Racial, Ethnic, and Socioeconomic Disparities in Patient Outcomes After Craniotomy for Tumor in Adult Patients in the United States, 1988–2004

OBJECTIVE: Racial disparities in American health care outcomes are well documented. We investigated racial disparities in hospital mortality and adverse discharge disposition after brain tumor craniotomies performed in the United States from 1988 to 2004. We explored potential explanations for the disparities.

METHODS: The data source was the Nationwide Inpatient Sample. We used multivariate ordinal logistic regression corrected for clustering by hospital and adjusted for age, sex, primary payer for care, income in postal code of residence, geographic region, admission type and source, medical comorbidity, treatment year, hospital case volume, and disease-specific factors. Random-effects pooling was also used.

RESULTS: A total of 99,665 craniotomies were studied. Hospital mortality and adverse discharge disposition (any discharge other than directly home) were more likely in black patients than others for all tumor types. Pooled odds ratios (ORs) and 95% confidence intervals (CIs) for blacks were: hospital craniotomy mortality (OR, 1.64; 95% CI, 1.32–2.03; \( P < .001 \)), and adverse discharge disposition (OR, 1.43; 95% CI, 1.31–1.56; \( P < .001 \)). Medicaid patients had higher mortality, while private-pay patients had lower mortality. Hospital annual case volume was lower for black and Hispanic patients and for those with Medicaid as the primary payer in pooled analyses, whereas patients with private insurance received care at higher-volume hospitals. Black patients generally presented with higher disease severity, including more emergency or urgent admissions (OR, 1.71; 95% CI, 1.54–1.89; \( P < .001 \)); more hemiparesis and hemiplegia for primary tumors, meningiomas, and metastases (\( P < .04 \) for all); and more hydrocephalus for acoustic neuromas (\( P = .1 \)).

CONCLUSION: Black patients died more often or had an adverse discharge disposition after tumor craniotomies in the United States in the period studied (1988–2004). Blacks had more severe disease at presentation and were treated at lower-volume hospitals for surgery. Other socially defined patient groups also showed disparities in access and outcomes of care.

KEY WORDS: Brain, Craniotomy, Health care, Meningioma, Neoplasm, Vestibular schwannoma

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Disparities in health care outcomes in the United States for populations defined by race, ethnicity, and socioeconomic status have been extensively documented.\(^1\)\(^2\) Disparities have been found to affect outcomes of many types of health care, including preventive care, treatment of acute illnesses, and management of chronic disease. In cancer medicine, patients who belong to minority populations defined by race, ethnicity, and socioeconomic status have been found to present more often with advanced stages of disease, undergo appropriate care less often and in a less timely manner, and have higher rates of disease recurrence and shorter survival.\(^3\)\(^5\)

Relatively few studies in neurosurgery or neuro-oncology have examined patient outcomes for these disparities. Some researchers have suggested that black Americans diagnosed with certain malignant brain tumors may have shorter survival.\(^6\)\(^7\) Others have demonstrated that white pediatric patients with brain tumors have lower in-hospital mortality and less frequent adverse discharge disposition than those of other races in the United States from 1988 to 2000.\(^8\) and we have documented racial disparities in short-term outcomes of some complex cerebrovascular proce-
In this study, we examined short-term outcomes after craniotomy for resection of primary brain tumors, meningiomas, metastases, and acoustic neuromas for possible disparities based on race, ethnicity, or socioeconomic status.

PATIENTS AND METHODS

The data source for the study was the Nationwide Inpatient Sample (NIS) database for the years 1988 to 2004, obtained from the Healthcare Cost and Utilization Project of the Agency for Healthcare Research and Quality. The NIS is a hospital discharge database that represents approximately 20% of all inpatient admissions to nonfederal hospitals in the United States. The NIS contains discharge data on 100% of discharges from a sample of hospitals that are selected for inclusion in the database using a stratified random sampling technique. This produces a representative 20% subsample of all United States nonfederal hospital discharges, so that conclusions drawn from the database can be confidently generalized to the entire United States medical community. Because the NIS contains data on all patients discharged from sampled hospitals during the year regardless of age or payer, it can be used to obtain the annual total volume of specified procedures at individual hospitals. An overview of the NIS is available at http://www.hcup-us.ahrq.gov/nisoverview.jsp (accessed November 4, 2009).

Inclusion and Exclusion Criteria and Definition of End Points

An admission for surgical treatment of an adult brain tumor patient of one of the 4 tumor types was defined using the combinations of patient age and International Classification of Diseases, 9th revision, Clinical Modification (ICD-9-CM), diagnosis and treatment codes that we used in previous studies (Table 1). All patients were 18 years old or older. For primary brain tumor admissions, procedures coded as biopsies or resections were included in the study; these analyses were stratified by primary procedure. Although most procedures coded as “closed needle biopsies” were likely performed using stereotactic techniques, the same ICD-9-CM procedure code was used for closed needle biopsies performed freehand without stereotactic targeting.

Two primary end points were examined: in-hospital mortality and disposition at hospital discharge. In-hospital mortality was coded directly in the NIS database and was analyzed using logistic regression. Discharge disposition was coded on a 4-level scale that included death, discharge to a long-term facility, discharge to short-term or intermediate-term facilities, or discharge directly home, and it was analyzed using ordinal logistic regression.

Patient Characteristics

Patient age, sex, race, median household income for zip code of residence (specified by quartile with reference to United States national values), primary payer (Medicare, Medicaid, private insurance, self-pay, no charge, or other), type of admission (emergency, urgent, or elective), and admission source (emergency room, transfer from another hospital, transfer from long-term care, or routine) were coded in NIS data. Some small strata for certain variables were combined to avoid unstable coefficients in multivariate models. Patients of Native American race (0.1%) were reclassified as “other” race. Patients with a payment source of “no charge” (0.2%) were reclassified as “other” payment source. Patients with an admission type described as “court/law enforcement” or “other” (0.07%) were classified as routine admissions.

| Tumor Type       | Primary Procedure and Diagnosis Codes                                                                 |
|------------------|------------------------------------------------------------------------------------------------------|
| Primary brain tumor | Primary diagnosis code: 191.0-191.5, 191.8, 191.9 (malignant brain tumor excluding cerebellum or brainstem), or 225.0 (benign brain tumor), or 237.5 (brain tumor of uncertain behavior) |
| Meningioma       | Primary procedure code: 01.53 (lobectomy) or 01.59 (excision or destruction of tissue or lesion of brain) or 01.13 (closed brain biopsy) or 01.14 (open brain biopsy) |
| Metastasis       | Primary diagnosis code: 198.3 (secondary malignant neoplasm of brain)                                   |
| Acoustic neuroma | Primary diagnosis code: 225.1 (benign neoplasm of cranial nerve)                                       |

For 3 variables used in the analysis, more than 5% of discharges had missing values: race (29% missing), admission type (12% missing), and whether the principal procedure was performed on the first hospital day (14% missing). Of the 37 states contained in the NIS database, 11 states never reported information on patient race, and 6 reported race information for some years but not all. State-level missing data accounted for 83% of the patients who were missing information on race in the database. Racial composition of states that always, never, or sometimes reported race information to NIS were roughly comparable. Based on United States Census data for 1995 (www.census.gov/population/projections/state/stp1race.txt, accessed November 4, 2009), and weighted by the number of patients contributed by each state to the total of 99,665 adult tumor craniotomy patients in the NIS between 1988 and 2004, the 20 states that always reported race had populations that were 82.1% white, 11.8% black, and 14.5% Hispanic. Unlike NIS, in United States Census data, race and ethnicity are reported separately. For 11 states that never reported race in the NIS, populations were 83.4% white, 13.2% black, and 6.0% Hispanic, and for 6 states that reported race for some years but not all, populations were 86.5% white, 11.2% black, and 9.4% Hispanic. In addition to state-level missing race data, 4.9% of all patients in the database were missing race on a non–state-level basis. For the purposes of this study, patients with missing race data were included in the analysis as a separate stratum, and these patients usually had results very similar to those of whites.

Missing values for admission type (12%) were designated as “emergency” for admissions whose source was the emergency room, “urgent”...
for admissions that were transfers from another hospital, and “routine” for admissions from other sources. For the years 2002 to 2004, missing admission type was designated as “routine” for admissions coded in NIS data as “elective.” Whether the principal procedure was performed on the first hospital day (14% missing) was not imputed.

To assess the effect of general medical comorbidity, the set of 30 comorbidities described by Elixhauser et al., excluding 2 specific neurologic comorbidity variables (“paralysis” and “other neurologic deficit”) and 3 comorbidity variables likely to represent postoperative conditions (“fluid and electrolyte disorders,” “blood loss anemia,” and “deficiency anemias”), were calculated using Agency for Healthcare Research and Quality software (www.hcup-us.ahrq.gov/toolssoftware/comorbidity/comorbidity.jsp, accessed November 4, 2009) and summed to give a single comorbidity score between 0 and 25.

Hemiplegia and hemiparesis were defined as ICD-9-CM diagnosis codes 342.0 to 342.9, hydrocephalus was labeled as codes 331.3 to 331.4, and neurofibromatosis was defined as codes 237.7 to 237.72. For patients with craniotomies for metastasis, ICD-9-CM diagnosis codes were used to identify lung cancer as the primary site of origin (ICD-9-CM code 162), and the presence of other (extracranial) metastases was defined as ICD-9-CM codes 197 to 198 (excluding 198.3 or 198.4 or 199.0). This definition excludes metastases to lymph nodes. Postoperative neurologic complications, including those due to infarction or hemorrhage, were identified using ICD codes 997.00 to 997.09.

**Hospital Characteristics**

Hospital region (Northeast, Midwest, South, or West) was coded in the NIS data. Annual volumes of brain tumor surgery in hospitals were derived for each individual study year by counting the cases for each identified hospital in the database for each tumor type separately. Because hospital caseload distributions were positively skewed, the logarithmic transforms were used when volume measures were entered into regression models. When the annual volume was the object of the analysis (such as when comparing hospital volume across racial or socioeconomic categories), hospitals were ranked by tumor- and year-specific quartiles of case volume, and ordinal logistic regression was used on the quartile score.

**Statistical Analysis**

Statistical methods included the Fisher’s exact and Wilcoxon rank tests, Spearman rank correlation, and loglinear least-squares, ordinary logistic, and proportional-odds ordinal logistic regression. Logistic and ordinal logistic regression analyses treated the sample as a simple random draw from an infinite possible population without weighting or correction for a finite sampling fraction). To correct for possible clustering of similar outcomes within hospitals, which could cause falsely inflated estimates of the statistical significance of regression coefficients, confidence intervals (CIs) and statistical significance were calculated using a sandwich variance-covariance matrix estimated by using the Huber and White method, with adjustment for clustering by hospital.

Multivariate models reported are the full models (all-variables). In addition to race/ethnicity, primary payer for care, and income (by quartile) in the patient’s postal code of residence, the variables in the mortality and adverse hospital discharge diagnosis models included age (spline fit), sex, hospital geographic region, comorbidity score, admission type and source, whether the primary procedure was performed on the first hospital day, hospital volume of care (logarithmic transform), and year of treatment. In addition, the primary brain tumor models included diagnosis (ie, location within the brain) and procedure (including biopsy versus resection). Metastasis models included the presence of other known extracranial metastases and whether the primary cancer was lung or other. Acoustic neuroma models included neurofibromatosis and hydrocephalus. For models examining volume of care across racial and socioeconomic categories, hospital volume, admission type and source, and whether the procedure was performed on the first hospital day were not included in the models.

For each end point, the 4 individual odds ratios (ORs) for the different tumor types were combined into a pooled OR using random-effects meta-analyses. To test for heterogeneity of ORs across the tumor types, Cochran’s Q statistic was used, with \( P < .1 \) considered evidence of significant heterogeneity. Calculations were performed using SAS (version 8.2; SAS Institute, Cary, NC), S-plus (version 3.3 for Windows; Insightful, Inc, Seattle, WA), and R (version 2.4.0 for Windows; R Foundation for Statistical Computing, Vienna, Austria) with the Hmisc and Design modeling function software libraries written by Harrell and the Locfit local-likelihood regression library written by Loader. \( P \) values are 2 tailed.

**RESULTS**

There were 99 665 inpatient admissions for brain tumor resections included in the NIS database from 1988 to 2004, which corresponded to an estimated 512 000 total admissions to all non-federal United States hospitals during this interval. Of the 99 665 admissions, 70 279 (71%) had race specified in the database. Clinical characteristics of the patients are shown in Table 2. About half of the patients were male (48%); median age was 57 years (interquartile range, 45–68 years). For the 4 tumor types combined, 84% of patients were white, 6.3% were black, and 5.7% were Hispanic. The percentage of patients who were white for the individual tumor types ranged from 78% (meningiomas) to 86% (metastases). The percentage of patients who were black for the individual tumor types ranged from 3.5% (acoustic neuromas) to 9.8% (meningiomas). For Hispanics, the percentage for the individual tumor types ranged between 3.7% (metastases) and 7.1% (meningiomas). A total of 52.4% of all patients had private insurance as the anticipated primary payer for care, 34.0% had Medicare, and 6.7% had Medicaid. Payer mix was similar for tumor types other than acoustic neuroma; these patients were more likely to have private insurance than patients with other tumor types (73%) and less likely to have Medicare (16%) or Medicaid (4%). Sixty percent of admissions were routine, 18% were urgent, and 22% were emergent. Patients with acoustic neuroma were most likely to have elective admissions (90% routine).

**Mortality and Adverse Discharge Outcome**

Results for crude in-hospital mortality and adverse hospital discharge disposition (any discharge other than direct home) by patient race for the 4 tumor types are shown in Tables 3 and 4. Patients of black race had higher in-hospital mortality and higher adverse discharge disposition rates for all tumor types. In multivariate models including race, payer for care, income in postal code of residence, and other variables (see Patients and Methods), adjusted ORs for black patients (compared with white patients)
TABLE 2. Clinical Characteristics of Patients with 4 Specified Tumor Types

| Primary Brain Tumors | Meningiomas | Metastases | Acoustic Neuromas |
|----------------------|-------------|------------|-------------------|
| Patients, no. (% of total) | 52 060 (52%) | 20 921 (21%) | 20 064 (20%) | 6 620 (7%) |
| **Age (y)** | | | | |
| Median | 56 | 60 | 61 | 51 |
| Mean | 55 | 59 | 60 | 51 |
| Interquartile range | 42–68 | 48–70 | 51–69 | 42–60 |
| Range | 18–99 | 18–98 | 18–94 | 18–92 |
| **Sex (% male)** | | | | |
| 56% | 30% | 50% | 47% |
| **Race/ethnicity missing (%)** | | | | |
| 30% | 29% | 30% | 24% |
| **Race/ethnicity (% of those with race reported)** | | | | |
| White | 85.5% | 77.6% | 86.3% | 85.1% |
| Black | 4.8% | 9.8% | 7.2% | 3.5% |
| Hispanic | 6.0% | 7.1% | 3.7% | 5.3% |
| Asian/Pacific Islander | 1.5% | 2.9% | 1.2% | 3.4% |
| American Indian | 0.1% | 0.2% | 0.1% | 0.2% |
| Other | 2% | 2.4% | 1.4% | 2.5% |
| **Primary payer for care (%)** | | | | |
| Medicare | 32.3% | 38.7% | 38.5% | 16.1% |
| Medicaid | 6.8% | 6.7% | 7.4% | 4.1% |
| Private insurance | 53.5% | 48.5% | 47.7% | 73.3% |
| Self-pay | 3.4% | 2.7% | 2.8% | 3.2% |
| No charge | 0.2% | 0.2% | 0.2% | 0.3% |
| Other | 3.7% | 3.3% | 3.4% | 3.0% |
| Missing | 0.7% | 0.7% | 0.5% | 1.3% |
| **Admission type (after imputation based on admission source) (%)** | | | | |
| Emergency | 24.3% | 14.0% | 27.8% | 2.3% |
| Urgent | 20.5% | 14.1% | 22.1% | 6.3% |
| Routine | 2.6% | 69.5% | 47.6% | 89.7% |
| Missing | 2.6% | 2.4% | 2.5% | 1.8% |

were 1.61 (95% CI, 1.26–2.05; \( P < .001 \)) for in-hospital mortality (Fig. 1) and 1.42 (95% CI, 1.30–1.54; \( P < .001 \)) for adverse discharge disposition (Fig. 2), with no significant evidence of heterogeneity in either analysis. No other racial group had significantly increased risk of mortality compared with white patients. Asian/Pacific Islander patients had significantly increased adverse discharge disposition \( (P = .002) \) (Table 4).

We also tested anticipated primary payer for care and median household income in postal code of residence (by quartile) as predictors of in-hospital mortality. Compared with Medicare patients (reference group), patients with Medicaid payers had significantly increased mortality \( (OR, 1.25; 95\% CI, 1.01–1.55; P = .045) \) in the adjusted multivariate models, and those with private insurance had decreased mortality \( (OR, 0.81; 95\% CI, 0.68–0.97; P = .02) \). There was no evidence of heterogeneity in either analysis. Self-pay patients had in-hospital mortality comparable to that of Medicare patients \( (OR, 1.11; 95\% CI, 0.82–1.48; P = .5) \). Median household income by postal code of residence, grouped into quartiles and analyzed using ordinal logistic regression, was not a significant predictor of in-hospital mortality in multivariate models \( (OR, 1.01; 95\% CI, 0.92–1.10; P = .9) \).

Hospital Annual Volume of Care

Recent studies have suggested that one reason for disparities in outcomes after complex surgery is the tendency for members of socially defined patient groups to attend different hospitals, where outcomes may vary systematically.\(^{26}\) One marker of quality of care for brain tumor craniotomy is hospital case volume, with busier hospitals consistently delivering better short-term outcomes after procedures for all tumor types examined here.\(^{12–15,27,28}\) We examined annual hospital case volumes by generating year- and tumor-specific volumes for each hospital, ranking and assigning
### TABLE 3. In-Hospital Mortality For 4 Tumor Types by Race

| Race                | Primary Brain Tumors (%) | Meningiomas (%) | Metastases (%) | Acoustic Neuromas (%) | Pooled OR (95% CI)\(^b\) | P Value | Heterogeneity Test |
|---------------------|--------------------------|-----------------|----------------|-----------------------|--------------------------|---------|---------------------|
| White               | 2.5%                     | 1.9%            | 2.6%           | 0.4%                  | Reference group          |         |                     |
| Black               | 4.1%                     | 2.7%            | 4.1%           | 1.1%                  | 1.61 (1.26–2.05)         | <.001   | 0.41                |
| Hispanic            | 2.3%                     | 1.6%            | 1.7%           | 0.7%                  | 0.94 (0.73–1.22)         | .7      | 0.43                |
| Asian/Pacific Islander | 2.6%                        | 1.9%            | 3.0%           | 0.6%                  | 1.43 (0.96–2.13)         | .08     | 0.28                |
| Other\(^c\)         | 2.4%                     | 3.7%            | 3.6%           | 0%                    | 1.34 (0.91–1.99)         | .14     | 0.28                |
| Missing race        | 2.7%                     | 2.3%            | 3.2%           | 0.5%                  | 1.09 (0.91–1.30)         | .32     | 0.21                |
| All patients        | 2.6%                     | 2.1%            | 2.9%           | 0.4%                  |                          |         |                     |

\(\text{a}\) OR, odds ratio; CI, confidence interval.
\(\text{b}\) Pooled adjusted ORs and 95% CIs for the 4 tumor types for each race, compared with white patients.
\(\text{c}\) Data for acoustic neuromas was omitted from this analysis because there were zero deaths in patients with “other” race.

### TABLE 4. Hospital Discharge Other than Directly Home for 4 Tumor Types by Race

| Race                | Primary Brain Tumors (%) | Meningiomas (%) | Metastases (%) | Acoustic Neuromas (%) | Pooled OR (95% CI)\(^b\) | P Value | Heterogeneity Test |
|---------------------|--------------------------|-----------------|----------------|-----------------------|--------------------------|---------|---------------------|
| White               | 22.0%                    | 23.1%           | 20.5%          | 5.1%                  | Reference group          |         |                     |
| Black               | 25.8%                    | 26.1%           | 25.1%          | 9.2%                  | 1.42 (1.30–1.54)         | <.001   | 0.9                 |
| Hispanic            | 20.7%                    | 19.3%           | 14.8%          | 7.5%                  | 0.97 (0.77–1.23)         | .8      | 0.01                |
| Asian/Pacific Islander | 22.7%                        | 24.0%           | 26.3%          | 4.8%                  | 1.28 (1.10–1.49)         | .002    | 0.9                 |
| Other\(^c\)         | 20.3%                    | 18.2%           | 21.0%          | 4.6%                  | 1.01 (0.86–1.19)         | .9      | 0.8                 |
| Missing race        | 20.9%                    | 21.4%           | 18.6%          | 5.3%                  | 0.93 (0.87–1.00)         | .04     | 0.9                 |
| All patients        | 21.7%                    | 22.6%           | 20.1%          | 5.3%                  |                          |         |                     |

\(\text{a}\) OR, odds ratio; CI, confidence interval.
\(\text{b}\) Pooled adjusted ORs and 95% CIs for the 4 tumor types for each race, compared with white patients.

### DISPARITIES IN PATIENT OUTCOMES AFTER CRANIOTOMY FOR TUMOR SURGERY

In subgroups defined by race or socioeconomic status, we sought evidence for different severity of disease at presentation by examining markers of admission urgency (admission type—emergency, urgent, or routine—analyzed using ordinal logistic regression). More-urgent admissions were significantly more common for black patients (OR, 1.71; 95% CI, 1.54–1.89; \(P < .001\)) (Table 6; Fig. 3), Hispanic patients (OR, 1.45; 95% CI, 1.27–1.65; \(P < .001\)), and Asian/Pacific Islander patients (OR, 1.33; 95% CI, 1.15–1.54; \(P < .001\)). Compared with Medicare patients (reference group), more-urgent admissions were more common for Medicaid patients (OR, 1.76; 95% CI, 1.51–2.06; \(P < .001\)) and for self-pay patients (OR, 2.19; 95% CI, 1.58–3.05; \(P < .001\)) but were slightly less common for patients with private insurance (OR, 0.92; 95% CI, 0.88–0.97; \(P < .001\)). Higher median household income in the patient’s postal code of residence (by quartile) was associated with less-urgent admissions (OR, 0.94; 95% CI, 0.92–0.97; \(P < .001\)). There was evidence of heterogeneity in the analyses for Medicaid and self-pay patients.

### Severity of Disease at Presentation

#### Urgency of Admission

In subgroups defined by race or socioeconomic status, we sought evidence for different severity of disease at presentation by examining markers of admission urgency (admission type—emergency, urgent, or routine—analyzed using ordinal logistic regression). More-urgent admissions were significantly more common for black patients (OR, 1.71; 95% CI, 1.54–1.89; \(P < .001\)) (Table 6; Fig. 3), Hispanic patients (OR, 1.45; 95% CI, 1.27–1.65; \(P < .001\)), and Asian/Pacific Islander patients (OR, 1.33; 95% CI, 1.15–1.54; \(P < .001\)). Compared with Medicare patients (reference group), more-urgent admissions were more common for Medicaid patients (OR, 1.76; 95% CI, 1.51–2.06; \(P < .001\)) and for self-pay patients (OR, 2.19; 95% CI, 1.58–3.05; \(P < .001\)) but were slightly less common for patients with private insurance (OR, 0.92; 95% CI, 0.88–0.97; \(P < .001\)). Higher median household income in the patient’s postal code of residence (by quartile) was associated with less-urgent admissions (OR, 0.94; 95% CI, 0.92–0.97; \(P < .001\)). There was evidence of heterogeneity in the analyses for Medicaid and self-pay patients.

### Disease-Specific Markers of Severity

We also examined certain disease-specific end points as possible markers of disease severity at presentation. For tumors usually located supratentorially (primary brain tumors, meningiomas, and metastases), we used hemiparesis or hemiplegia (ICD-9-CM diagnosis codes 342.0–342.9) as the marker of severity. For acoustic neuromas, we used hydrocephalus (codes 331.3–331.4) as the marker of severity. Because the NIS did not contain a marker of presence at admission for these codes, we...
Black patients had more severe disease at presentation for all 4 tumor types (Table 7), as did Hispanic and Asian/Pacific Islander patients. For black patients, ORs were between 1.4 and 2.0, with P values between .1 and <.001 for the 4 tumor types. Disparities among Hispanic patients tended to be less severe. Patients whose primary payer was Medicaid had more severe disease at presentation for all 4 tumor types and significantly more severity for primary brain tumors (P = .007) and meningiomas (P = .03) (Table 7). Patients with private insurance who had acoustic neuromas had significantly less hydrocephalus (P = .001) and similar severity for the other 3 tumor types. After adjustment for race and insurance status, income in the patient’s postal code of residence was not a significant risk factor for severity at presentation for any tumor type.

**DISCUSSION**

We studied short-term outcomes after craniotomy for 4 tumor types (primary brain tumor, meningioma, metastasis, and acoustic neuroma) in a large number of patients treated in the United States using a nationally representative database, seeking disparities in outcome based on race, ethnicity, or socioeconomic status. Our results suggest that there are significant differences in outcomes across groups defined by these social factors. We found that patient groups with worse short-term outcomes typically received care at hospitals that had lower annual case volumes for

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**TABLE 5. Hospital Annual Case Volume for Racial and Socioeconomic Subgroups**

| Subgroup          | Pooled OR (95% CI) for 4 Tumor Types<sup>b</sup> | P Value | Heterogeneity Test (P Value) |
|-------------------|-----------------------------------------------|--------|-----------------------------|
| Race              |                                               |        |                             |
| White             | Reference group                               |        |                             |
| Black             | 0.90 (0.78–1.04)                              | .1     | .9                          |
| Hispanic          | 0.77 (0.62–0.95)                              | .02    | .9                          |
| Asian/Pacific Islander | 1.22 (0.95–1.55)                           | .12    | .9                          |
| Other race        | 0.86 (0.71–1.04)                              | .13    | .7                          |
| Missing race      | 0.79 (0.60–1.02)                              | .07    | .2                          |
| Primary payer     |                                               |        |                             |
| Medicare          | Reference group                               |        |                             |
| Medicaid          | 0.83 (0.75–0.92)                              | <.001  | .7                          |
| Private insurance | 1.07 (1.00–1.14)                              | .05    | .12                         |
| Self-pay          | 0.83 (0.62–1.11)                              | .2     | .07                         |
| Income in postal code of residence | 1.03 (0.97–1.09)                          | .3     | .2                          |

<sup>a</sup> OR, odds ratio; CI, confidence interval.  
<sup>b</sup> ORs and 95% CIs are compared with white patients for race, with Medicare patients for payer, and by quartile for income.
tumor craniotomy. Previous research has also demonstrated this correlation. The same patient groups had much more frequent urgent and emergency admissions for craniotomy compared with white patients and those with favorable insurance status. However, because our analyses adjusted for hospital volume and urgency of admission, these factors alone cannot explain our findings. We found additional, disease-specific evidence that groups with worse short-term outcomes also had more severe disease at presentation, such as more frequent hemiparesis for patients with primary brain tumors, meningiomas, and metastases and more frequent hydrocephalus for acoustic neuroma patients. Together, these findings suggest that lack of access to both timely care and to high-volume providers may be compromising patient outcomes for important socially defined groups of brain tumor patients in the United States.

There is substantial evidence that not all patients in the United States health care system receive the same quality of health care, and outcomes studies consistently demonstrate the predictable effects of these disparities. For example, both race and socioeconomic status or position have been shown to be important predictors of outcomes after complex surgical procedures both in the United States and in other countries. For example, Lucas et al found that black Medicare patients in the United States had higher operative mortality after 7 of 8 major surgical procedures examined, with crude odds of operative mortality more than 20% higher than for white patients. Birkmeyer et al reported differences in mortality of a similar magnitude for 6 major surgical procedures when comparing Medicare patients who lived in zip code regions with high or low socioeconomic status.

Similar disparities in access and outcome have been demonstrated for some neurosurgical procedures in the United States. Black patients have poorer access to carotid endarterectomy and worse short-term outcomes after the procedure. We have previously shown racial disparities in short-term outcomes after extracranial-intracranial bypass and clipping of unruptured aneurysms. Black patients are less likely to receive surgical treatment for epilepsy, although they appear to have an equal chance to benefit from the procedure. We have shown similar underrepresentation of black patients among persons receiving neurostimulators for Parkinson disease and more expensive treatments for trigeminal neuralgia, such as radiosurgery or microvascular decompression (W.T.C. and F.G.B., unpublished data, 2004). We have also documented better outcomes after craniotomies for brain tumor among white pediatric patients, who had lower in-hospital mortality and less frequent adverse discharge disposition than patients of other races. Some evidence has suggested that black patients diagnosed with malignant brain tumors may have shorter survival.

Here, we studied a large, nationally representative cohort of patients who underwent craniotomies for diverse types of brain tumor in the United States from 1988 to 2004. The database we used did not contain information on race from all participating states in the United States, although most missing information on race was attributable to individual states’ decisions not to report this variable. However, racial composition was similar for states that

### Table 6. Admission Type (Emergent/Urgent/Routine) for 4 Tumor Types by Race

| Race          | Primary Brain Tumors (%) | Meningiomas (%) | Metastases (%) | Acoustic Neuromas (%) | Pooled OR (95% CI) | P Value | Heterogeneity Test |
|---------------|-------------------------|-----------------|----------------|-----------------------|-------------------|---------|--------------------|
| White         | 24/20/56                | 12/14/74        | 27/22/50       | 2/6/92                | Reference group   |         |                    |
| Black         | 38/17/45                | 26/13/61        | 48/18/34       | 7/6/86                | 1.53 (1.39–1.67)  | .001    | 0.5                |
| Hispanic      | 33/18/49                | 21/12/67        | 37/23/40       | 3/4/93                | 1.41 (1.26–1.58)  | .001    | 0.3                |
| Asian/Pacific Islander | 29/13/58             | 14/8/78         | 37/15/48       | 1/5/95                | 1.25 (1.08–1.43)  | .002    | 0.8                |
| Other         | 28/17/56                | 19/12/69        | 29/20/51       | 6/5/89                | 1.10 (0.92–1.31)  | .3      | 0.3                |
| Missing race  | 24/24/52                | 14/17/69        | 26/24/49       | 2/8/90                | 1.03 (0.95–1.12)  | .4      | 0.7                |
| All patients  | 35/21/54                | 14/14/71        | 29/23/49       | 2/6/91                |                   |         |                    |

*OR, odds ratio; CI, confidence interval. Some totals differ from 100% due to rounding.

*Pooled adjusted ORs and 95% CIs for the 4 tumor types for each race, compared with white patients.
did or did not report race. The accuracy of the diagnosis and procedure codes in accurately and completely identifying the episodes of care we sought to study (craniotomy for 4 tumor types) has not been formally studied to our knowledge, and for some neurologic conditions, such as stroke or Parkinson disease, ICD-9 coding has been shown to be insensitive.69-72 However, hospitals are typically careful in coding primary surgical procedures for billing reasons, and parallel studies on invasive cardiac procedures such as angioplasty or bypass surgery have shown excellent coding accuracy.63 Although some tumors reported here could have been miscoded (eg, “primary brain tumor” when “metastasis” would have been correct), this is relatively unlikely, given that we only accepted concordant diagnosis/procedure ICD-9 coding pairs for all 4 tumor types in our study. Additionally, because our results showed no significant heterogeneity across different tumor types, such misclassifications would have had little effect on our findings to the extent that they did occur.

We found consistent evidence of poorer short-term outcomes for members of certain socially disadvantaged groups (both racially and socioeconomically defined) after craniotomies for tumors of all 4 types examined. Specifically, black patients had more frequent in-hospital mortality and adverse hospital discharge disposition than white patients after tumor craniotomies. Asian/Pacific Islander patients also had more frequent adverse hospital discharge disposition than whites. Compared with Medicare patients (reference group), Medicaid patients had higher mortality, whereas patients with private insurance were less likely to die in the hospital after tumor craniotomies. Judging by the magnitude of the hazard ratio, the disparities we found were most severe for black patients. Disparities persisted after multivariate adjustment for a variety of demographic variables.

Disparities in cancer-related health care outcomes may arise from many causes, including differences in disease processes, patient-related prognostic factors such as medical comorbidities, choice of surgeon or hospital, and factors arising from patient interactions with the health care system, such as whether a tumor is found through screening (such as mammography, or brain imaging in patients with systemic cancer) or symptomatically. Our results indicate that some disparities in short-term outcomes in brain tumor craniotomy patients may arise because certain groups of patients present to medical attention with more severe disease. For patients with brain tumor, emergency presentation is often a marker of tumors that are causing neurologic symptoms, either through increased intracranial pressure or proximity to eloquent cortex, and such patients are likely at higher risk for poor short-term outcome compared with patients with incidental or minimally symptomatic tumors. Urgent or emergency admissions were significantly more common among black, Hispanic and Asian patients in our cohort, as well as patients with less favorable insurance status (Medicaid or self-pay). Patients with private insurance and those who resided in wealthier areas were significantly more likely to have elective admissions. Similar findings have been reported previously for black patients undergoing complex general surgical procedures.32

Another explanation that has been recently proposed to explain health care disparities is the tendency for members of socioeconomically disadvantaged groups to receive care, including complex surgical procedures, at hospitals that have characteristically

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### TABLE 7. Disease-Specific Markers of Severity for 4 Tumor Types by Race and Socioeconomic Variables

| Race                  | Primary Brain Tumors: Hemiparesis | Meningiomas: Hemiparesis | Metastases: Hemiparesis | Acoustic Neuromas: Hydrocephalus |
|-----------------------|-----------------------------------|--------------------------|-------------------------|----------------------------------|
|                       | % OR P Value                       | % OR P Value             | % OR P Value            | % OR P Value                     |
| White                 | 10.6% Ref.                         | 5.4% Ref.                | 7.4% Ref.               | 2.3% Ref.                        |
| Black                 | 13.4% 1.4 <.001                    | 7.3% 1.4 .007           | 10.4% 1.4 .03           | 5.2% 2.0 .1                      |
| Hispanic              | 12.2% 1.1 .1                       | 7.4% 1.4 .008           | 12.6% 1.6 .001          | 4.5% 1.5 .3                      |
| Asian/Pacific Islander| 15.5% 1.5 .01                      | 9.0% 1.8 .001           | 14.8% 2.1 .001          | 3.3% 1.9 .2                      |
| Other race            | 8.2% 0.8 .2                        | 3.3% 0.6 .09            | 11.1% 1.7 .04           | 1.7% 0.3 .3                      |
| Missing race          | 9.3% 0.8 .03                       | 4.7% 0.7 .01            | 6.1% 0.7 .002           | 2.1% 0.6 .08                     |
| Primary payer         |                                    |                          |                         |                                  |
| Medicare              | 13.2% Ref.                         | 7.5% Ref.                | 8.2% Ref.               | 4.8% Ref.                        |
| Medicaid              | 11.3% 1.3 .007                     | 7.2% 1.4 .03            | 9.4% 1.3 .07            | 5.2% 0.5 .2                      |
| Private insurance     | 8.6% 1.0 .4                        | 3.8% 0.8 .09            | 6.4% 1.0 1.0            | 1.7% 0.3 .001                    |
| Self-pay              | 10.3% 1.0 1.0                      | 3.9% 0.7 .2             | 8.3% 1.1 1.7            | 2.7% 0.7 .5                      |
| Income in postal code | 1.0 1.0                            | 1.06 0.7                | 1.0 0.8                | 1.05 0.6                         |

a OR, odds ratio; Ref., reference group. ORs are compared with white patients for race, with Medicare patients for payer, and by quartile for income.
worse outcomes and poorer quality of care.26 Where patients are treated may actually explain a larger share of health care disparities than variations in quality of care within individual health care settings. Supporting this is evidence that hospitals in economically disadvantaged areas are more likely to lack structural components of high-quality care, such as high-technology equipment and adequate staffing with intensivists and nurses.64-68 Another marker of high-quality care for brain tumor surgery is high annual volume of surgery, as has been shown by our group and others.12-15,27,28 In the present study, we found that black patients, Hispanic patients, and patients with Medicaid insurance were more likely to receive surgery at lower-volume hospitals, whereas patients with private insurance received care at higher-volume hospitals. Again, our findings are similar to those documented for both racial and socioeconomic disparities in complex general surgical procedures.26-32

Although these findings may partially explain the difference in gross mortality and morbidity rates we observed, our analysis was adjusted using multivariate models for both urgency of admission and hospital volume of care. It is likely that the effects of these variables are not entirely controlled by our analysis and that the interplay of other complex factors may also explain the disparities. Multiple explanations have been proposed to explain American health care disparities,1 and our analysis is not capable of distinguishing between them. Socially disadvantaged groups typically contain more persons who are uninsured or poorly insured and lack access to regular contact with defined primary care physicians and expensive diagnostic imaging tests. Such patients may fail to seek care for minor complaints for these reasons, or wait times may be longer.1,69 Supporting this argument is the fact that patients may actually explain a larger share of health care disparities than variations in quality of care within individual health care settings. Supporting this is evidence that hospitals in economically disadvantaged areas are more likely to lack structural components of high-quality care, such as high-technology equipment and adequate staffing with intensivists and nurses.64-68 Another marker of high-quality care for brain tumor surgery is high annual volume of surgery, as has been shown by our group and others.12-15,27,28 In the present study, we found that black patients, Hispanic patients, and patients with Medicaid insurance were more likely to receive surgery at lower-volume hospitals, whereas patients with private insurance received care at higher-volume hospitals. Again, our findings are similar to those documented for both racial and socioeconomic disparities in complex general surgical procedures.26-32

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COMMENT

Curry et al have performed an important and thought-provoking study that assesses the effects of race, ethnic group, and socioeconomic status on short-term outcome for patients undergoing a craniotomy for brain tumor in the United States. On the basis of data from the Nationwide Inpatient Sample (NIS) hospital discharge database, the authors studied nearly 100 000 adult patients admitted to a hospital for a brain tumor resection between 1988 and 2004. Race was specified in more than 70 000 of these patients, which enabled analysis regarding the effect of race on outcome. Using in-hospital mortality and disposition at hospital discharge as primary endpoints, the authors used multivariate regression analysis to determine the effects of race, ethnic group, and socioeconomic status on short-term outcome with correction for multiple possible confounding variables. Analysis was performed separately for primary brain tumors, metastases, meningiomas, and acoustic neuromas.

For each of these 4 tumor types, the authors found that black patients were more likely to have died in the hospital or to have adverse discharge disposition (defined as discharge to a location other than home) than patients who were white, Hispanic, or Asian/Pacific Islander. Blacks were more likely to be cared for at lower-volume centers and to present to the hospital with higher disease severity, as defined by requirement for urgent admission, the presence of hydrocephalus for acoustic neuromas, and hemiparesis or hemiplegia at presentation with primary brain tumors, meningiomas, and metastases. However, even when the data were controlled for care at a lower-volume center and greater disease severity, black patients still had significantly worse outcomes than white patients. Hispanic patients, as well as those with Medicaid, also tended to be treated at lower-volume hospitals than white patients. Hispanics, blacks, and Asian/Pacific Islander patients all had higher rates of urgent admission than whites, but only blacks had higher in-patient mortality. For all racial and ethnic groups, patients receiving care at a low-volume center were more likely to have worse outcomes, a finding which has been previously reported for patients with brain tumors and many other diseases.

In addition to racial and ethnic variation, the role of socioeconomic status in determining outcome for patients with brain tumors was studied. The authors found that, when compared with patients with Medicare, those with Medicaid had significantly increased mortality, and those with private insurance had decreased mortality. Interestingly, household income, as assessed by postal code of residence, did not predict in-hospital mortality. The validity of this finding, in my opinion, may be limited by the inability of this data set to distinguish between patients within a given postal code who have wide disparities in income. Median household income would perhaps be a more meaningful tool in assessing the effect of socioeconomic status on outcome, but this information is presumably not available using the NIS database.

Although the authors’ primary conclusion that black patients with brain tumors are more likely to have adverse short-term outcomes than whites or other racial/ethnic groups is likely to be valid, determining exactly why this is true is difficult, both because of the limitations of the data used to draw this conclusion and because of the likely variation in its cause or causes in communities around the country. Many questions relevant to this finding cannot be answered on the basis of data from the NIS database. For example, would the authors’ statistical results regarding racial...
disparity be altered if the multivariate analysis could also control for the highest educational level of the patient and his/her family members? One would assume that higher educational level would correlate with a higher likelihood to seek care from an expert at a high-volume center and perhaps with an ability to overcome the many obstacles to obtaining timely medical care in our current health care system. Additionally, pertinent clinical details are lacking in a data set of this size. For patients with metastatic disease, were black patients more likely to have a greater number of metastases or leptomeningeal disease at presentation? Are there any racial or ethnic disparities regarding tumor location (eg, are black patients more likely to have tumors in the thalamus, brainstem, or other locations, rendering an aggressive surgical resection either less likely or more hazardous)? For patients with primary brain tumors or acoustic neuromas, were black patients more likely to present with larger tumors? Although corrections were made for medical comorbidity in the multivariate regression analysis, it is unclear whether the NIS database allows for distinctions in the severity of each comorbidity. Were black patients with heart failure, diabetes mellitus, or obesity, for example, more likely to have more advanced cases of these clinical conditions than white patients, increasing the risk of death or morbidity in the perioperative period?

Cultural factors may influence one of the primary outcome end points, disposition at hospital discharge. It is possible, for example, that some ethnic groups may be more likely than others to prefer caring for a debilitated family member at home rather than having the patient discharged to an outside care facility. If this is the case, then a patient with the same neurologic deficit or other morbidity may be more likely to be discharged to a nursing home in one racial or ethnic group and to be discharged home in another group. Analysis of this data set does not allow questions such as this one to be answered.

Despite the inherent limitations in the data set studied, the study’s findings are compelling and will hopefully inspire significant thought among neurosurgeons reading this article. I strongly agree with the authors’ conclusion that, although there is no easily achieved simple remedy for the disparities found by this study, raising neurosurgeons’ awareness of the existence of these disparities is an important first step toward finding solutions that will eventually eliminate them. The authors have achieved this first step and have performed a study that will stir the social conscience of the neurosurgical community. My hope is that this study will inspire each of us to do everything possible within our own communities to improve access to first-rate neurosurgical care for all patients, regardless of race, ethnicity, or socioeconomic status.

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