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Racial Disparity in Surgical Mortality after Major Hepatectomy

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Abstract

Background—The relationship between surgical mortality and race has not been studied for major hepatectomy. We sought to quantify and explore the nature of racial disparities in surgical mortality after major hepatectomy in a nationally representative cohort of patients.

Study Design—We conducted a retrospective cohort study using data from the Nationwide Inpatient Sample (1998 to 2005). Adult patients undergoing major hepatectomy within 1 day of nontrauma admission were included. Logistic regression models were used to assess the variation of in-hospital mortality by race after adjustment for other risk factors.

Results—The study cohort consisted of 3,552 observations representing 17,794 patients undergoing major hepatectomy. Unadjusted analyses revealed that African-American patients had a twofold increased odds of surgical mortality (odds ratio 2.22, 95% CI 1.38 to 3.57) relative to Caucasians. Even after adjustment for other risk factors, African Americans had a two-fold increased odds of surgical mortality (odds ratio 2.15, 95% CI 1.28 to 3.61) relative to Caucasians. Stratified analyses restricting the cohort to patients without comorbidities, those with neoplasms, those with private insurance, or those treated at high-volume hospitals all demonstrated racial disparities in surgical mortality.

Conclusions—In-hospital mortality after major hepatectomy varies substantially by race. After adjustment for potential confounders, African-American patients have two-fold higher population-level odds of surgical mortality than Caucasian patients do. Our analyses suggest that clinical factors, insurance status, and hospital factors do not account for these differences. Additional studies to clarify the nature of this disparity and identify targets for intervention are warranted. (*J Am Coll Surg* 2008;207:312–319.)

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A large body of evidence indicates the existence of significant racial disparities in health care and outcomes in the US.¹ Identification and elimination of these disparities have been identified as national public health priorities.² Racial differences in health care use may be explained to a significant extent, although not completely, by insurance status and socioeconomic factors.³ The immediate outcomes of health care procedures, such as major operations, might be expected to be less dependent on such factors. But previous studies have documented racial disparities in surgical mortality after coronary artery bypass surgery,^{4,5} carotid endarterectomy,⁵ abdominal aortic aneurysm repair,⁵ and prostate cancer surgery.⁶ In addition, a comprehensive study of eight cardiovascular and cancer procedures found higher risks of surgical mortality for African Americans versus Caucasians.⁷

No previous work has focused on disparities in outcomes after liver resection; this procedure is of special interest because the use of hepatic resection has increased dramatically in the US.⁸ With the increasing incidence of hepatocellular carcinoma in the US⁹ and expanding indications for resection of metastatic lesions,¹⁰⁻¹² the rate of hepatic resection will likely continue to rise. The objective of this study was to quantify and explore the nature of racial disparities in surgical mortality after major hepatectomy (ie, hemihepatectomy) in a nationally representative cohort of patients.

Methods

To evaluate potential differences in surgical mortality after major hepatectomy, we analyzed hospital discharge data from the Nationwide Inpatient Sample (NIS), compiled and distributed by the Healthcare Cost and Utilization Project (HCUP). The NIS database is the largest all-payor inpatient care database in the US, representing an approximately 20% stratified sample of nonfederal hospitals from 37 states and capturing approximately 90% of all hospital discharges in the US.¹³ The NIS databases from years 1998 to 2005 were used to identify all adult (age 18 years or greater) patients with a primary procedure code for hepatic lobectomy (ICD-9-CM code 50.3). To enhance the homogeneity of the cohort, only patients undergoing hepatectomy within 1 day of admission were included, and patients with an admission code for trauma were excluded. Six states (IL, KS, OH, UT, WA, and WV) do not report the day of the procedure, so all patients from these states were retained.

Patient race was defined according to the NIS definitions: Caucasian, African American, Hispanic, Asian/Pacific Islander, or other/unknown. Native Americans were included in the "other" category because of their low number. Of the 37 states in the NIS, 11 states (GA, IL, KY, ME, MN, NE, NV, OH, OR, WA, and WV) do not provide patient race. Because excluding these patients could potentially introduce bias and reduce the study's power, these patients were included in the "other" category, similar to the approach used by others.¹⁴ Two patients with missing gender and eight patients with missing primary payor type were excluded. Missing data categories were created for all variables with at least 1% missing data (race, nonelective admission, and ZIP code income quartile).

Comorbidity adjustment was carried out using the Deyo adaptation¹⁵ of the Charlson index¹⁶ with empirically derived weights.^{17,18} Weighted Charlson scores were collapsed into three categories as follows: 0 (0 score < 1), 1 (1 score < 2), 2 (score ≥ 2). Sensitivity

analyses using published weights,¹⁶ the Romano modification of the Charlson index,¹⁹ and varying groupings of Charlson scores did not reveal substantially different conclusions. In all analyses, codes that were likely to represent complications rather than true comorbidities (572.2 hepatic coma and 586 renal failure not otherwise specified) were removed from the standard algorithms.

Hospital hemihepatectomy volumes were calculated on an annual basis and included all hemihepatectomies performed in each hospital, not just those performed on the analytic cohort. Hospital hemihepatectomy volume was analyzed in regression models as a log-transformed continuous variable, but was also divided into terciles for descriptive purposes. The use of concomitant hepatic wedge resection (ie, partial hepatectomy, ICD-9-CM code 50.22) and other destruction of a liver lesion (eg, radiofrequency ablation or enucleation, ICD-9-CM code 50.29) were ascertained from procedure codes in any position. Other variables (eg, primary payor, ZIP code income quartile, hospital bed number, hospital teaching status, and hospital rural or urban location) were used as defined by the Healthcare Cost and Utilization Project in the NIS database.²⁰

Descriptive statistics were compared using chi-square tests that accounted for the survey design for categorical variables and a multinomial logistic regression model for age. Odds ratios (OR) and 95% confidence intervals (95% CI) for the associations of variables with mortality were calculated using logistic regression models. For variables with more than two categories, reported p values represent the overall comparisons.

Multivariable models were initially constructed using all variables that were significant at the $p < 0.25$ level in unadjusted analyses²¹ and were refined using a backward stepwise algorithm based on Akaike information criteria.²² Patient age and median income in the patient's ZIP code were retained in the final multivariable model based on perceived importance, although they were not independently associated with mortality. Both main effects and interaction terms (between race and all other statistically significant variables) were evaluated. Stratified analyses were then performed that restricted the cohort to patients with specific characteristics, with models developed by beginning with the final multivariable model and removing nonsignificant variables based on Akaike information criteria values.

All analyses accounted for the stratified sampling design of the NIS.²³ All tests of statistical significance were two-sided, and statistical significance was established at $\alpha = 0.05$. Statistical analyses were performed using Stata/MP 10.0 for Linux (StataCorp). This study was deemed exempt from review by the Johns Hopkins University School of Medicine Institutional Review Boards.

Results

Study cohort

Our selection criteria identified 3,552 observations in the NIS data, corresponding to 17,794 patients undergoing hemihepatectomy. Primary diagnoses were metastatic disease in 53%, hepatobiliary cancer in 26%, benign neoplasm in 9%, other liver disease in 4%, and an

assortment of other diseases in the remaining 9% of patients. The overall racial makeup was 59% Caucasian, 6% African-American, 5% Hispanic, 7% Asian/Pacific Islander, and 24% other or unknown, including those with missing race and those from states that do not report race.

Baseline differences between all races are shown in Table 1. Table 1 presents p values for overall comparisons among all racial groups. Additionally, we performed comparisons directly between African-American and Caucasian patients, which are presented here, because analyses of mortality revealed the largest difference in African Americans relative to Caucasians. African-American patients were younger than Caucasians on average (53 versus 59 years, $p < 0.001$), but they also tended to have more comorbidities. African-American patients had higher rates of cirrhosis (11% versus 6%, $p = 0.001$) and viral hepatitis (15% versus 5%, $p < 0.001$), and higher Charlson scores ($p = 0.039$), than Caucasians. The use of concomitant hepatic wedge resection (3% overall) and other destruction of a liver lesion (eg, radiofrequency ablation or enucleation, 9% overall) were similar between the groups. Higher proportions of African Americans than Caucasians were dependent on Medicaid (13% versus 3%), but fewer African Americans than Caucasians were on Medicare (25% versus 39%, $p < 0.001$ for overall comparison of insurance status between African Americans and Caucasians). Even among those below 65 years of age, African Americans had a higher rate of Medicare enrollment than Caucasians (8% versus 5%, $p < 0.001$), suggesting that these individuals had a condition such as end-stage renal disease or a qualifying disability. African Americans underwent operations at lower-volume hospitals (13% versus 8% treated at low-volume hospitals, $p = 0.029$ for overall comparison of hospital volume between African Americans and Caucasians), but there were no significant differences in the number of hospital beds, teaching status, or rural or urban location of the hospitals at which African Americans and Caucasians were treated. The majority of these major hepatic resections, as expected, were performed at large urban teaching hospitals with high annual hemihepatectomy volumes.

In-hospital mortality: unadjusted and multivariable analyses

Crude in-hospital mortality ranged from 5% for Caucasians to 10% for African Americans (Table 1). Because the observed difference in mortality was largest for African Americans versus Caucasians, those groups are emphasized in the preceding text summary although patients from all groups were included in the models and are presented in the tables.

In unadjusted analyses of in-hospital mortality (Table 2), African-American patients had a 2.22-fold increased odds of mortality (95% CI 1.38 to 3.57) relative to Caucasians. The odds ratios of mortality for other racial groups relative to Caucasians did not exclude null effects. The point estimate of the odds ratio for patients of other or unknown race, 1.09, was consistent with what would be expected for a majority Caucasian population with some representation of the other groups.

Clinical factors associated with mortality in unadjusted analyses were cirrhosis, viral hepatitis, increasing Charlson index, and nonelective admission (Table 2). Neither concomitant wedge resection nor other destruction of a liver lesion was associated with increased mortality. Of socioeconomic factors, insurance status was associated with

mortality, with Medicare and uninsured patients having higher odds of mortality as compared with privately insured patients. Median household income by ZIP code, on the other hand, was not associated with mortality. Patients treated at higher-volume hospitals had lower mortality, and teaching hospitals also demonstrated a protective effect, as expected. In contrast, hospital bed number and rural location were not associated with differences in mortality. There were no significant time trends in mortality over the 8-year period included in the study.

In the final multivariable model (Table 3), female gender (OR 0.69, 95% CI 0.51 to 0.94) and higher hospital volumes (OR 0.53 for each 10-fold increase, 95% CI 0.41 to 0.70) were associated with decreased odds of mortality after major hepatectomy. In contrast, increasing Charlson index (1 and < 2 versus 0, OR 3.24, 95% CI 2.05 to 5.14; 2 versus 0, OR 11.0, 95% CI 6.51 to 18.5) and nonelective admission (OR 3.04, 95% CI 2.10 to 4.42) were associated with increased mortality. Lack of insurance was also significantly associated with mortality (OR 2.90, 95% CI 1.46 to 5.73), but there were no differences between various types of insurance coverage. Interestingly, median household income by ZIP code was not associated with mortality in unadjusted or multivariable models. The year of operation was initially entered into the multivariable model to ensure that time trends were not overlooked, but was subsequently removed because of a lack of a statistically significant time trend in mortality.

After adjusting for these and other factors (Table 3), African Americans still had a 2.15-fold increased odds of mortality (95% CI 1.28 to 3.61) relative to Caucasians. For illustrative purposes, we calculated predicted probabilities of in-hospital mortality using our final multivariable model, assuming no comorbidities, elective admission, private insurance, the second-highest quartile of income, and mean values of other covariates. Under these relatively favorable circumstances, African Americans had a predicted in-hospital mortality of 4.7%, compared with 2.2% for Caucasians.

We conducted several analyses to explore the potential impact of missing data. The 434 observations with missing day of procedure (including 423 from states that routinely do not report procedure day) did not significantly differ from the remainder of the cohort with respect to their odds of mortality (OR 1.20, $p = 0.42$). The racial makeup of these patients was 20% Caucasian, 1% African-American, and 79% other or unknown, which was significantly different from that of the rest of the cohort ($p < 0.001$). To explore the impact of inclusion of these patients on our results, we fitted our final model of mortality using only the patients for whom the day of the primary procedure was known, and the results were similar to those previously obtained (African Americans versus Caucasians: OR 2.20, 95% CI 1.30 to 3.74).

The 850 observations with missing race (including 617 from states that routinely do not report race) did not significantly differ from those for the remainder of the cohort with respect to their odds of mortality (OR 0.94, $p = 0.72$). To explore the impact of inclusion of these patients on our results, we fitted our final model of mortality using only the patients for whom race was known, and the results were similar to those previously obtained (African Americans versus Caucasians: OR 2.14, 95% CI 1.29 to 3.56).

Multivariable regression methods have well-known limitations that can result in residual confounding.²⁴ Although we specifically included interaction terms between race and other statistically significant variables in our final model and found none of significance, we explored the possibility that there might be interactions between race and other variables that had not been identified. Stratified analyses restricting the analytic cohort to specific subpopulations of patients were performed to characterize the association between surgical mortality and race (Table 4). These models were developed by beginning with the final multivariable model reported in Table 3 and refining it based on Akaike information criteria values. In analyses restricting the cohort based on clinical characteristics, such as the presence of cirrhosis or hepatitis or both, Charlson index, and the presence of neoplasm, disparities in adjusted mortality between African Americans and Caucasians persisted (OR 1.96 to 2.59, all 95% CI excluding null effects). When the cohort was restricted to those with private insurance, there again remained a disparity between African Americans and Caucasians (OR 2.36, 95% CI 1.08 to 5.18). There were not sufficient deaths in other socioeconomic strata to allow additional stratified analyses. To explore the effect of hospital factors, we restricted the analysis to patients undergoing operations in high-volume hospitals. Again, a disparity remained (OR 2.33, 95% CI 1.17 to 4.63). A model that included hospital indicator variables was also constructed, creating a fixed-effects model that accounted for factors that affected mortality odds for all patients in a given hospital.⁷ The remaining effect reflected within-hospital differences by race. In this analysis, there again remained a disparity (OR 2.81, 95% CI 1.33 to 5.95).

Processes of care

Finally, we sought to characterize in more detail any differences in the care and postoperative courses of African-American versus Caucasian patients. Among all patients undergoing hemihepatectomy, the incidence of acute liver failure was 1.5% for African Americans versus 1.4% for Caucasians ($p = 0.86$); among those who died in the hospital, the incidence of acute liver failure was 14.9% for African Americans versus 9.3% for Caucasians ($p = 0.44$). Similarly, the incidence of hepatic coma was 2.0% for African Americans versus 1.1% for Caucasians ($p = 0.19$) among all patients, and 5.3% for African Americans versus 13.8% for Caucasians ($p = 0.32$) among those who died. There were no differences in the use of diagnostic radiology procedures among all patients (mean 0.21 procedures per patient for African Americans versus 0.23 for Caucasians, $p = 0.72$) or among those who died (0.34 for African Americans versus 0.29 for Caucasians, $p = 0.86$). African Americans did have higher rates of blood transfusion than Caucasians overall (31.5% versus 20.5%, $p < 0.001$), perhaps reflecting their higher rates of cirrhosis. But there was no difference in transfusion rates among those who died (33.6% for African Americans versus 34.1% for Caucasians, $p = 0.97$). For those who died, the mean time from operation to death was significantly shorter for African Americans than for Caucasians (6.5 versus 15.6 days, $p = 0.020$).

Discussion

Racial disparities in surgical mortality have been documented for several surgical procedures but have not been previously studied for liver resection. Using a nationally

representative, all-payor data set, we found a greater than two-fold disparity in surgical mortality odds after major hepatectomy. Our finding is of special note because of the magnitude and constancy of the observed disparity. This disparity in surgical mortality between African Americans and Caucasians persisted even after multivariable adjustment for clinical, socioeconomic, and hospital factors. Particularly strong effects on mortality were exerted by patient comorbidities, a lack of insurance, and hospital volume. But even the relatively large effects of these variables attenuated the effect of race on mortality only modestly, from a crude OR of 2.22 to an adjusted OR of 2.15. So, we found a large residual disparity that was not explained by the factors considered in our model.

To explore potential explanations for this disparity, we performed several sets of stratified analyses, sequentially examining clinical, socioeconomic, and hospital factors. In these stratified analyses, clinical comorbidities did not appear to play a major role in explaining the disparity in surgical mortality. But restriction of the cohort to patients with neoplasm did result in a modest attenuation of the mortality disparity. A possible explanation for this finding is that our other analyses assessed the presence or absence of various comorbidities, but not disease severity per se. It is likely that restriction of the cohort to those with neoplasms produced a subcohort that was more homogeneous with respect to overall disease severity, explaining a small portion of the mortality disparity between African Americans and Caucasians. The notion that preoperative health status underlies some of the observed disparity is also supported by our finding that African-American patients who died did so much sooner than their Caucasian counterparts, suggesting a difference in the ability to withstand the physiologic insult of major surgery that might be related to preoperative health status. Nevertheless, the residual disparity (OR 1.96) remained quite large, even after restriction to patients with neoplasm.

Insurance status may determine postoperative outcomes by its effect on preoperative health both in terms of comorbidity burden and disease severity. So we expected that restricting the analysis to patients with private insurance would attenuate the racial disparity in mortality because these patients would be more likely to receive adequate preoperative care for other medical conditions, making them better operative candidates in general. Surprisingly, an unattenuated mortality disparity was found among patients with private insurance. This may imply that insurance status alone may be a poor proxy for preoperative health status because even patients with private health insurance may differ in their ability and willingness to adequately address health problems. Alternately, it may suggest that preoperative health status is not a determinant of outcomes, as our other analyses suggested. In either case, this finding has important policy implications because it suggests that simply expanding health insurance coverage alone is unlikely to overcome racial disparities in health care outcomes.

Hospital factors may explain racial disparities in outcomes insofar as minority patients might receive care at hospitals with generally poorer outcomes.^{5,7,14} Hospital volume is known to be a strong predictor of surgical mortality after complex operations^{25,26} and has been specifically shown to predict mortality after hepatectomy.^{8,27-29} We hypothesized that higher-volume hospitals would be better able to equalize outcomes through standardized processes of care and greater ability to care for complex patients. But unattenuated racial disparities persisted in high-volume hospitals. In a fixed-effects model that accounted for

potential differences between hospitals that might not be captured by hospital volume, there again remained an unattenuated disparity between African Americans and Caucasians. Collectively, these results suggest that, although African-American patients tend to undergo hemihepatectomy at lower-volume hospitals, hospital factors do not play a major role in explaining the disparity in surgical mortality after hemihepatectomy. This finding is consistent with that of Trivedi and colleagues,⁵ who found a disparity in cardiovascular procedural mortality even after accounting for hospital volume, but it contrasts with that of Lucas and associates,⁷ who found that racial disparities in surgical mortality are largely explained by hospital factors. In addition, patterns of care did not appear to differ substantially between African Americans and Caucasians. The similar rates of diagnostic radiology use and blood transfusion among those who died suggest that the postoperative care of African Americans and Caucasians is not substantially different. Our findings suggest that in-hospital factors may not play as much of a role as prehospital factors in determining mortality differences after major hepatectomy.

Several limitations must be considered in interpreting the results of this study. Risk adjustment based on administrative data is inherently limited.³⁰ Our analyses addressed this limitation by using several different risk adjustment methods and several stratified analyses, none of which affected our overall conclusions. But inadequate capture of comorbidities could have led to an underestimation of the role of clinical factors in explaining the observed disparity. Additionally, disease severity is difficult to assess using administrative data. Unmeasured clinical and socioeconomic confounders might explain some of the disparity found in this study. But the finding of racial disparities in surgical mortality in several different procedures, across surgical disciplines and disease processes, suggests that the observed disparities are not completely the result of procedure- or disease-specific confounders. Finally, the missing data in this study might have biased the analysis. This seems unlikely, though, because the empiric data suggested that the population for whom race was unknown or missing was appropriately represented by the remainder of the cohort. Additionally, analyses that excluded those with missing values for race did not yield substantially different conclusions. We attempted to minimize any potential bias by including missing data categories where appropriate, but the potential for residual bias when using this strategy to account for missing data is well known.²⁴

In conclusion, in-hospital mortality after major hepatectomy varies substantially by race. After adjustment for potential confounders, African-American patients have twofold higher population-level odds of surgical mortality than Caucasian patients do. Our analyses suggest that clinical and hospital factors do not account for these differences, although differences in disease severity may play a role. The role of socioeconomic factors is less clear, but insurance status alone does not explain the observed disparity. Given the increasing use of liver resection in this country, more studies to clarify the nature of this disparity and identify targets for intervention are warranted.

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Table 1

Clinical, Socioeconomic, and Hospital Characteristics

Race, weighted													
Variable	Caucasian		African American		Hispanic		API		Other/unknown		p Value*		
	n	%	n	%	n	%	n	%	n	%			
n	10,502	59	1,017	6	861	5	1,156	7	4,258	24	—		
In-hospital mortality	513	5	104	10	68	8	79	7	226	5	0.008		
Mean age, y	59		53		54		56		57		<0.001		
Female	5,221	50	532	52	436	51	422	37	2,133	50	0.004		
Cirrhosis	629	6	117	11	83	10	320	28	294	7	<0.001		
Hepatitis	492	5	151	15	60	7	436	38	290	7	<0.001		
Neoplasm	9,765	93	875	86	745	87	1,051	91	3,829	90	<0.001		
Hepatobiliary cancer	2,414	23	291	29	240	28	672	58	1,026	24	<0.001		
Charlson category											<0.001		
0	9,613	92	875	86	774	90	831	72	3,884	91			
1 and < 2	662	6	125	12	68	8	280	24	299	7			
2	227	2	17	2	19	2	45	4	76	2			
Concomitant liver procedure													
Wedge resection	372	4	39	4	35	4	17	1	139	3	0.62		
Other destruction of lesion	969	9	65	6	80	9	44	4	383	9	0.13		
Admission type											0.012		
Elective	8,635	82	787	77	621	72	889	77	3,595	84			

Variable	Race, weighted										p Value*
	Caucasian		African American		Hispanic		API		Other/unknown		
	n	%	n	%	n	%	n	%	n	%	
Nonelective	1,211	12	144	14	122	14	119	10	546	13	
Unknown	656	6	86	8	118	14	148	13	117	3	
Primary payor											<0.001
Private insurance	5,568	53	563	55	425	49	654	57	2,538	60	
Medicare	4,096	39	255	25	260	30	284	25	1,313	31	
Medicaid	352	3	129	13	69	8	148	13	231	5	
Self-pay	230	2	47	5	78	9	42	4	70	2	
Other	256	2	23	2	28	3	29	2	105	2	
ZIP code income quartile											0.10
Lowest	806	8	189	19	134	16	108	9	292	7	
Second	1,154	11	106	10	121	14	133	12	381	9	
Third	1,084	10	83	8	115	13	112	10	465	11	
Highest	1,530	15	101	10	54	6	235	20	689	16	
Unknown	5,928	56	538	53	437	51	567	49	2,431	57	
Hospital volume tercile											0.32
Low-volume	858	8	134	13	104	12	53	5	341	8	
Mid-volume	1,260	12	152	15	136	16	102	9	545	13	
High-volume	8,383	80	732	72	621	72	1,001	87	3,373	79	
Hospital bed number											0.22

Variable	Race, weighted										p Value*
	Caucasian		African American		Hispanic		API		Other/unknown		
	n	%	n	%	n	%	n	%	n	%	
Small	612	6	74	7	59	7	80	7	114	3	
Medium	1,120	11	135	13	172	20	192	17	401	9	
Large	8,770	84	809	80	630	73	884	76	3,743	88	
Teaching hospital	8,881	85	866	85	731	85	1,042	90	3,613	85	0.76
Rural hospital	204	2	10	<1	10	<1	10	<1	75	2	0.33

Weighted n and percentages may not sum exactly as expected because of rounding.

* For overall comparison by race.
API, Asian/Pacific Islander.

Table 2
In-Hospital Mortality: Unadjusted Analyses

Variable	Odds ratio	95% CI	p Value
Race			0.010
Caucasian	1.00	Referent	
African-American	2.22	1.38–3.57	
Hispanic	1.66	0.95–2.92	
Asian/Pacific Islander	1.43	0.85–2.39	
Other/unknown	1.09	0.76–1.57	
Age (per year over 40)	1.02	1.01–1.03	0.003
Female	0.57	0.43–0.76	<0.001
Cirrhosis	4.40	2.74–7.04	<0.001
Viral hepatitis	2.57	1.75–3.76	<0.001
Charlson category			<0.001
0	1.00	Referent	
1 and < 2	3.24	2.05–5.14	
2	11.00	6.51–18.5	
Concomitant liver procedure			
Wedge resection	0.83	0.31–2.28	0.72
Other destruction of lesion	0.61	0.33–1.10	0.10
Nonelective admission *	3.31	2.35–4.65	<0.001
Primary payor			<0.001
Private insurance	1.00	Referent	
Medicare	1.86	1.38–2.50	
Medicaid	1.54	0.79–3.02	
Self-pay	3.44	1.83–6.47	
Other	2.65	1.26–5.56	
ZIP code income quartile ^{*,†}			0.07
Lowest	1.00	Referent	
Highest	0.38	0.18–0.80	
Hospital volume tercile			<0.001
Low-volume	1.00	Referent	
Mid-volume	0.57	0.34–0.96	
High-volume	0.32	0.22–0.48	
Hospital bed number			0.81
Small	1.00	Referent	
Medium	0.90	0.42–1.93	
Large	0.83	0.46–1.50	
Teaching hospital	0.66	0.44–1.00	0.049

Variable	Odds ratio	95% CI	p Value
Rural hospital	1.66	0.69–3.96	0.26

* Missing categories included for these variables.

[†] Other categories of income included in analysis but omitted here for brevity.

Table 3
In-Hospital Mortality: Multivariable Analyses

Variable	Odds ratio	95% CI	p Value
Race			
Caucasian	1.00	Referent	
African-American	2.15	1.28–3.61	0.004
Hispanic	1.48	0.78–2.82	0.23
Asian/Pacific Islander	1.32	0.70–2.49	0.39
Other/unknown	1.15	0.78–1.71	0.47
Age (per year > 40 y)	1.02	1.00–1.04	0.06
Female	0.69	0.51–0.94	0.020
Charlson category			
0	1.00	Referent	
1 and < 2	3.18	2.11–4.78	<0.001
2	11.50	6.30–20.9	<0.001
Nonelective admission *	3.04	2.10–4.42	<0.001
Primary payor			
Private insurance	1.00	Referent	
Medicare	1.18	0.73–1.90	0.50
Medicaid	0.81	0.40–1.65	0.56
Self-pay	2.90	1.46–5.73	0.002
Other	2.00	0.96–4.18	0.07
ZIP code income quartile *†			
Lowest	1.00	Referent	
Highest	0.54	0.25–1.16	0.12
Hospital volume (log)	0.53	0.41–0.70	<0.001

* Missing categories included for these variables.

† Other categories of income included in analysis but omitted here for brevity.

Table 4
Adjusted Mortality of African Americans Versus Caucasians: Full Versus Restricted Subcohorts

Subpopulation	n [*]	Odds ratio [†]	95% CI	p Value
Full cohort	199/3,552	2.15	1.28–3.61	0.004
Clinical factors				
No cirrhosis	148/3,262	2.56	1.54–4.28	<0.001
No viral hepatitis	164/3,264	2.09	1.18–3.71	0.012
No cirrhosis or hepatitis	138/3,120	2.24	1.28–3.90	0.004
Charlson index 0	137/3,188	2.59	1.54–4.33	<0.001
Neoplasm only	159/3,251	1.96	1.06–3.61	0.032
Socioeconomic factors				
Private insurance	78/1,942	2.36	1.08–5.18	0.032
Hospital factors				
High-volume	126/2,798	2.33	1.17–4.63	0.016
Fixed-effects model [‡]	166/2,026	2.81	1.33–5.95	0.007

* Unweighted number of deaths and total observations included in model.

[†] For African Americans versus Caucasians.

[‡] Fitted by using an indicator variable for each hospital to remove within-hospital effects.