76)	1.56 (1.33, 1.83)	1.27 (0.83, 1.94)
Age (1 year increase in age)		1.014 (1.010, 1.018)	1.023 (1.020, 1.026)	1.012 (1.005, 1.019)
Male		1.45 (1.26, 1.67)	0.40 (0.37, 0.44)	1.64 (1.29, 2.09)
Distance to the hospital (<= 2 miles as reference)				
	2-5 miles	0.79 (0.66, 0.95)	0.80 (0.71, 0.89)	0.81 (0.59, 1.12)
	>5 miles	0.35 (0.30, 0.42)	0.37 (0.33, 0.40)	0.49 (0.37, 0.63)
Neighborhood Median Household Income (>$75,000 as reference				
	$50,001-75,000	1.70 (1.20, 2.43)	1.32 (1.07, 1.63)	1.16 (0.70, 1.92)
	$30,001-50,000	2.00 (1.42, 2.81)	1.59 (1.30, 1.94)	1.34 (0.82, 2.18)
	<=$30,000	2.28 (1.60, 3.26)	1.83 (1.49, 2.26)	1.90 (1.12, 3.20)
Primary payer				
< 65 years of age	Private HMO as reference			
	Medicaid	1.26 (1.02, 1.55)	1.54 (1.34, 1.76)	1.90 (1.35, 2.67)
>=65 years of age	Medicare Part A + other	0.95 (0.68, 1.34)	1.18 (0.96, 1.46)	1.12 (0.63, 1.99)
	Medicare Part A only	1.01 (0.78, 1.31)	1.39 (1.18, 1.64)	0.98 (0.63, 1.53)
	No Medicare / Private	0.79 (0.56, 1.13)	1.02 (0.82, 1.27)	1.10 (0.63, 1.99)
Comorbidity present on admission				
	Diabetes	1.22 (1.04, 1.43)	1.36 (1.24, 1.50)	1.09 (0.82, 1.44)
	Renal failure	4.48 (3.86, 5.21)	2.63 (2.37, 2.91)	3.43 (2.65, 4.45)
	Malignancy	1.63 (1.36, 1.96)	1.13 (0.99, 1.28)	0.98 (0.68, 1.40)
	Transplant history	2.92 (2.07, 4.12)	2.52 (1.96, 3.25)	2.10 (1.11, 3.97)
	Substance abuse	1.14 (0.86, 1.51)	0.98 (0.79, 1.22)	2.40 (1.64, 3.50)
	Chronic dermatitis	2.81 (2.22, 3.55)	1.48 (1.22, 1.80)	0.91 (0.48, 1.71)
Charlson score	2+ vs 0,1	2.63 (2.27, 3.05)	1.58 (1.45, 1.73)	2.66 (2.08, 3.42)
Admission through the ER		7.49 (5.97, 9.41)	5.85 (5.12, 6.68)	3.73 (2.69, 5.17)

Table 3

Contribution of present-on-admission on the difference in log odds of community-acquired infections by race/ethnicity

	Community-acquired bloodstream infection		Community-acquired urinary tract infection			
Model	**coefficient for non-Hispanic Blacks vs. Whites**	**% reduction**	**coefficient for non-Hispanic Blacks vs. Whites**	**% reduction**	**coefficient for Hispanic vs. Whites**	**% reduction**
Model A: Age, sex, distance to hospital, month and year adjusted	0.463	-	0.436	-	0.267	-
Model A + Admission through the ER	0.035	92%	0.006	87%	−0.070	126%
Model A + comorbidity	0.270	42%	0.321	26%	0.215	19%
Model A + median neighborhood household income	0.358	23%	0.351	20%	0.197	27%
Model A + primary payer status	0.459	1%	0.440	0%*	0.259	3%
All variables	−0.058	112%	0.029	93%	−0.07	128%

* Negative % value was replaced with 0% as the inclusion of the covariates explains greater difference than exists by race/ethnic categories.

Table 4

Age, sex, distance to hospital, month and year adjusted associations with healthcare-associated infections

		Healthcare-associated bloodstream infection	Healthcare-associated urinary tract infection	Healthcare-associated pneumonia
Factors present on admission		**HR**	**HR**	**HR**
Race/Ethnicity (non-Hispanic White as reference)				
	Non-Hispanic Black	1.31 (1.02, 1.69)	1.19 (0.98, 1.46)*	1.14 (0.86, 1.51)
	Hispanic	1.19 (0.92, 1.54)	1.36 (1.07, 1.73)*	1.11 (0.84, 1.48)
	Other	0.94 (0.61, 1.45)	1.46 (1.02, 2.08)*	1.18 (0.77, 1.82)
	Missing	0.79 (0.56, 1.10)	2.02 (1.08, 3.76)*	1.10 (0.79, 1.55)
	Interaction with time*	n/a**	0.96 (0.93, 0.99)	n/a**
Age (1 year increase in age)		1.008 (1.003, 1.014)	1.021 (1.018, 1.025)	1.016 (1.010, 1.021)
Male		2.80 (1.59, 4.94)	0.42 (0.37, 0.47)	1.54 (1.26, 1.88)
	Interaction with time*	0.72 (0.58, 0.90)	n/a**	n/a**
Distance to the hospital (<= 2 miles as reference)				
	2-5 miles	0.84 (0.65, 1.09)	0.91 (0.75, 1.09)	1.18 (0.91, 1.54)
	>5 miles	0.82 (0.67, 0.99)	1.00 (0.87, 1.15)	0.91 (0.73, 1.14)
Neighborhood Median Household Income (>$75,000 as reference				
	$50,001-75,000	0.87 (0.63, 1.21)	0.83 (0.67, 1.03)	1.45 (1.08, 2.26)
	$30,001-50,000	0.88 (0.65, 1.21)	0.87 (0.71, 1.08)	1.23 (0.85, 1.78)
	<=$30,000	1.10 (0.77, 1.57)	0.97 (0.76, 1.23)	0.98 (0.65, 1.48)
Primary payer				
< 65 years of age	Private HMO as reference			
	Medicaid	1.34 (1.02, 1.75)	0.92 (0.73, 1.15)	1.16 (0.85, 1.58)
>=65 years of age	Medicare Part A + other	0.83 (0.54, 1.28)	1.11 (0.83, 1.49)	1.19 (0.76, 1.86)
	Medicare Part A only	0.86 (0.62, 1.19)	1.06 (0.84, 1.33)	1.10 (0.77, 1.57)
	No Medicare / Private	0.85 (0.54, 1.33)	1.01 (0.74, 1.39)	0.89 (0.55, 1.44)
Comorbidity present on admission				
	Diabetes	1.03 (0.84, 1.27)	1.10 (0.95, 1.27)	1.18 (0.95, 1.46)
	Renal failure	1.36 (1.13, 1.64)	0.90 (0.78, 1.05)	1.35 (1.12, 1.62)
	Malignancy	1.38 (1.13, 1.69)	1.23 (1.06, 1.41)	1.01 (0.82, 1.25)
	Transplant history	1.45 (0.92, 2.26)	0.98 (0.61, 1.54)	1.01 (0.60, 1.70)
		n/a	n/a	

		Healthcare-associated bloodstream infection	Healthcare-associated urinary tract infection	Healthcare-associated pneumonia
Factors present on admission		**HR**	**HR**	**HR**
	Substance abuse	0.69 (0.47, 1.02)	0.87 (0.64, 1.17)	0.74 (0.49, 1.12)
	Chronic dermatitis	0.83 (0.58, 1.19)	0.59 (0.44, 0.80)	0.89 (0.64, 1.24)
Charlson score	2+ vs 0,1	1.44 (1.19, 1.74)	1.22 (1.07, 1.38)	1.24 (1.03, 1.50)
Admission through the ER		1.29 (1.03, 1.61)	0.31 (0.21, 0.46)	1.14 (0.92, 1.40)
		n/a	1.55 (1.31, 1.82)	
During the hospitalization				
ICU stay		1.02 (0.85, 1.23)	0.87 (0.77, 1.00)	6.12 (4.89, 7.65)
Operations > 30 min		0.88 (0.72, 1.07)	1.17 (1.02, 1.33)	1.29 (1.07, 1.56)
Mechanical ventilation		0.95 (0.77, 1.17)	0.04 (0.02, 0.08)	5.71 (4.76, 6.86)
	Interaction with time*	n/a**	2.89 (2.25, 3.71)	n/a**
Vascular catheters		0.23 (0.10, 0.53)	0.92 (0.78, 1.09)	1.01 (0.80, 1.27)
	Interaction with time*	1.62 (1.21, 2.17)	n/a**	n/a**
Urinary catheter		1.37 (1.15, 1.65)	2.14 (1.88, 2.43)	2.47 (2.04, 3.00)
Central venous line		1.48 (1.21, 1.82)	0.58 (0.49, 0.70)	4.79 (3.97, 5.78)

* Two-way interaction with log-days of hospital stay was significant, indicating non-proportional hazard. Significant interaction terms were kept in the model. Ratios less than 1 indicates that the contribution of the risk factor to infection risk decreases over time, whereas ratios greater 1 indicates that the contribution of the risk factor increases with time. Hazard ratios of the main effect of the covariates with significant interaction with time indicates the estimated hazard ratio for infection at time = 0 for healthcareassociated infections (day 4 of admission), based on changing relative hazard over time.

** Interaction with log-days of hospital stay was not significant, and therefore not included in the model.

Table 5

Contribution of present-on-admission and in-hospital factors on the difference in log-hazard of healthcare-associated bloodstream by race/ethnicity

	Healthcare-associated bloodstream infection	
Model	**Coefficient for non-Hispanic Blacks vs. Whites**	**% reduction**
Model A: Age, sex, distance to hospital, month and year adjusted	0.270	-
Model A + Admission through the ER	0.223	17%
Model A + primary payer status	0.231	15%
Model A + comorbidity	0.235	13%
Model A + median neighborhood household income	0.257	5%
Model A + central venous line	0.263	3%
Model A + other invasive procedures	0.275	0%*
All variables	0.135	50%

*Negative % value was replaced with 0% as the inclusion of the covariates explains greater difference than exists by race/ethnic categories.