Disparities in Access to Neuro-oncologic Care in the United States

Debraj Mukherjee, MD, MPH; Hasan A. Zaidi, BS; Thomas Kosztowski, BS; Kaisorn L. Chaichana, MD; Henry Brem, MD; David C. Chang, PhD, MPH, MBA; Alfredo Quinones-Hinojosa, MD

Hypothesis: Race/ethnicity and social status influence admission to high-volume hospitals among patients who undergo craniotomy for tumor biopsy or resection.

Design: Retrospective analysis of the Nationwide Inpatient Sample (1988-2005), with additional factors from the Area Resource File.

Setting: A 20% representative sample of all hospitals in 37 US states.

Patients: A total of 76,436 patients 18 years or older who were admitted and underwent craniotomy for tumor biopsy or resection.

Main Outcome Measures: Odds ratios (ORs) for the association of age, sex, race/ethnicity, insurance status, Charlson Comorbidity Index, and county-level characteristics with admission to high-volume hospitals (>50 craniotomies per year) or low-volume hospitals.

Results: A total of 25,481 patients (33.3%) were admitted to high-volume hospitals. Overall access to high-volume hospitals improved over time. However, racial/ethnic disparities in access to high-volume hospitals dramatically worsened for Hispanics (OR, 0.49) and African Americans (OR, 0.62) in recent years. Factors associated with better access to high-volume hospitals included years since 1988 (OR, 1.11), greater countywide neurosurgeon density (OR, 1.66), and higher countywide median household income (OR, 1.71). Factors associated with worse access to high-volume hospitals included older age (OR, 0.34 per year increase), increased countywide poverty rate (OR, 0.57), Hispanic race/ethnicity (OR, 0.68), and higher Charlson Comorbidity Index (OR, 0.96 per point increase).

Conclusions: African Americans and Hispanics have disproportionately worse access to high-quality neuro-oncologic care over time compared with whites. Higher countywide median household income and decreased countywide poverty rate were associated with better access to high-volume hospitals, implicating socioeconomic factors in predicting admission to high-quality centers.

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See Invited Critique at end of article

Over the past decade, numerous studies have examined the association between treatment at high-volume hospitals and improved outcomes. Within surgical subspecialties, this association has been observed in neurosurgery, and in bariatric, cataract, breast, colorectal, urologic, and cardiothoracic surgery. To date, no major studies have tracked disparity trends relative to specialized high-volume hospital care over time while concomitantly exploring novel prehospitalization determinants of access.

Improving access to care by reducing disparities has long been a goal of public health and clinical practice. The field has focused on identifying subgroups of patients who are at greatest risk of poor access to specialty or potentially lifesaving care, including neurosurgical care. Studies about determinants of access to care have traditionally included patient characteristics such as age or race/ethnicity. This study seeks to further explore traditional factors and upstream factors using a novel method of linking 2 national databases to investigate previously unstudied socioeconomic determinants of health care access that are possibly amenable to health policy intervention, including countywide neurosurgeon density and countywide poverty rate. By analyzing these factors, this study seeks to better understand recent trends and disparities in access to specialized high-quality neuro-oncologic care in the United States to identify key targets for future policy intervention. We hypothesized that, despite greater national emphasis on the development of centers of excellence and the elimination of health care barriers, there remain deep
disparities in access to specialized neuro-oncologic care nationwide based on race/ethnicity and social status.

METHODS

PATIENT POPULATION

A retrospective analysis of the Nationwide Inpatient Sample (NIS) (1988-2005) was performed. The NIS is a database compiled by the Agency for Healthcare Research and Quality comprising discharge information from approximately 7 million inpatient hospitalizations annually. It contains a 20% representative sample of all hospitals in 37 states. Available data include patient and hospital demographics, payer information, primary and concomitant diagnoses, inpatient treatments and procedures, inpatient mortality, and length of stay. This publicly available data set was exempted from study approval by the Johns Hopkins Institutional Review Board.

Data concerning patients’ socioeconomic background and environment were obtained from the Area Resource File (ARF), also exempted from study approval by the Johns Hopkins Institutional Review Board. The ARF is a large database compiling national statistics from more than 50 sources, including the US Census Bureau and the National Center for Health Statistics. The ARF provides a cross-sectional view of more than 6000 socioeconomic and environmental variables of interest for each county within the United States. These data include countywide poverty rates and countywide neurosurgeon densities.

An underlying assumption that the relative countywide poverty rates, countywide neurosurgeon densities, and other ARF data elements were unlikely to drastically change over time was tested and confirmed by querying these data elements in random years of the ARF between 1988 and 2007. Countywide data elements from the 2007 ARF were linked to specific patient and hospital events in the NIS from 1988 to 2005 by a common 3-digit state-modified or county-modified Federal Information Processing Standards (FIPS) code that is unique to each hospital and county in the United States. By linking the NIS with the most recent version of the ARF, we were able to infer new information, unavailable in the large NIS database alone, about the environments in which patients were most likely to reside. In doing so, we were able to draw associations between patients’ prehospitalization environmental determinants of health and access to neuro-oncologic care at high-volume hospitals. The results of multivariate analysis following linkage of the NIS (1988-2005) to the 2007 ARF were replicated with selected other years from the ARF ranging from 1988 to 2007, with no statistically significant (P < .05) difference in outcomes. Therefore, for succinctness and clarity, we present in this study the results of a single multivariate analysis using the most recent 2007 ARF, representative of numerous multivariate analyses run on the 1988 to 2007 ARFs.

Inclusion criteria used to identify patients in the NIS were a primary International Classification of Diseases, Ninth Revision (ICD-9) diagnosis code of brain tumor or any ICD-9 procedure code consistent with craniotomy for tumor biopsy or resection. This included 18 diagnosis codes and 52 procedure codes (Table 1). Patients younger than 18 years were excluded from the study.

OUTCOMES

The primary outcome assessed in this study was admission to a high-volume hospital. Criteria for defining operative high-volume hospitals were obtained from the literature. High-volume craniotomy centers have been defined as those performing more than 41 craniotomies per year by Tigliev and Chernov and more than 50 craniotomies per year by Long et al. This study used the threshold by Long et al of more than 50 craniotomies per year to define high-volume hospitals to incorporate the most strict criteria. A sensitivity analysis using the lower threshold by Tigliev and Chernov of 41 craniotomies per year yielded similar results to those presented herein.

Patient-level covariates available in the NIS included age, sex, race/ethnicity, Charlson Comorbidity Index, median household income, and insurance status. The Charlson Comorbidity Index is a standardized 10-point measure of patient comorbidities and is determined by weighted evaluation of preexisting health conditions, including cardiac, vascular, pulmonary, neurologic, endocrine, renal, hepatic, gastrointestinal, and immune diseases, as well as any documented history of cancer. The Charlson Comorbidity Index was adapted for use in administrative data sets by Romano et al. Income, a measure of actively incoming economic value, was assessed using the median household income of a patient’s county. This value was adjusted for inflation from 1988 to 2005. Our study reports quartiles of countywide median household income as defined by the NIS.

Environmental or area-specific covariates of patients in the ARF included countywide poverty rates and countywide neurosurgeon densities. Reference groups in the multivariate analysis included age 18 to 24 years, male sex, white race/ethnicity, uninsured status, and the lowest median household income
(<$25,000/y from 1988-2002 and <$36,000/y from 2003-2005).

**STATISTICAL ANALYSIS**

Statistical analyses were performed using commercially available software (STATA/MP 10; StataCorp LP, College Station, Texas). Multivariate analyses were performed using multivariate logistic regression models, adjusting for age, sex, race/ethnicity, Charlson Comorbidity Index, insurance status, geographic region, urbanicity, median household income, countywide poverty rate, countywide percentage of non-English speakers, countywide neurosurgeon density, and years since 1988. P<.05 was considered statistically significant.

## PATIENT CHARACTERISTICS

A total of 76,436 patients with brain tumor–related neurosurgical intervention were identified using ICD-9 diagnosis and procedure codes in this 20% representative sample of inpatients in 37 US hospitals over an 18-year period (1988-2005) (Table 2). Of these, 25,481 patients (33.3%) were admitted to high-volume hospitals. Among the total cohort, patients had a mean (median) age of 55.6 (55) years, and 56.1% were female. Most patients (81.1%) were of white race/ethnicity. Patients had a mean (median) Charlson Comorbidity Index of 1.47 (2), representing few comorbidities. Almost all patients (99.8%) were insured. Results were stratified by diagnosis code, including malignant neoplasms, benign neoplasms, and neoplasms of uncertain behavior. Stratified results were similar to overall results, with low-volume and high-volume hospitals having a similar diagnostic case mix. Disparities in access to care noted among all patients were similar to those noted among stratified subsets. Therefore, for succinctness and clarity, we present in this study the results of a single multivariate analysis using overall data, representative of numerous multivariate analyses among patients with subtypes of brain tumors.

### PATIENT COUNTY (ZIP CODE) CHARACTERISTICS

Patients were evenly distributed among 4 median household income brackets. The mean (median) countywide poverty rate was 10.7% (10.6%) (Table 2). The mean (median) countywide neurosurgeon density per 100,000 population was 2.64 (2.28).

### PATIENT DISTRIBUTION ACROSS HOSPITALS

Few patients (33.3%) with brain tumor were seen at high-volume hospitals. The number of patients undergoing operative treatment for brain tumor remained stable over 18 years, ranging from 2,117 to 3,165 patients per year. However, the overall proportion of patients with brain tumor undergoing operative treatment at high-volume hospitals increased from 23.9% of patients in 1988 to 43.6% of patients in 2005. Furthermore, the overall odds for admission to high-volume hospitals during latter years of the analy-

## RESULTS

### Table 2. Patient Characteristics, Distribution, and Countywide Data Among 76,436 Patients With Brain Tumor–Related Neurosurgical Intervention From 1988 to 2005

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient Characteristics</strong></td>
<td></td>
</tr>
<tr>
<td>Age, mean (median), y</td>
<td>55.8 (55)</td>
</tr>
<tr>
<td>Race/ethnicity, No. (%)a</td>
<td>(n=53,457)</td>
</tr>
<tr>
<td>White</td>
<td></td>
</tr>
<tr>
<td>African American</td>
<td>9,992 (18.6)</td>
</tr>
<tr>
<td>Hispanic</td>
<td>3,644 (6.8)</td>
</tr>
<tr>
<td>Asian</td>
<td>1,200 (2.2)</td>
</tr>
<tr>
<td>Native American</td>
<td>100 (0.2)</td>
</tr>
<tr>
<td>Other</td>
<td>1,213 (2.3)</td>
</tr>
<tr>
<td>Sex, No. (%)</td>
<td>(n=76,436)</td>
</tr>
<tr>
<td>Male</td>
<td>33,559 (43.9)</td>
</tr>
<tr>
<td>Female</td>
<td>42,877 (56.1)</td>
</tr>
<tr>
<td>Charlson Comorbidity Index, mean (median)</td>
<td>1.47 (2)</td>
</tr>
<tr>
<td>Insurance status, No. (%)</td>
<td>(n=71,026)</td>
</tr>
<tr>
<td>Insured</td>
<td>70,865 (99.8)</td>
</tr>
<tr>
<td>Uninsured</td>
<td>161 (0.2)</td>
</tr>
<tr>
<td><strong>Distribution, No. (%) (n=76,542)</strong></td>
<td></td>
</tr>
<tr>
<td>Hospital volume</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>25,481 (33.3)</td>
</tr>
<tr>
<td>Low</td>
<td>51,061 (66.7)</td>
</tr>
<tr>
<td>Geographic region</td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>15,906 (20.8)</td>
</tr>
<tr>
<td>Midwest</td>
<td>16,566 (21.6)</td>
</tr>
<tr>
<td>South</td>
<td>23,457 (33.3)</td>
</tr>
<tr>
<td>West</td>
<td>18,613 (24.3)</td>
</tr>
<tr>
<td><strong>Countywide Data</strong></td>
<td></td>
</tr>
<tr>
<td>Median household income, $, No. (%) (n=73,361)</td>
<td></td>
</tr>
<tr>
<td>&lt;36,000</td>
<td>13,039 (17.8)</td>
</tr>
<tr>
<td>36,000-44,999</td>
<td>15,971 (21.8)</td>
</tr>
<tr>
<td>45,000-59,999</td>
<td>16,386 (22.3)</td>
</tr>
<tr>
<td>≥60,000</td>
<td>27,974 (38.1)</td>
</tr>
<tr>
<td>Poverty rate, median (median), %</td>
<td>10.7 (10.5)</td>
</tr>
<tr>
<td>Neurosurgeon density per 100,000 population, mean (median)</td>
<td>2.64 (2.28)</td>
</tr>
</tbody>
</table>

*Not all states collected information on race/ethnicity; therefore, 30.0% of race/ethnicity data are missing. Due to rounding the percentages do not total 100%.

sis (2001-2005) were more than 3 times the odds for admission to such centers during earlier years (1988-1995).

Over the 18-year period examined, there was no statistically significant difference in access to high-volume hospitals between African Americans and whites, while Hispanics were significantly less likely to be seen at high-volume hospitals (Figure). However, when examined across shorter periods, the odds for access to neuro-oncologic care at high-volume hospitals among African Americans and Hispanics were dramatically reduced over time. In the late 1980s and early 1990s, African Americans (odds ratio [OR], 1.42; 95% confidence interval [CI], 1.16-1.74) and Hispanics (OR, 0.49; 95% CI, 0.41-0.59) had similar or slightly higher odds for admission to high-volume hospitals compared with whites. Following a steady decline over time, African Americans (OR, 0.62; 95% CI, 0.53-0.74) and Hispanics (OR, 0.49; 95% CI, 0.41-0.59) were significantly less likely than whites to be admitted to high-volume hospitals over the last 4 years examined (2001-2005).
FACTORS ASSOCIATED WITH ACCESS TO HIGH-VOLUME HOSPITALS

Factors associated with access to high-volume hospitals were demonstrated on adjusted multivariate logistic regression analysis. The largest categorical ORs are reported (P < .05 for all). The following factors were associated with increased access to high-volume hospitals: years since 1988 (OR, 1.11), greater countywide neurosurgeon density (OR, 1.66), and higher countywide median household income (OR, 1.71) (Table 3). The following factors were associated with decreased access to high-volume hospitals: older age (OR, 0.34), increased countywide poverty rate (OR, 0.57), Hispanic race/ethnicity (OR, 0.68), and higher Charlson Comorbidity Index (OR, 0.96). Factors not affecting access to high-volume hospitals to a statistically significant degree included female sex and insurance status.

COMMENT

In this study, we demonstrate by multivariate analysis using a novel protocol linking 2 large national databases that the likelihood of being admitted to high-volume hospitals for specialized neuro-oncologic surgical care has improved for patients overall during the past 18 years. However, deep disparities in access to care for certain groups, including African Americans and Hispanics, have significantly worsened over time, despite increased national emphasis on reducing racial/ethnic barriers. We also identified several previously undescribed associations between prehospitalization factors, including countywide poverty rate, countywide median household income, and countywide neurosurgeon density, that may help further inform and alleviate persistent disparities in access to specialized care for minorities.

Numerous studies discuss access barriers to general medical and surgical care. Since publication of the breakthrough Crossing the Quality Chasm by the Institute of Medicine in 1998, there has been greater emphasis on reducing disparities in access to care while concomitantly developing national centers of excellence for specialized care. To our knowledge, ours is the first study to use national databases to explore the relationship between greater specialization of care and disparities in access. Disturbingly, we find that access to high-volume hospitals for minorities has significantly worsened over time, despite national efforts to counter such trends.

While our results demonstrate persistently worse access to care among Hispanics, our combined findings over 18 years initially demonstrated no statistically significant difference in care between African Americans and whites (Figure). However, on further analysis, access to high-volume hospitals steadily declined for Hispanics and for African Americans, perhaps demonstrating the need to more closely examine recent findings that national disparities are being reduced. In the field of specialized surgical care, Mukamel et al noted decreasing rates of racial/ethnic access barriers to coronary artery bypass surgery. However, that study reports on patients during a limited period (1997-2003) and uses the New York State Cardiac Surgery Reports data set, which is much more limited in time and scope than the NIS. Our findings are more in line with publications demonstrating current racial/ethnic disparities in specialized surgical care, including studies in the fields of transplant surgery, gastrointestinal surgery, and orthopedic surgery. A unique finding of our study is that, despite increased attention to such barriers, access to care has dramatically worsened over recent years.

It has been suggested that the cause of these persistent disparities is multifactorial, with language barriers, cultural differences in health behaviors, and even basic transportation issues likely contributing to minority populations having reduced access to quality medical care. Our analysis sought to identify possible targets to alleviate these barriers by examining additional prehospitalization covariates associated with worse access such as older age, higher Charlson Comorbidity Index, lower countywide median household income, increased...
countywide poverty rate, and decreased countywide neurosurgeon density.

In our study, older patients with brain tumor were less likely to be admitted to high-volume hospitals. Similar results are reported in the neurology literature, with Rudd et al. demonstrating that older patients had worse access to care following cerebrovascular accident. Sudore et al. suggest that additional factors independently associated with age such as poor literacy may undervalue the association between older age and worse access, although further research to confirm such hypotheses has not yet been published to date. To our knowledge, this study is the first to report a direct association between older patient age and worse access to complex neurooncologic specialty care.

We also demonstrate that patients with more comorbidities, as assessed by a higher Charlson Comorbidity Index, had worse access to care. Although similar trends are reported in the general medical literature, our study represents one of the first to date to report an association between more comorbidities and worse access to care among patients undergoing surgical subspecialty care.

In addition, we report that patients with higher countywide median household income were significantly more likely to be admitted to high-volume hospitals (Table 3). Conversely, our work demonstrates that patients with higher countywide poverty rates were significantly less likely to be admitted to high-volume hospitals. The mechanism by which countywide median household income may influence access to quality medical centers is complicated and warrants further investigation. For example, it is well known that patients of lower socioeconomic status are more likely to engage in risky health behavior such as smoking and alcohol consumption and are more likely to have medical comorbidities such as obesity and diabetes. Additional psychosocial risk factors that are more prevalent among the less wealthy such as depression and weak social support suggest that patients from lower socioeconomic backgrounds lack health care knowledge and community support that emphasize and reinforce the importance of receiving high-quality health care. Health care policies that serve to improve medical education and build social support among low-income patients may help reduce the disparities highlighted in our study.

We also report that patients residing in counties with greater neurosurgeon density are much more likely to be admitted to high-volume hospitals (Table 3). Rising medical malpractice costs, declining reimbursement rates, an increase in liability concerns, and a decreasing number of practicing neurosurgeons relative to the growing American population have resulted in mounting public concern about inadequate neurosurgical coverage in large parts of the United States. A lack of subspecialty surgeons has translated to poor patient care, with Byrne et al. reporting that fewer neurosurgeons in Cook County, (Illinois), community hospitals resulted in dangerously longer time to treatment for patients in need of emergency care. Ours is the first national study to date to demonstrate a direct correlation between countywide subspecialty surgeon density and access to care during almost 2 decades. Health policy interventions aimed at recruiting subspecialty surgeons to underserved populations may help reduce some disparities highlighted in this study.

This analysis is subject to weaknesses inherent to all retrospective studies using national administrative databases. Given the inability of the data set to capture successive hospital visits, our results may underrepresent the true incidence of patients with brain tumor undergoing neurosurgical intervention. However, such limitations are likely evenly distributed throughout the data set. Therefore, we believe that the large sample analyzed in this study validity characterizes patients with brain tumor undergoing operative care at a representative subset of hospitals across the United States. Given our precise outcome measure of admission to a high-volume hospital, our findings offer useful insight for surgical subspecialists and health policy experts into the relationship between various upstream prehospitalization socioeconomic determinants of health that are amenable to change and access to potentially lifesaving neuro-oncologic care.

In presenting a new method to link 2 interrelated databases, we took particular care to ensure that it is sound.
In conclusion, our unique method of linking 2 large administrative databases identified previously unstudied countywide socioeconomic and environmental factors that have a critical role in access to quality health care in the United States. Elimination of health care barriers by targeted means remains essential to the practice of modern medicine. Prospective studies may more fully elucidate the causes of the trends identified in this study to ensure that targeted interventions improve access to specialized neuro-oncologic care throughout the United States in the years to come.

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Correspondence: Alfredo Quinones-Hinojosa, MD, Neuro-Oncology Surgical Outcomes Research Laboratory, Department of Neurosurgery and Oncology, The Johns Hopkins School of Medicine, 1550 Orleans St, Cancer Research Bldg II, Room 253, Baltimore, MD 21231 (aquilon2@jhmi.edu).

Author Contributions: Dr Quinones-Hinojosa had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Mukherjee, Chang, and Quinones-Hinojosa. Acquisition of data: Mukherjee and Chang. Analysis and interpretation of data: Mukherjee, Zaidi, Kosztowski, Chaichana, Brem, Chang, and Quinones-Hinojosa. Drafting of the manuscript: Mukherjee and Chang. Analysis and interpretation of data: Mukherjee, Zaidi, Kosztowski, Chaichana, Brem, Chang, and Quinones-Hinojosa. Critical revision of the manuscript for important intellectual content: Mukherjee, Zaidi, Kosztowski, Chaichana, Brem, Chang, and Quinones-Hinojosa. Statistical analysis: Mukherjee, Chang, and Quinones-Hinojosa. Obtained funding: Chang and Quinones-Hinojosa. Administrative, technical, and material support: Chang and Quinones-Hinojosa. Study supervision: Chang and Quinones-Hinojosa.

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Additional Contributions: Chaitali Mukherjee, MD, MPH, critically reviewed the manuscript.

REFERENCES

What Do We Gain and Lose From Database Studies?

This work by Mukherjee and coworkers provides valuable insight into health care disparities in the United States with regard to access for neuro-oncologic care. Such work is important in elucidating necessary policy interventions, and the authors are to be applauded for their efforts. While findings of regional neurosurgeon density, younger patient age, and higher median county income expectedly correlate with increased access to high-quality care, a surprising finding from multivariate analysis was that Hispanic race/ethnicity independently further predicted less access to such care.

Quality of surgical care was evaluated by the surrogate variable of case volume of the treatment center. High-quality neuro-oncologic care was defined by a treatment load of more than 50 craniotomies per year, which effectively reduces to 1 craniotomy per week at a given institution. The group provides support from other data set work based on volume stratification deciding these thresholds, but that work as well is retrospective and illustrative primarily of mortality, length of stay, hospitalization cost, and discharge destination.

Studies based on such nationwide databases have advantages of large patient samples to increase study power and facilitate multivariate analysis, broad ranges of treating physicians for whom the results are consequently generalizable, and access to socioeconomic data that may be unavailable from conventional medical record review.