ORIGINAL ARTICLE

Postoperative Mortality After Surgery for Brain Tumors by Patient Insurance Status in the United States

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Objective: To examine whether being uninsured is associated with higher in-hospital postoperative mortality when undergoing surgery in the United States for a brain tumor.

Design: Retrospective cohort study using the Nationwide Inpatient Sample, January 1, 1999, through December 31, 2008.

Setting: The Nationwide Inpatient Sample contains all inpatient records from a stratified sample of 20% of hospitals in 37 states.

Patients: A total of 28 581 patients, aged 18 to 65 years, who underwent craniotomy for a brain tumor. Three groups were studied: Medicaid recipients and privately insured and uninsured patients.

Main Outcome Measure: The main outcome measure was in-hospital postoperative death. Associations between this outcome and insurance status were examined within the full cohort and within the subset of patients with no comorbidity using Cox proportional hazards models. These models were stratified by hospital to control for any clustering effects that could arise from differing access to care.

Results: In the unadjusted analysis, the mortality rate for privately insured patients was 1.3% (95% CI, 1.1%-1.4%) compared with 2.6% for uninsured patients (95% CI, 1.9%-3.3%; $P < .001$) and 2.3% for Medicaid recipients (95% CI, 1.8%-2.8%; $P < .001$). After adjusting for patient characteristics and stratifying by hospital in patients with no comorbidity, uninsured patients still had a higher risk of experiencing in-hospital death (hazard ratio, 2.62; 95% CI, 1.11-6.14; $P = .03$) compared with privately insured patients. In this adjusted analysis, the disparity was not conclusively present in Medicaid recipients (hazard ratio, 2.03; 95% CI, 0.97-4.23; $P = .06$).

Conclusions: Uninsured patients who underwent craniotomy for a brain tumor experienced the highest in-hospital mortality. Differences in overall health do not fully account for this disparity.

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INEQUALITIES IN HEALTH CARE CONtinue to be a matter of public concern. As new legislation is being developed to improve health care access in the United States, an examination of factors that give rise to differences in health outcomes would be especially informative. Insurance status may be associated with differences in specialized medical and surgical care. For many surgical procedures, including hypophysectomy,[1] lung resection,[2] coronary artery bypass,[2] and gastrointestinal procedures,[2,3] nonprivately insured patients fare worse postoperatively than privately insured patients. The mechanisms responsible for insurance-related disparities have not been identified, but public health efforts could be targeted more effectively if more about them were known.

Limited research has examined insurance-related disparities in patients undergoing surgery for brain tumors. Approximately 612 000 people in the United States have a diagnosis of a primary brain or central nervous system tumor.[4] Malignant brain tumors cause 13 000 deaths annually[5] and have a 5-year survival rate of approximately 35%.[6] Existing therapies only modestly extend survival. Even small improvements on this prognosis might be meaningful, regardless of whether they are achieved by medical advances or nonclinical means, such as public health efforts.

See Invited Critique at end of article

We hypothesized that after craniotomy for brain cancer, uninsured patients experience higher rates of in-hospital death compared with privately insured patients. To evaluate this hypothesis, we analyzed in-hospital mortality rates in the Nationwide Inpatient Sample (NIS),

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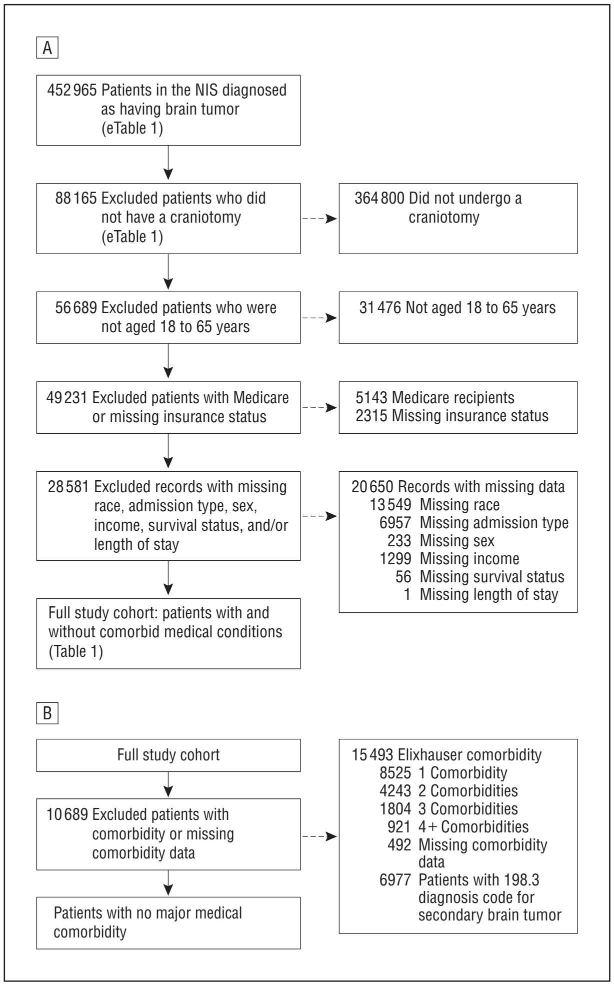

Figure 1. Flow of patients in the study. A, Derivation of the final study cohort. A total of 78 210 598 patient records were available in the Nationwide Inpatient Sample (NIS) database from 1999 to 2008. Of these, 28 581 patients underwent a craniotomy for a brain tumor; were 18 to 65 years of age; had private insurance, Medicaid, or no insurance; and had no missing data. B, For the subset analysis of patients with no major medical comorbidity, 17 892 records were excluded because of the presence of a comorbidity or missing comorbidity data, leaving 10 689 patients with no major comorbid condition.

the largest all-payer inpatient database. Because any disparity could be attributed to baseline differences in overall health, we decided to include a subset analysis of patients with no major comorbidity. Furthermore, we controlled for possible patient clustering effects that could arise from differences in access to care.

METHODS

PATIENT POPULATION

This is a population-based, retrospective cohort study of patients hospitalized for surgical treatment of brain cancer in the United States from January 1, 1999, through December 31, 2008. The data source was the Agency for Healthcare Research and Quality's (AHRQ's) NIS. The NIS contains all patient records from a stratified sample of 20% of nonfederal short-term hospitals in 37 states. The sample is representative of hospitals in these states along the parameters of region, urban vs rural locale, teaching status, bed size, and public ownership. The last 10 years of data were thought to be the most appropriate timeframe to analyze because they are most reflective of the current state of Medicaid recipients and the uninsured. Significant changes in the economy and government support programs for the poor occurred during the mid-1990s, and these changes could percolate into the ability to access health care through mechanisms that are not identified or understood. This publicly available, deidentified database was exempt from review by an institutional review board.

PATIENT SELECTION

Patients 18 to 65 years of age were included if they had a diagnosis consistent with a brain tumor per *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) codes; were admitted for a craniotomy per *ICD-9-CM* procedural codes; and had private insurance, Medicaid, or no insurance (eMethods 1.1 and eTable 1 [http://www.archsurg.com], as well as **Figure 1**A). Patients older than 65 years were not included because age-related factors in this population could exert the dominant influence on postoperative prognosis. Patients younger than 18 years were not included because younger patients are affected by different types of brain tumors than adults (eMethods 1.2). Patients with Medicare were excluded because individuals younger than 65 years are not eligible for Medicare unless they are in a severe medical state. Eligibility for Medicare for individuals younger than 65 years is limited to those who are permanently disabled (for >2 years), have end-stage renal disease, or have amyotrophic lateral sclerosis. Patients were excluded if data on insurance type, race, admission type, sex, income, length of stay, and/or survival status were missing (eMethods 1.3 and eTable 2).

COVARIATES

The primary variable of interest was insurance status, classified as private, Medicaid, or uninsured (eMethods 1.4). Patient characteristics that were studied included admission type, age, sex, race, income, malignant vs benign tumor characteristics, and year. Admission type was classified as emergent, urgent, or elective, as defined by the AHRQ criteria. Race was assessed because prior studies[7-10] reported that African Americans have less access to neuro-oncologic care and poorer neurosurgical outcomes. Race was classified according to categories predefined by state inpatient databases from which the NIS derives. Available categories were white, black, Hispanic, Asian/Pacific Islander, Native American, other, or unspecified. Patients classified as other or unspecified were not analyzed because it is difficult to infer the racial composition of this group. Income data from 1999 to 2002 were supplied as a range and were merged into income quartile data from 2003 to 2008 (eMethods 1.5).

ROLE OF COMORBID CONDITIONS

For each medical record, we determined whether a major medical comorbidity was present using the Elixhauser method.[11] The Elixhauser method is designed to minimize the possibility of mislabeling as a comorbidity a condition that was, in reality, related to the primary reason for the hospitalization (as reflected in the principal diagnosis), the severity of the principal diagnosis, or a complication of care. For example, a patient who was hospitalized for a kidney transplantation could not be assigned renal failure as a comorbidity under the Elixhauser method because these 2 entities have a high likelihood of being related. More important, an Elixhauser comorbidity must not relate directly to the diagnosis-related group assigned to the patient, thus maximizing the likelihood that the comorbidity is a discreet and separate condition from the primary diagnosis. The Elixhauser method has been shown to capture most comorbid conditions experienced among surgical admissions and may be superior to the Charlson/Deyo method when administrative databases are used to study surgical populations.[12,13] Elixhauser comorbidities were determined for each patient through an established series of algorithms that are available in software from the AHRQ.[14]

Comorbid medical conditions presented one possible confounding element because insurance companies may disproportionately enroll patients in good health (the insurance selection bias), and simultaneously these patients are less prone to die of their medical state than patients in poor health.[15] It was problematic to control for the effects of comorbid disease statistically for several reasons. First, the number of possible comorbidities is large, even with Elixhauser classifications. Second, the interactions of these conditions are complex and probably lack consistency from patient to patient. Third, there is no information on the severity of each comorbidity or how well it was managed. Poor management of comorbid conditions (in particular, hyperglycemia) decreases survival of neurosurgical patients.[16,17] For these reasons, it was believed that any attempt to model comorbidity would require strong assumptions, which are unlikely to hold and whose violations could drastically influence any inference. Instead, an alternate approach was used to isolate the effects of insurance status from those of comorbid conditions.

We asked whether an insurance-related disparity observed in the full patient cohort would also be present in a subset of patients in whom it is not likely for comorbidity to be a confounding factor: those with no known comorbid illness. The presence of a disparity in this subset would argue against differences in baseline health as being the causal mechanism for differing outcomes. In addition, this subset would be relevant to study because, in practice, patients with a high disease burden (aside from the intracranial disease) are often excluded from neurosurgical consideration because of the added risks of operative intervention on an already precarious medical state. Therefore, the subset of patients with no Elixhauser comorbidity was isolated and studied (eMethods 1.6 , eTable 3 , and Figure 1B).

STATISTICAL ANALYSIS

The outcome of interest was in-hospital death. Results were reported as odds ratios or hazard ratios (HRs), comparing nonprivately insured groups (Medicaid recipients and uninsured patients) and privately insured patients. An unadjusted logistic regression was performed first on the full cohort and next on the subset of patients with no comorbidity. Subsequently, an adjusted analysis was performed on the subset of patients with no comorbidity. A Cox proportional hazards model was used because time to event (death or discharge) can be derived from the length of the hospitalization (eMethods 1.7). The model was stratified by hospital and adjusted for admission type, age, sex, race, income, malignant vs benign tumor characteristics, and year. All tests were 2-sided, with a type I error rate set to .05. Models were checked via visual inspection and statistical tests for proportionality based on Schoenfeld residuals.[18] R (version 2.12.0, The R Project) was used for statistical analysis.

RESULTS

STUDY COHORT

The full study cohort was composed of 28 581 patients, of whom 23 051 (80.7%) had private insurance, 3685 (12.9%) had Medicaid, and 1845 (6.5%) were uninsured (Figure 1A and **Table 1**). The mean age of all patients was 48.5 years, with privately insured patients having a mean age of 49.0 years, Medicaid recipients having a mean age of 45 years, and uninsured patients having a mean age of 48 years. Almost half of the patients were male (13 305 [46.6%]). Most patients were white (23 431 [82.0%]), followed by African American (2595 [9.1%]), Hispanic (1990 [7.0%]), Asian/Pacific Islander (445 [1.6%]), and Native American (120 [0.4%]), a distribution similar to the US population from US Census data.[19] A total of 79.1% of cases took place in teaching hospitals. All baseline characteristics differed significantly by insurance type because even small differences in these categories could be detected statistically because of the large number of patients. Baseline characteristics of the full cohort were similar to those of the subset with no comorbidity (**Table 2** and **Figure 2**). A slightly higher percentage of the latter was insured privately (83.0%)

Table 1. Characteristics of the Full Study Cohort, by Insurance Status[a]

Characteristic	Final Cohort (N = 28 581)	Private (n = 23 051)	Medicaid (n = 3685)	Uninsured (n = 1845)
Insurance				
Private	80.7			
Medicaid	12.9			
Uninsured	6.5			
Admission type				
Emergent	26.8	23.2	40.4	44.4
Urgent	14.7	14.1	16.4	18.2
Elective	58.5	62.7	43.2	37.4
Age				
Mean (SD), y	48.5 (11.2)	49.0 (10.9)	45.4 (12.1)	47.6 (11.6)
Median age, y	51	51	47	49
18-44 Years old	32.2	30.2	43.8	34.2
45-65 Years old	67.8	69.8	56.2	65.8
Sex				
Male	46.6	46.5	44.6	50.8
Female	53.4	53.5	55.4	49.2
Race				
White	82.0	86.6	62.6	63.7
Black	9.1	7.2	18.6	14.0
Hispanic	7.0	4.6	15.9	19.2
Asian/Pacific Islander	1.6	1.4	2.2	2.7
Native American	0.4	0.4	0.8	0.4
Median income quartile				
1 (lowest)	16.2	12.8	32.5	26.1
2	23.6	22.1	30.3	29.0
3	26.4	27.2	22.5	24.8
4 (highest)	33.8	38.0	14.8	20.0
Tumor				
Nonmalignant	29.0	29.4	26.3	28.8
Malignant	71.0	70.6	73.7	71.2
Region				
South	46.7	44.4	49.8	70.6
Northeast	29.3	30.5	28.4	16.2
Midwest	16.7	17.8	14.2	8.4
West	7.2	7.4	7.6	4.9
Hospital size				
Large	78.3	78.7	78.4	73.4
Medium	16.6	16.0	18.2	20.5
Small	5.1	5.3	3.4	6.1
Hospital location				
Rural	2.2	2.1	2.2	2.5
Urban	97.8	97.9	97.8	97.5
Hospital teaching status				
Nonteaching	20.9	20.6	20.5	25.2
Teaching	79.1	79.4	79.5	74.8

[a] Data are presented as percentage of study participants unless otherwise indicated.

Table 2. Characteristics of the Subset of Patients With No Comorbidity, by Insurance Status[a]

Characteristic	Final Cohort (N = 10 689)	Private (n = 8866)	Medicaid (n = 1145)	Uninsured (n = 678)
Insurance				
Private	83.0			
Medicaid	10.7			
Uninsured	6.3			
Admission type				
Emergent	21.1	18.2	32.8	39.2
Urgent	13.0	12.6	14.7	16.2
Elective	65.9	69.2	52.5	44.5
Age				
Mean, y	44.0	44.8	39.0	41.9
Median, y	45	46	38	42.5
18-44 Years old	48.4	45.5	66.7	55.0
45-65 Years old	51.6	54.5	33.3	45.0
Sex				
Male	49.6	49.6	47.8	53.0
Female	50.4	50.4	52.2	47.0
Race				
White	83.4	87.5	63.7	62.7
Black	6.4	5.1	13.7	10.5
Hispanic	7.9	5.4	18.6	22.9
Asian/Pacific Islander	1.9	1.6	3.1	3.8
Native American	0.4	0.4	0.9	0.2
Median income quartile				
1 (lowest)	13.4	11.0	26.9	22.3
2	23.0	21.4	33.0	27.6
3	26.4	26.9	23.1	26.4
4 (highest)	37.1	40.7	17.0	23.8
Tumor				
Nonmalignant	34.6	34.9	31.6	34.7
Malignant	65.4	65.1	68.4	65.3
Region				
South	45.3	43.3	47.2	68.6
Northeast	28.9	29.7	29.8	17.0
Midwest	18.0	19.1	14.7	9.1
West	7.8	7.9	8.4	5.3
Hospital size				
Large	79.2	79.5	78.0	76.6
Medium	15.9	15.3	19.3	17.3
Small	5.0	5.2	2.7	6.2
Hospital location				
Rural	2.2	2.2	2.4	2.4
Urban	97.8	97.8	97.6	97.6
Hospital teaching status				
Nonteaching	17.9	17.6	17.9	22.1
Teaching	82.1	82.4	82.1	77.9

[a] Data are presented as percentage of study participants unless otherwise indicated.

compared with the full cohort (80.7%). In addition, the mean age of this subset was approximately 5 years younger than the full patient cohort because comorbidity becomes more likely with age.

UNIVARIATE ANALYSES OF POSTOPERATIVE OUTCOMES

In the unadjusted analysis of the full study cohort, lack of insurance and Medicaid receipt were associated with higher in-hospital postoperative mortality compared with private insurance (**Table 3**). The in-hospital mortality rate for privately insured patients was 1.3% (n = 295; 95% CI, 1.1%-1.4%) compared with 2.6% for uninsured patients (n = 48; 95% CI, 1.9%-3.3%; $P < .001$) and 2.3% for Medicaid recipients (n = 86; 95% CI, 1.8%-2.8%; $P < .001$). The overall in-hospital mortality rate of this subset was 1.5% (95% CI, 1.4%-1.6%; n = 429 patient deaths).

This insurance-related disparity was also present in the subset of patients with no known comorbid illness (Table 3). The mortality rate for privately insured patients was 0.7% (n = 65; 95% CI, 0.6%-0.9%) compared with 1.8% for uninsured patients (n = 12; 95% CI, 0.8%-2.8%; $P = .005$) and 1.6% for Medicaid recipients (n = 18; 95% CI, 0.8%-2.3%; $P = .004$). The overall in-hospital mortality rate of this subset was 0.9% (95% CI, 0.7%-1.1%; n = 95 patient deaths).

In the full patient cohort, other factors were also associated with in-hospital postoperative mortality, including admission type, age, sex, race, malignant vs benign tumor characteristics, hospital size, and hospital teaching status. However, in the subset of patients with no comorbid disease, only admission type, age, race, and malignant vs benign tumor characteristics continued to be associated with in-hospital postoperative mortality (Table 3). Patients admitted nonelectively experienced higher in-hospital mortality rates compared with elective admissions (1.4% for urgent and 1.9% for emergent admissions vs 0.5% for elective admissions, $P < .001$). Race was also associated with in-hospital mortality ($P < .001$). Whites experienced a 0.7% mortality, whereas Hispanics and blacks experienced 1.3% and 2.0% mortality, respectively. In addition, an association was found between malignant tumors and postoperative death ($P = .001$).

MULTIVARIATE ANALYSIS OF POSTOPERATIVE OUTCOMES IN PATIENTS WITH NO COMORBIDITY

The subset of patients with no comorbidity was further examined to determine whether insurance-related disparities would be present in a multivariate analysis. With the use of a Cox proportional hazards model, controlling for patient demographics, admission type, malignant vs benign tumor characteristics, and year and after stratification by hospital, uninsured status was still associated with higher in-hospital mortality rates than private insurance, with an adjusted HR of 2.62 (95% CI, 1.11-6.14) (**Table 4**). In the adjusted analysis, Medicaid receipt was not definitively associated with higher in-hospital mortality compared with private insurance. The Medicaid adjusted HR was 2.03 (95% CI, 0.97-4.23) (Table 4).

A post hoc subset analysis was performed on patients with no comorbidity in teaching hospitals. Teaching hospitals account for 79.1% of neurosurgical procedures and provide training for future generations of medical and surgical physicians. Within teaching hospitals, uninsured patients still experienced higher in-hospital mortality than privately insured patients (adjusted HR, 3.55; 95% CI, 1.41-8.95). However, Medicaid receipt was not associated with higher in-hospital mortality (adjusted HR, 1.63; 95% CI, 0.69-3.85). Nonteaching hospitals could not be analyzed reliably because they represented such a small portion of the sample size.

COMMENT

Among patients with brain tumors with no other major medical condition, uninsured patients (but not neces-

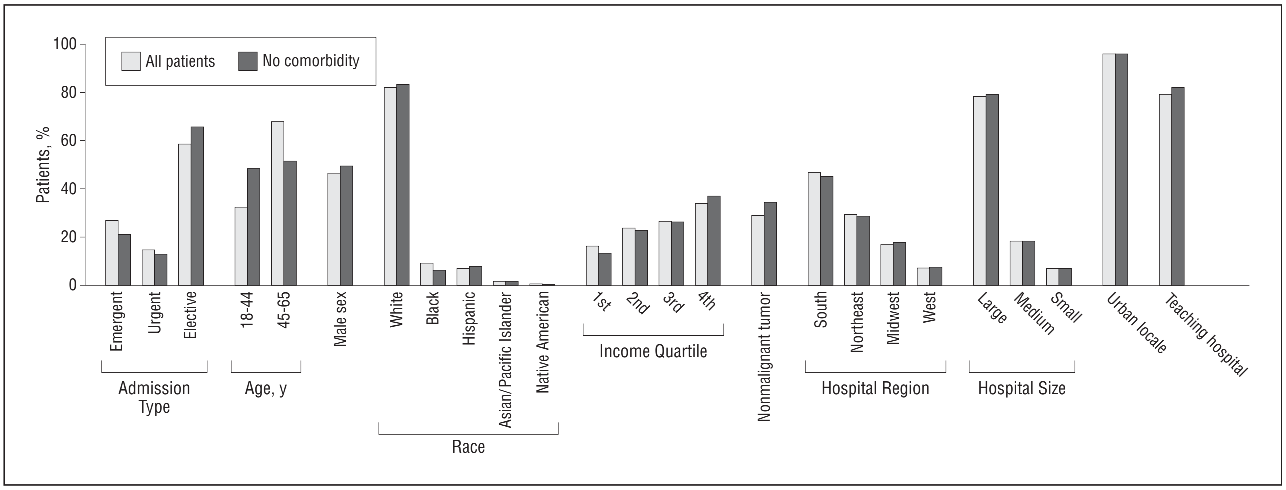

Figure 2. Baseline characteristics for all neurosurgical patients vs those with no comorbid disease. By selecting patients with no comorbidity, there is minimal inadvertent selection for other characteristics. Patients with no comorbidity have similar baseline characteristics compared with all neurosurgical patients. The main exception was age, which was approximately 5 years younger in patients with no comorbidity compared with the full patient cohort and was among the variables adjusted for in the final analysis.

sarily Medicaid recipients) have higher in-hospital mortality than privately insured patients, a disparity that was pronounced in teaching hospitals. These findings further reinforce prior data indicating insurance-related disparities in medical and surgical settings.[2,20-22]

These insurance-related disparities might be explained by 1 of 3 possible mechanisms. Insurance status could influence health outcomes by affecting (1) a patient's overall state of health,[20] (2) the ability to access care (affecting the acuity of disease presentation),[23-26] or (3) the quality of treatment that is provided.[27,28] With regard to the first possibility, we tried to control for the effects of comorbid disease as best as possible by studying the subset of patients with no recorded comorbidity. However, the reliability of comorbidity data for uninsured patients remains questionable. Uninsured patients are less likely to see a physician regularly, and there is probably a tendency for medical conditions to be undiagnosed in this group. These data may be problematic because hospital records often depend on what patients know and say when asked about their medical history. Furthermore, diagnosing some comorbidities in the acute care setting is not always straightforward; for example, high-dose corticosteroids interfere with blood glucose levels, and blood pressure values are routinely labile after craniotomy. With regard to the second possibility, there is no direct measure of disease severity in the NIS, but there was an indirect indication that uninsured patients may present with more advanced stages of brain cancer. Uninsured patients tended to undergo biopsy procedures more often than privately insured patients or Medicaid recipients (eMethods 1.8 and eTable 4). This finding may give some insight about disease progression because biopsy without surgery may be reserved for larger, more invasive tumors, particularly eloquent cortex, in sicker patients. This finding is reflected in a higher mortality rate in patients who undergo biopsy procedures alone (eMethods 1.8 and eTable 4). Third, it is possible that hospitals provide different care to uninsured patients, but our study does not prove this, and the available data do not support unambiguous conclusions or policy statements in this regard. We think it is important to mention this possibility because it might prompt health care professionals to reflect on this question of the quality of care that we provide to our patients.[29]

The phenomenon of statistical clustering is unlikely to explain the insurance-related disparity observed in this study. A disparity may seem to be present if patients with a certain insurance status disproportionately seek care at hospitals that have poor overall outcomes (which arise independently of factors related to the insurance status of their patients). Alternatively, both the diagnosis of an operative brain tumor and lack of insurance could make it far more likely that a patient will be transferred to a tertiary care center, which may skew the population being cared for at teaching hospitals. This possible clustering effect, in which both the exposure (insurance type) and outcome of interest (in-hospital mortality) are associated with the same hospital type, may result in statistical confounding.[30,31] A difference in outcomes that arises only from such clustering effects would not be genuine evidence of unequal care, although it may indicate variations in hospital choice or impaired access to high-quality institutions. To minimize the possibility of confounding by clustering, we used a model that was stratified by hospital. In this model, the insurance-related disparity was still present, suggesting that clustering did not account for the disparity.

Putting our results in context with data from other medical specialties, there are several points to be made. First, insurance-related disparities are not unique to the field of neurosurgery. Uninsured patients fare worse than privately insured patients in the settings of critical illness[32] (higher chance of having life support withdrawn), ischemic or hemorrhagic stroke[21,33] (higher mortality and neurologic impairment), myocardial infarction[21] (higher mortality), and physical trauma (higher mortality).[34,35] However, it is not clear that enrolling in a state-funded health plan would help the uninsured because Medicaid recipients also seem to experience a simi-

Table 3. Unadjusted Outcomes After Surgery for Brain Tumors

Characteristic	All Patients: No. (In-Hospital Mortality, %)	All Patients: *P* Value	Patients With No Comorbidity: No. (In-Hospital Mortality, %)	Patients With No Comorbidity: *P* Value
Overall	**28 581** (1.5)		**10 689** (0.9)	
Insurance				
Private	23 051 (1.3)	<.001	8866 (0.7)	.001
Medicaid	3685 (2.3)		1145 (1.6)	
Uninsured	1845 (2.6)		678 (1.8)	
Admission type				
Emergent	7650 (2.7)	<.001	2258 (1.9)	<.001
Urgent	4199 (2.2)		1391 (1.4)	
Elective	16 732 (0.8)		7040 (0.5)	
Age, y				
18-44	9207 (1.2)	.002	5174 (0.7)	.04
45-65	19 374 (1.6)		5515 (1.2)	
Sex				
Male	13 305 (1.8)	.001	5307 (1.0)	.11
Female	15 276 (1.3)		5382 (0.7)	
Race				
White	23 431 (1.4)	.002	8913 (0.7)	<.001
Black	2595 (2.2)		683 (2.0)	
Hispanic	1990 (2.0)		846 (1.3)	
Asian/Pacific Islander	445 (2.0)		205 (2.4)	
Native American	120 (0.8)		42 (0)	
Median income quartile				
1 (lowest)	4618 (1.9)	.12	1437 (1.0)	.15
2	6739 (1.5)		2459 (1.2)	
3	7560 (1.4)		2826 (0.7)	
4 (highest)	9664 (1.4)		3967 (0.8)	
Tumor				
Nonmalignant	8286 (0.8)	<.001	3694 (0.5)	.001
Malignant	20 295 (1.8)		6995 (1.1)	
Region				
South	13 360 (1.6)	.39	4843 (1.0)	.49
Northeast	8374 (1.4)		3091 (0.8)	
Midwest	4775 (1.5)		1925 (0.8)	
West	2072 (1.2)		830 (0.6)	
Hospital size				
Large	22 391 (1.4)	.003	8460 (0.8)	.37
Medium	4741 (2.0)		1697 (1.2)	
Small	1449 (1.1)		532 (0.9)	
Hospital location				
Rural	621 (1.1)	.44	236 (0.8)	.94
Urban	27 960 (1.5)		10 453 (0.9)	
Hospital teaching status				
Nonteaching	5962 (1.9)	.005	1911 (1.0)	.42
Teaching	22 619 (1.4)		8778 (0.8)	

lar disparity in other settings, including pneumonia,[21] appendicitis,[36,37] abdominal aortic aneurysm repair,[38,39] limb-threatening ischemia,[39] and surgery for colorectal carcinoma.[3] Of note, this Medicaid disparity was also present in our full cohort but was not convincingly present in the adjusted analysis of patients with no comorbid disease, especially in teaching hospitals. This observation led us to wonder whether differences in baseline health contribute to the Medicaid disparity and, moreover, what would have happened if prior studies had analyzed patients with no comorbidity separately. Finally, there is the question of a disparity's effect size. With the advanced state of modern medicine, catastrophic outcomes are infrequent. In this setting, many of the high HRs reported in past studies and in this study originate from small absolute percentage differences. Although professional ethics compel us to be concerned with all inequalities, the question is whether correcting small effect size disparities should take priority over other promising strategies for improving public health.

Uninsured patients are a heterogeneous group and should not necessarily be thought of as being poor. Uninsured patients usually fall into one of several categories: (1) poor and/or unemployed people who cannot afford insurance; (2) individuals who qualify for Medicaid but have not yet signed up for it; (3) young, healthy individuals who choose to forgo insurance; or (4) self-employed people at a broad range of incomes who are deterred by the high cost of individual insurance. This last group of patients is probably not small, as reflected by the fact that 1 of 5 uninsured patients in our study were in the highest income quartile. In addition, state-

Table 4. In-Hospital Mortality After Surgery for a Brain Tumor

	Unadjusted Outcomes, OR (95% CI)		Adjusted Outcomes, HR (95% CI)	
Covariate	All Patients (N = 28 581)	Patients With No Comorbidity (n = 10 689)	Patients With No Comorbidity (n = 10 689)	Patients With No Comorbidity in Teaching Hospitals (n = 8778)
Insurance type (vs private)				
Medicaid	1.84 (1.45-2.35)[a]	2.16 (1.28-3.66)[b]	2.03 (0.97-4.23)	1.63 (0.69-3.85)
Uninsured	2.06 (1.51-2.81)[c]	2.44 (1.31-4.54)[d]	2.62 (1.11-6.14)[e]	3.55 (1.41-8.95)[f]
Admission type (vs emergent)				
Urgent			0.66 (0.30-1.43)	0.51 (0.21-1.25)
Elective			0.69 (0.37-1.26)	0.60 (0.29-1.23)
Age			1.01 (0.99-1.03)	1.00 (0.98-1.03)
Female vs male			0.88 (0.53-1.47)	0.97 (0.55-1.71)
Race (vs white)				
Black			1.12 (0.44-2.87)	0.80 (0.27-2.38)
Others			0.83 (0.35-1.95)	1.01 (0.39-2.56)
Income quartile			0.97 (0.73-1.28)	0.99 (0.72-1.35)
Malignant tumor (vs benign)			1.32 (0.70-2.48)	1.22 (0.61-2.42)
Year			0.99 (0.89-1.11)	0.99 (0.87-1.12)

Abbreviations: HR, hazard ratio; OR, odds ratio.
[a] $P < .001$ (all P values are compared with patients with private insurance).
[b] $P = .004$.
[c] $P < .001$.
[d] $P = .005$.
[e] $P = .03$.
[f] $P = .002$.

specific policies and procedures may give rise to regional variations in the demographics of the uninsured. Some states in the South make it extremely hard to enroll in Medicaid, and 70.6% of this study's uninsured patients came from the South. In contrast, Massachusetts has a universal insurance law that covers almost everyone except for a few mostly affluent, self-employed people who choose to pay a fine for not enrolling. These variations in patient demographic characteristics underscore the need for adjusting for socioeconomic variables, such as income status and geographic location, in studies of the uninsured.

For this study, a retrospective analysis performed with the NIS database was the best available design. The NIS presented several advantages over other data sources. Its massive size was critical for a study of rare outcomes, such as in-hospital mortality. It is the only database with information on all patients regardless of payer, including those with no payer.[40] The NIS is amenable to statistical analyses that are stratified at the hospital level because its sampling method is based at the hospital level (not the patient level). Finally, the possibilities for a prospective design were limited by the low overall incidence of surgically resectable brain tumors, the rarity of in-hospital mortality as an outcome, and the difficulty of obtaining a representative sample of the entire country. There are 4 limitations that could not be overcome. First, Medicaid and privately insured groups are heterogeneous in terms of what medical procedures they cover. Medicaid coverage varies by state, and private insurance varies by plan. Even some privately insured patients may not have adequate coverage for major surgery. Second, the patient follow-up interval was confined to the time between admission and discharge, although deaths that occurred immediately after discharge would also have reflected the quality of postoperative care. Third, no detailed information is recorded for tumor histologic type, anatomical location, grade, or stage, although such factors are related to treatment choice and mortality risk. Fourth, uninsured patients sometimes enroll in Medicaid during their hospitalization, and the rates at which this occurs may vary by state. The NIS classifies them as Medicaid recipients, although the more appropriate classification may be uninsured. It is difficult to separate these patients from other Medicaid recipients (eMethods 1.9 and eFigure).

Uninsured patients undergoing craniotomy for a brain tumor experience worse outcomes than privately insured patients, and this difference is pronounced in teaching hospitals. This variation in postoperative outcomes remains unexplained by hospital characteristics, including clustering effects, comorbid disease, or socioeconomic variations. This study did not exclude the possibilities that comorbid conditions are underdiagnosed in uninsured patients or that uninsured patients are presenting with more advanced stages of disease.

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REFERENCES

1. Barker FG II, Klibanski A, Swearingen B. Transsphenoidal surgery for pituitary tumors in the United States, 1996-2000: mortality, morbidity, and the effects of hospital and surgeon volume. *J Clin Endocrinol Metab.* 2003;88(10):4709-4719.
2. LaPar DJ, Bhamidipati CM, Mery CM, et al. Primary payer status affects mortality for major surgical operations. *Ann Surg.* 2010;252(3):544-551.
3. Kelz RR, Gimotty PA, Polsky D, Norman S, Fraker D, DeMichele A. Morbidity and mortality of colorectal carcinoma surgery differs by insurance status. *Cancer.* 2004;101(10):2187-2194.
4. Porter KR, McCarthy BJ, Freels S, Kim Y, Davis FG. Prevalence estimates for primary brain tumors in the United States by age, gender, behavior, and histology. *Neuro Oncol.* 2010;12(6):520-527.
5. American Cancer Society. *Cancer Facts & Figures 2010.* Atlanta, GA: American Cancer Society; 2010.
6. *CBTRUS Statistical Report: Primary Brain and Central Nervous System Tumors Diagnosed in the United States in 2004-2007* . Hinsdale, IL: Central Brain Tumor Registry of the United States; 2010.
7. Curry WT Jr, Carter BS, Barker FG II. Racial, ethnic, and socioeconomic disparities in patient outcomes after craniotomy for tumor in adult patients in the United States, 1988-2004. *Neurosurgery.* 2010;66(3):427-437.
8. Mukherjee D, Kosztowski T, Zaidi HA, et al. Disparities in access to pediatric neurooncological surgery in the United States [published online September 28, 2009]. *Pediatrics.* 2009;124(4):e688-e696. doi: 10.1542/peds.2009-0377.
9. Mukherjee D, Zaidi HA, Kosztowski T, et al. Disparities in access to neurooncologic care in the United States. *Arch Surg.* 2010;145(3):247-253.
10. Mukherjee D, Zaidi HA, Kosztowski T, et al. Predictors of access to pituitary tumor resection in the United States, 1988-2005. *Eur J Endocrinol.* 2009;161(2):259-265.
11. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care.* 1998;36(1):8-27.
12. Southern DA, Quan H, Ghali WA. Comparison of the Elixhauser and Charlson/Deyo methods of comorbidity measurement in administrative data. *Med Care.* 2004;42(4):355-360.
13. Stukenborg GJ, Wagner DP, Connors AF Jr. Comparison of the performance of two comorbidity measures, with and without information from prior hospitalizations. *Med Care.* 2001;39(7):727-739.
14. Elixhauser A, Steiner C, Kruzikas D. Comorbidity software documentation: HCUP Methods Series Report 2004-01. http://www.hcup-us.ahrq.gov/reports/methods. Accessed May 2, 2011.
15. Tammemagi CM, Nerenz D, Neslund-Dudas C, Feldkamp C, Nathanson D. Comorbidity and survival disparities among black and white patients with breast cancer. *JAMA.* 2005;294(14):1765-1772.
16. McGirt MJ, Chaichana KL, Gathinji M, et al. Persistent outpatient hyperglycemia is independently associated with decreased survival after primary resection of malignant brain astrocytomas. *Neurosurgery.* 2008;63(2):286-291.
17. Chaichana KL, McGirt MJ, Woodworth GF, et al. Persistent outpatient hyperglycemia is independently associated with survival, recurrence and malignant degeneration following surgery for hemispheric low grade gliomas. *Neurol Res.* 2010;32(4):442-448.
18. Schoenfeld D. Partial residuals for the proportional hazards regression model. *Biometrika.* 1982;69(1):239-241.
19. US Census Bureau. *Overview of Race and Hispanic Origin: Census 2000 Brief.* Washington, DC: US Census Bureau; March 2001.
20. Franks P, Clancy CM, Gold MR. Health insurance and mortality: evidence from a national cohort. *JAMA.* 1993;270(6):737-741.
21. Hasan O, Orav EJ, Hicks LS. Insurance status and hospital care for myocardial infarction, stroke, and pneumonia. *J Hosp Med.* 2010;5(8):452-459.
22. Sada MJ, French WJ, Carlisle DM, Chandra NC, Gore JM, Rogers WJ; Participants in the National Registry of Myocardial Infarction. Influence of payor on use of invasive cardiac procedures and patient outcome after myocardial infarction in the United States. *J Am Coll Cardiol.* 1998;31(7):1474-1480.
23. Brown DL, Schneider DL, Colbert R, Guss D. Influence of insurance coverage on delays in seeking emergency care in patients with acute chest pain. *Am J Cardiol.* 1998;82(3):395-398.
24. Hafner-Eaton C. Physician utilization disparities between the uninsured and insured: comparisons of the chronically ill, acutely ill, and well nonelderly populations. *JAMA.* 1993;269(6):787-792.
25. Roetzheim RG, Gonzalez EC, Ferrante JM, Pal N, Van Durme DJ, Krischer JP. Effects of health insurance and race on breast carcinoma treatments and outcomes. *Cancer.* 2000;89(11):2202-2213.
26. Roetzheim RG, Pal N, Tennant C, et al. Effects of health insurance and race on early detection of cancer. *J Natl Cancer Inst.* 1999;91(16):1409-1415.
27. Landon BE, Schneider EC, Normand SL, Scholle SH, Pawlson LG, Epstein AM. Quality of care in Medicaid managed care and commercial health plans. *JAMA.* 2007;298(14):1674-1681.
28. Asch SM, Kerr EA, Keesey J, et al. Who is at greatest risk for receiving poor-quality health care? *N Engl J Med.* 2006;354(11):1147-1156.
29. Manfuso J. Unequal outcomes. *Dome Magazine.* 2011;62(3):1-2.
30. Localio AR, Berlin JA, Ten Have TR. Confounding due to cluster in multicenter studies—causes and cures. *Health Serv Outcomes Res Methodol.* 2002;3(3-4):195-210.
31. Localio AR, Berlin JA, Ten Have TR, Kimmel SE. Adjustments for center in multicenter studies: an overview. *Ann Intern Med.* 2001;135(2):112-123.
32. Fowler RA, Noyahr LA, Thornton JD, et al; American Thoracic Society Disparities in Healthcare Group. An official American Thoracic Society systematic review: the association between health insurance status and access, care delivery, and outcomes for patients who are critically ill. *Am J Respir Crit Care Med.* 2010;181(9):1003-1011.
33. Shen JJ, Washington EL. Disparities in outcomes among patients with stroke associated with insurance status. *Stroke.* 2007;38(3):1010-1016.
34. Haider AH, Chang DC, Efron DT, Haut ER, Crandall M, Cornwell EE III. Race and insurance status as risk factors for trauma mortality. *Arch Surg.* 2008;143(10):945-949.
35. Maybury RS, Bolorunduro OB, Villegas C, et al. Pedestrians struck by motor vehicles further worsen race- and insurance-based disparities in trauma outcomes: the case for inner-city pedestrian injury prevention programs. *Surgery.* 2010;148(2):202-208.
36. Braveman P, Schaaf VM, Egerter S, Bennett T, Schecter W. Insurance-related differences in the risk of ruptured appendix. *N Engl J Med.* 1994;331(7):444-449.
37. Smink DS, Fishman SJ, Kleinman K, Finkelstein JA. Effects of race, insurance status, and hospital volume on perforated appendicitis in children. *Pediatrics.* 2005;115(4):920-925.
38. Boxer LK, Dimick JB, Wainess RM, et al. Payer status is related to differences in access and outcomes of abdominal aortic aneurysm repair in the United States. *Surgery.* 2003;134(2):142-145.
39. Giacovelli JK, Egorova N, Nowygrod R, Gelijns A, Kent KC, Morrissey NJ. Insurance status predicts access to care and outcomes of vascular disease. *J Vasc Surg.* 2008;48(4):905-911.
40. Steiner C, Elixhauser A, Schnaier J. The Healthcare Cost and Utilization Project: an overview. *Eff Clin Pract.* 2002;5(3):143-151.