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ORIGINAL PAPER

# Racial differences in brain cancer characteristics and survival: an analysis of SEER data

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## Abstract

**Purpose** Racial disparity with shorter survival for Blacks than Whites is well known for many cancers. However, for brain cancer, some national cancer registry studies have shown better survival among Blacks compared to Whites. This study aimed to systematically investigate whether Blacks and Whites differ in survival and also in tumor characteristics and treatment for neuroepithelial brain tumors.

**Methods** The National Cancer Institute's Surveillance Epidemiology and End Results (SEER) database was used to identify non-Hispanic White and Black patients diagnosed with malignant, histologically confirmed neuroepithelial brain cancer from 2004 through 2015. Racial differences in brain cancer survival were compared using Kaplan–Meier curve and Cox proportional hazard models. The associations of race with tumor and treatment characteristics (location, size, grade, surgical type) were examined using multinomial logistic regression.

**Results** After adjusting for demographic, tumor, and treatment factors, there were no significant differences in survival for non-Hispanic Blacks compared to non-Hispanic Whites [hazard ratio (HR) 1.05, 95% confidence interval (CI) 0.99–1.10]. Non-Hispanic Blacks had higher odds of being diagnosed with tumors of unknown grade [odds ratio (OR) 1.16, 95% CI 1.05–1.29], unknown size (OR 1.14, 95% CI 1.01–1.29), infratentorial (OR 1.12, 95% CI 1.01–1.24) or overlapping area (OR 1.39, 95% CI 1.14–1.70), and lower odds of having a total surgical resection (OR 0.83, 95% CI 0.74–0.93).

**Conclusion** Non-Hispanic Blacks do not exhibit longer brain cancer-specific survival than non-Hispanic Whites. They were more likely to have tumors of unknown size or grade and less likely to receive total surgical resection, which may result from racial differences in access to and use of healthcare.

**Keywords** Brain cancer · Disparity · Survival · SEER

## Introduction

Racial disparity with shorter survival for Blacks than Whites has been observed in the United States for common cancers, such as breast, prostate, colorectal, and lung cancers, as well as less common cancers such as cervical, pancreatic, and esophageal cancers [1–8]. However, the understanding of racial differences in survival from brain cancer is not clear. Several large studies based on the data from the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) displayed better relative survival from most brain cancers among Black patients as compared to White patients. These studies show that Black brain cancer patients had lower mortality and 6 to 10% longer 5-year relative survival compared to White patients [9–11], but they did not take into account important tumor or treatment factors related to survival. In contrast, several other registry studies

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found that Black patients have worse all-cause mortality than White patients after adjustment for tumor and treatment characteristics [12, 13]. Furthermore, two studies found no survival differences between Black and White brain cancer patients using cancer-specific survival while adjusting for tumor and treatment variables, but these studies were limited to only glioblastomas [14, 15].

Racial disparities in cancer survival may be related to racial differences in tumor characteristics (such as tumor stage, grade, and size) as well as treatment receipt [16–22]. For brain cancer in particular, brain tumor characteristics, such as location and grade at diagnosis, and treatment receipt may differ between racial groups and may at least partially account for racial difference in survival. However, to the best of our knowledge, no studies have examined racial differences in tumor and treatment characteristics in conjunction with brain cancer-specific survival.

The primary aim of this study was to investigate whether non-Hispanic Blacks have better cancer-specific survival from neuroepithelial brain cancers, the most commonly occurring type of brain tumors, than non-Hispanic Whites after adjusting for demographic characteristics and tumor and treatment variables. We further assessed whether there are racial differences in tumor characteristics (grade, size, location) and treatment type that might account for any racial differences in neuroepithelial brain cancer survival.

## Methods

### Data source and study population

This study utilized the data from the Surveillance, Epidemiology and End Results (SEER) 18 database of the National Cancer Institute. SEER 18 covers approximately 28% of the U.S. population with data from 18 cancer registries in Atlanta, Connecticut, Detroit, Hawaii, Iowa, New Mexico, San Francisco-Oakland, Seattle-Puget Sound, Utah, Los Angeles, San Jose-Monterey, Rural Georgia, Alaska, Greater California, Greater Georgia, Kentucky, Louisiana, and New Jersey [23].

Patients included in this study were non-Hispanic Blacks and Whites age 20 or older diagnosed from 2004 through 2015 with malignant, histologically confirmed primary neuroepithelial brain cancer (Fig. 1). Neuroepithelial tumors comprise well over 80% of malignant brain tumors in the United States [24]. The year of 2004 was used as the beginning of the study period as that when tumor grade, as described below, was included in the SEER dataset. Brain cancer site was defined using the following International Classification of Disease for Oncology, Third Edition (ICD-O-3) topology codes: C70.0–72.9, 75.1–75.3, and 30.0 (only histology codes: 9520–9523) as recommend by the Consensus Conference on Brain Tumor Definition [25]. Only tumors of the neuroepithelial tissue are included in this study.

### Tumor, treatment, and survival variables

Since brain tumors do not typically spread outside of the brain, they are not staged in terms of size, spread, and lymph involvement as are many other cancers [26]. Rather, they are graded based on tumor clinical features and behaviors such as cell type, growth rate, and aggressiveness [24]. Tumor grade was defined using the 2007 WHO standard [19]. Grade I and II tumors were grouped together as low-grade tumors and grade III and IV tumors were grouped together as high-grade tumors. According to the 2007 WHO Classification of Central Nervous System Tumors, cancers of neuroepithelial tissues were categorized into the following histologic subtypes: astrocytic tumors, glioblastomas, oligodendroglial tumors, oligoastrocytic tumors, gliomas, embryonal tumors, and other [19].

Tumor size was categorized into tertiles for neuroepithelial tumors overall. When the analyses were repeated by histology, tertiles were calculated for each histologic type, respectively. Using the SEER registry guidelines, tumor location was defined in relationship to the cerebellar tentorium: supratentorial (ICD-O-3 70.0, 70.9, 71.0–71.4, 72.2, 72.3, 75.1–75.3), infratentorial (ICD-O-3 C71.6, 71.7, 72.4, 72.5), spinal (70.1, 72.0, 72.1), or other (ICD-O-3 C30.0, 71.5, 71.8, 71.9, 72.8, 72.9) if the site was unspecified or had overlapping regions [27]. Surgery was classified as radical/total resection, subtotal resection (to include excisional biopsies), NOS (not otherwise specified), or unknown.

Survival was defined as being the time from the brain tumor diagnosis to the time of death attributed to the primary brain cancer. Cases were censored if they were alive at the end of the surveillance period or upon death from a cause other than brain cancer.

### Statistical analysis

We first analyzed the distributions of demographic and tumor characteristics by race. We then compared brain cancer-specific survival between racial groups using Kaplan–Meier curves and log rank tests. Patients were censored if they died from a cause other than brain cancer or if they remained alive after the last date of contact. We used Cox proportional hazard models to estimate the hazard ratios (HR) with 95% confidence intervals (95% CIs) with adjustment for potential confounders. Three models were used: univariate with unadjusted HRs, multivariate with HRs adjusted for sex, age at diagnosis, and year of diagnosis, and the full model, adjusted for sex, age at diagnosis, year of diagnosis, tumor characteristics (grade, size,

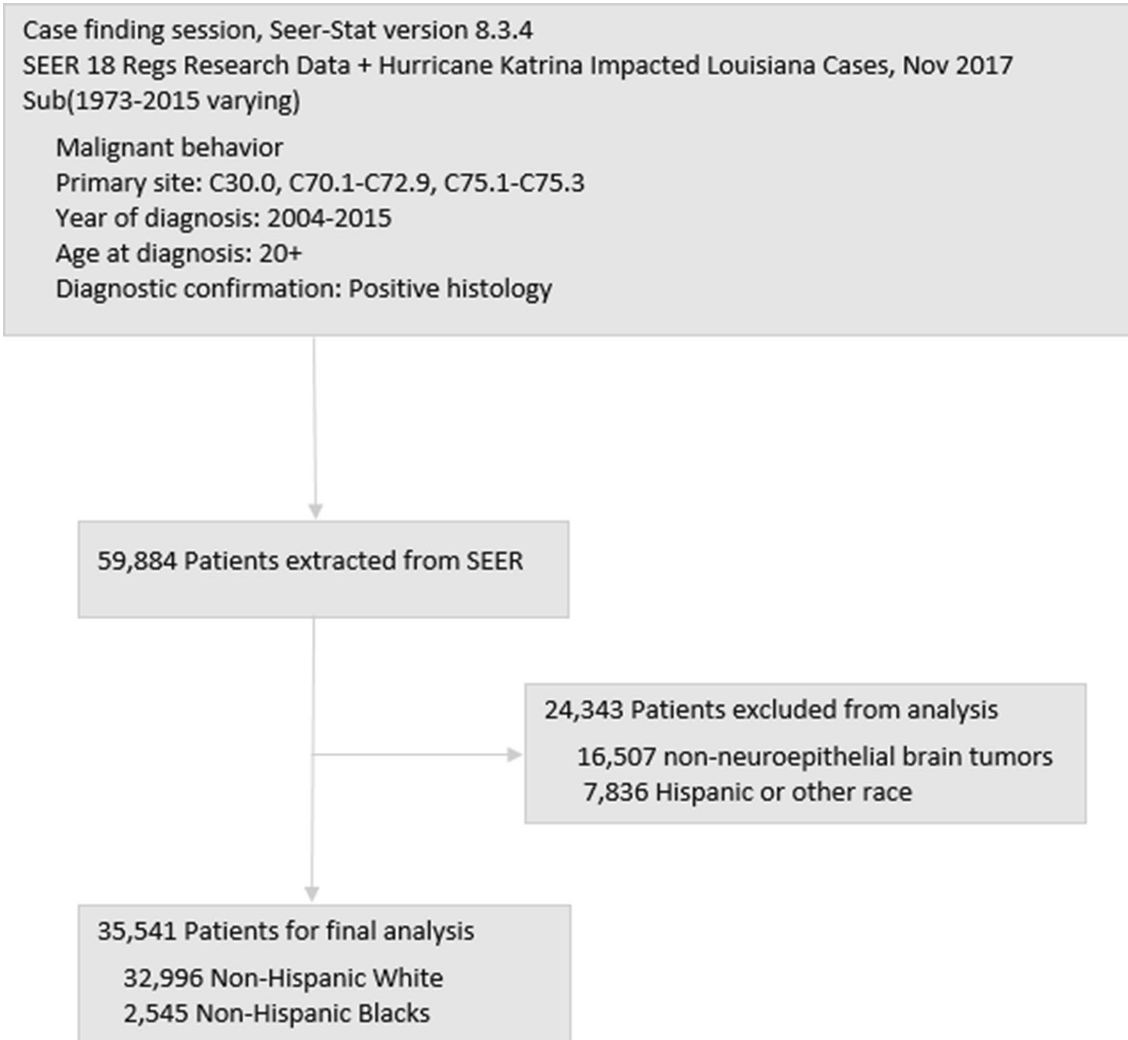


**Fig. 1** Seer*Stat Session information and selection of cases from SEER 18 diagnosed from 2004 to 2015 included in study

and location), histology as well as surgical treatment. We further conducted Cox regression stratified by histologic type using interaction terms between race and histology to assess the hazard ratio for each histological type. An adjusted survival curve using the final overall model was created using the fully adjusted Cox proportional hazard model. We also calculated the rates of 5-year survival, for which only patients diagnosed from 2004 through 2011 were included to allow for at least 5 years of follow-up.

Multinomial logistic regression was used to calculate the odds ratios (ORs) and 95% CIs to examine the association between race and tumor grade, categorized tumor size, tumor location, as well as between race and type of surgery. The models similar to those described above were used: unadjusted; adjusted for sex, age at diagnosis, and year of diagnosis; and the full model adjusted for sex, age at diagnosis, year of diagnosis, tumor characteristics (grade, size, and location), and histology.

All HRs and ORs were calculated with 95% confidence intervals (95% CI). All *P* values are two-sided with a significance level of 0.05. All statistical analysis was conducted using SAS version 9.4 (SAS Institute, Cary, NC).

## Results

The study population included 32,996 non-Hispanic White and 2,545 non-Hispanic Black patients (Table 1). As compared to non-Hispanic Whites, non-Hispanic Blacks were diagnosed at a younger age (median age of 54 vs 59) with fewer non-Hispanic Blacks being diagnosed above age 60 (35.5% vs 48.5%, $p < 0.0001$). There was a higher percentage of woman (46.4% vs 42.3%, $p < 0.0001$) among

**Table 1** Demographic and tumor characteristics for patients with malignant brain tumors of the neuroepithelial tissues by race diagnosed from 2004–2015, SEER 18

| | Non-Hispanic White | | Non-Hispanic Black | | *p* value |
|---|---|---|---|---|---|
| Age (median, IQR)[a] | 59 (48–69) | | 55 (46–64.5) | | |
| Age | | | | | |
| 20–29 | 2,057 | 6.23 | 239 | 9.40 | < .0001 |
| 30–39 | 2,742 | 8.32 | 294 | 11.56 | |
| 40–49 | 4,506 | 13.65 | 455 | 17.88 | |
| 50–59 | 7,686 | 23.29 | 653 | 26.66 | |
| 60–69 | 8,223 | 24.92 | 530 | 20.82 | |
| 70+ | 7,782 | 23.58 | 374 | 14.70 | |
| Sex (*n*, %) | | | | | |
| Male | 19,042 | 57.71 | 1,365 | 53.63 | < .0001 |
| Female | 13,954 | 42.29 | 1,180 | 46.37 | |
| Year of diagnosis (*n*, %) | | | | | |
| 2004–2007 | 10,665 | 32.32 | 757 | 29.74 | 0.0149 |
| 2008–2011 | 10,956 | 33.20 | 901 | 35.40 | |
| 2012–2015 | 11,375 | 34.47 | 887 | 34.85 | |
| Neuroepithelial histology group (*n*, %) | | | | | |
| Astrocytic tumors | 5,988 | 18.15 | 514 | 20.20 | < .0001 |
| Glioblastomas | 20,949 | 63.49 | 1,491 | 58.59 | |
| Oligodendroglial tumors | 2,379 | 7.21 | 142 | 5.58 | |
| Oligoastrocytic tumors | 1,146 | 3.47 | 79 | 3.10 | |
| Gliomas | 666 | 2.02 | 69 | 2.71 | |
| Embryonal tumors | 581 | 1.76 | 77 | 3.03 | |
| Other | 1,287 | 3.90 | 173 | 6.80 | |
| WHO grade (*n*, %) | | | | | |
| I | 416 | 1.26 | 45 | 1.77 | |
| II | 4,122 | 12.49 | 331 | 13.01 | 0.0002 |
| III | 4,067 | 12.33 | 312 | 12.26 | |
| IV | 16,718 | 50.67 | 1,188 | 46.68 | |
| Unknown | 7,673 | 23.25 | 669 | 26.29 | |
| Tumor size (*n*, %) | | | | | |
| First tertile (0–35 mm) | 8,874 | 26.89 | 706 | 27.74 | 0.0081 |
| Second tertile (> 35–50 mm) | 8,358 | 25.33 | 622 | 24.44 | |
| Third tertile (> 50 mm) | 8,643 | 26.19 | 610 | 23.97 | |
| Unknown | 7,121 | 21.57 | 601 | 24.04 | |
| Location (*n*, %) | | | | | |
| Supratentorial | 24,437 | 74.06 | 1,744 | 68.53 | < 0.0001 |
| Infratentorial | 1,123 | 3.40 | 154 | 6.05 | |
| Spinal | 894 | 2.71 | 115 | 4.52 | |
| Overlapping regions/ventricles | 6,542 | 19.83 | 532 | 20.90 | |
| Surgery at primary site (*n*, %) | | | | | |
| No surgery | 6,559 | 19.88 | 517 | 20.31 | 0.0004 |
| Local surgery/subtotal resection | 11,059 | 33.52 | 928 | 36.46 | |
| Radical/total resection | 14,991 | 45.43 | 1,056 | 41.49 | |
| Surgery NOS | 319 | 0.97 | 37 | 1.45 | |
| Unknown | 68 | 0.21 | 7 | 0.28 | |

Results based on chi squared test for categorical variables and Mann–Whitney/Wilcoxon test for continuous variables unless otherwise noted

[a]Interquartile range

non-Hispanic Black patients than non-Hispanic Whites and fewer non-Hispanic Blacks were diagnosed earlier in the study period than were non-Hispanic Whites (e.g., 29.7% vs 32.3% during 2004–2007, $p = 0.0143$). Non-Hispanic Blacks had a lower percentage of glioblastomas (58.6% vs 63.5%), and a higher percentage of embryonal (3.0% vs 1.8%) and other neuroepithelial tumors (6.8% vs 3.9%) than non-Hispanic Whites ($p < 0.0001$). Non-Hispanic Blacks were diagnosed with a lower percent of grade IV tumors (46.7% vs 50.7%, $p = 0.0006$), fewer large tumors (greater than 50 mm (24.0% vs 26.2%, $p = 0.0095$), were less likely to have a supratentorial tumor (68.5% vs 74.1%, $p < 0.0001$), and were less likely to have a total surgical resection of the tumor 41.5% vs 45.4%, $p = 0.0004$). Non-Hispanic Blacks also had a larger percentage of tumors of unknown grade (26.3% vs 23.3%, $p = 0.0002$) and unknown size (24.0% vs 21.6%, $p = 0.0095$).

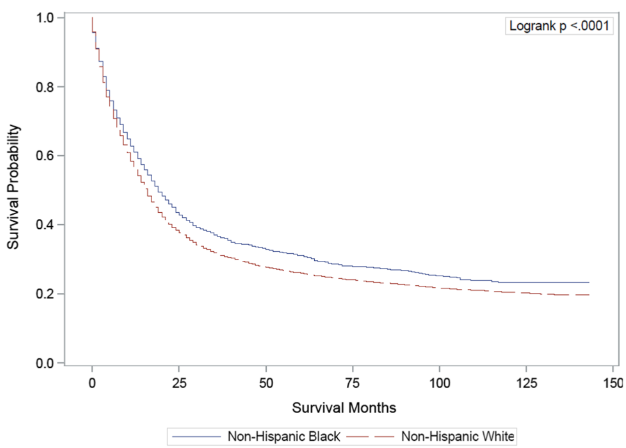


**Fig. 2** Kaplan–Meier brain cancer-specific survival curve for non-Hispanic Black and non-Hispanic White patients with malignant brain tumors of the neuroepithelial tissues by race diagnosed from 2004 to 2011, SEER 18

The 5-year brain cancer-specific survival rates were 36% and 29% for non-Hispanic Blacks Whites, respectively ($p < 0.0001$, results not shown). Kaplan–Meier curves show that non-Hispanic Blacks had a better brain cancer survival than non-Hispanic Whites during the study period ($p < 0.0001$, Fig. 2). Non-Hispanic Blacks had showed better brain cancer survival than non-Hispanic Whites (HR 0.88, 95% CI 0.84–0.93) overall and for glioblastomas specifically (HR 0.90, 95% CI 0.85–0.96) in the unadjusted model (model 1, Table 2). After further adjusting for sex, age at diagnosis, and year of diagnosis (model 2, Table 2), the direction of the association was reversed with non-Hispanic Black having worse brain cancer survival for all neuroepithelial tissue tumors (HR 1.07, 95% CI 1.02–1.13), astrocytic tumors (HR 1.16, 95% CI 1.02–1.33), and for oligoastrocytic tumors (HR 1.42, 95% CI 1.01–2.01), while the survival benefit disappeared for glioblastomas. The fully adjusted model (model 3, Table 2) which included demographic, tumor, and treatment characteristics shows no racial difference in brain cancer survival for neuroepithelial cancer overall (HR 1.05, 95% CI 0.99–1.10) or for any histology subtype (Fig. 3).

In the unadjusted model (model 1, Table 3), non-Hispanic Blacks were more likely to be diagnosed with a tumor of low grade (OR 1.15, 95% CI 1.02–1.29), and unknown grade (OR 1.21, 95% CI 1.10–1.33), smaller size (OR 1.13, 95% CI 1.01–1.36), unknown size (OR 1.21, 95% CI 1.08–1.36), non-supratentorial tumor (infratentorial: OR 1.92, 95% CI 1.61–2.29; spinal: OR 1.80, 95% CI 1.48–2.20; overlapping location: OR 1.14, 95% CI 1.03–1.26, Table 3). They were less likely to receive a total surgical resection compared to

**Table 2** Cox proportional hazard cancer-specific survival model comparing non-Hispanic Blacks to non-Hispanic Whites in SEER 18, 2004–2015

| | Hazard ratio (95% CI) | | |
|---|---|---|---|
| | Model 1 | Model 2 | Model 3 |
| Overall | 0.88 (0.84, 0.93)* | 1.07 (1.02, 1.13)* | 1.05 (0.99, 1.10) |
| Astrocytic | 0.92 (0.81, 1.05) | 1.16 (1.02, 1.33)* | 1.08 (0.95, 1.24) |
| Glioblastoma | 0.90 (0.85, 0.96)* | 1.03 (0.97, 1.09) | 1.03 (0.97, 1.09) |
| Oligodendroglial | 0.97 (0.68, 1.39) | 1.17 (0.82, 1.68) | 1.09 (0.76, 1.55) |
| Oligoastrocytic | 1.35 (0.96, 1.89) | 1.42 (1.01, 2.01)* | 1.26 (0.89, 1.77) |
| Gliomas | 0.80 (0.54, 1.17) | 0.96 (0.65, 1.42) | 0.95 (0.64, 1.40) |
| Embryonal | 1.26 (0.82, 1.92) | 1.26 (0.82, 1.95) | 1.26 (0.83, 1.93) |
| Other | 1.22 (0.78, 1.90) | 1.54 (0.98, 2.43) | 1.24 (0.79, 1.93) |

Hazard ratios presented are for Non-Hispanic Blacks compared to Non-Hispanic Whites

Model 1: univariable

Model 2: adjusted for sex, age, and year of diagnosis

Model 3: adjusted for sex, age, year of diagnosis, tumor grade, tumor size, tumor location, histology, and surgical type

*$p < 0.05$

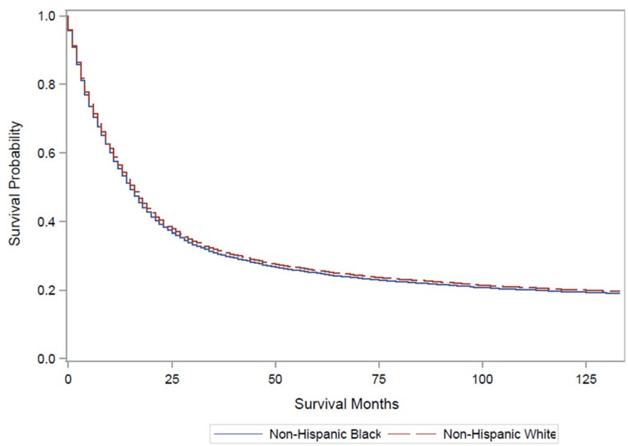


**Fig. 3** Adjusted brain cancer-specific survival curve for non-Hispanic Black and non-Hispanic White patients with malignant brain tumors of the neuroepithelial tissues by race diagnosed from 2004 to 2011, SEER 18. The model was adjusted for sex, age at diagnosis, year of diagnosis, tumor grade, tumor size, tumor location, and type of surgical treatment

non-Hispanic Whites (OR 0.89, 95% CI 0.80–1.00). After controlling for demographic variables (model 2, Table 3), compared to non-Hispanic White, non-Hispanic Blacks had lower odds of being diagnosed with a low-grade tumor (OR 0.87, 95% CI 0.77–0.99) and higher odds of having been diagnosed with a tumor of unknown grade (OR 1.26, 95% CI 1.14–1.39). Non-Hispanic Blacks were also more likely to have tumors in the smallest tertile (OR 1.13, 95% CI 1.01–1.26), and tumor of unknown size (OR 1.19, 95% CI 1.06–1.34), and more likely to have a non-supratentorial brain tumor (infratentorial: OR 1.60, 95% CI 1.34–1.91; spinal: OR 1.53, 95% CI 1.25–1.87; overlapping: OR 1.17, 95% CI 1.06–1.30). Non-Hispanic Blacks were less likely than non-Hispanic Whites to receive a radical total surgical resection (OR 0.81, 95% CI 0.73–0.91).

After including tumor characteristics (model 3, Table 3), only tumors of unknown grade and size, infratentorial and overlapping tumor locations, and total surgical resection remained significant. Non-Hispanic Blacks were still more likely to be diagnosed with tumors of unknown grade (OR 1.16, 95% CI 1.05–1.29) and unknown size (OR 1.14, 95% CI 1.01–1.29, Table 3). Non-Hispanic Blacks also had

**Table 3** Logistic regression estimates of the likelihood of brain tumor characteristics comparing non-Hispanic Blacks to non-Hispanic Whites in SEER 18, 2004–2015

| Characteristic | Tumors of the neuroepithelial tissues | | |
|---|---|---|---|
| | Odds ratio (95% CI) | | |
| | Model 1 | Model 2 | Model 3 |
| Tumor grade | | | |
| High grade | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Low grade | 1.15* (1.02, 1.29) | 0.87* (0.77, 0.99) | 0.90 (0.77, 1.04) |
| Unknown | 1.21* (1.10, 1.33) | 1.26* (1.14, 1.39) | 1.16* (1.05, 1.29) |
| Tumor size (mm) | | | |
| T3 (> 50 mm) | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| T2 (> 35–50 mm) | 1.05 (0.94, 1.18) | 1.07 (0.95, 1.20) | 1.05 (0.94, 1.18) |
| T1 (0–35 mm) | 1.13* (1.01, 1.26) | 1.13* (1.01, 1.26) | 1.08 (0.96, 1.21) |
| Unknown | 1.21* (1.08, 1.36) | 1.19* (1.06, 1.34) | 1.14* (1.01, 1.29) |
| Location | | | |
| Supratentorial | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Infratentorial | 1.92* (1.61, 2.29) | 1.60* (1.34, 1.91) | 1.39* (1.14, 1.70) |
| Spinal | 1.80* (1.48, 2.20) | 1.53* (1.25, 1.87) | 1.22 (0.91, 1.63) |
| Overlapping regions/ventricles | 1.14* (1.03, 1.26) | 1.17* (1.06, 1.30) | 1.12* (1.01, 1.24) |
| Surgery | | | |
| No surgery | 1.00 (reference) | 1.00 (reference) | 1.00 (reference) |
| Local surgery/subtotal resection | 1.07 (0.95, 1.19) | 0.96 (0.86, 1.08) | 0.96 (0.85, 1.08) |
| Radical/total resection | 0.89* (0.80, 1.00) | 0.81* (0.73, 0.91) | 0.83* (0.74, 0.93) |
| Surgery NOS | 1.48* (1.04–2.10) | 1.28 (0.90, 1.82) | 1.18 (0.83, 1.69) |

Odds ratios presented are for Non-Hispanic Blacks compared to Non-Hispanic Whites

Model 1: univariable

Model 2: adjusted for sex, age, and year of diagnosis

Model 3: adjusted for sex, age, year of diagnosis, mutually adjusted for tumor grade, tumor size, and tumor location

*$p < 0.05$

higher odds of having an infratentorial tumor (OR 1.39, 95% CI 1.14–1.70), a tumor in an overlapping or unspecified region (OR 1.12, 95% CI 1.01–1.24) and less likely to receive a radical or total surgical resection of their tumor (OR 0.83, 95% CI 0.74–0.93). After stratifying by histology type, similar significant results were only observed among glioblastomas (results not shown).

## Discussion

After controlling for tumor and treatment variables, this study found no difference in brain cancer-specific survival between non-Hispanic Black and non-Hispanic White patients with neuroepithelial brain cancer. Comparison of the tumor characteristics and surgical treatment type showed that non-Hispanic Blacks were more likely to be diagnosed with tumors of unknown grade, unknown size, and infratentorial or overlapping (or unspecified) located tumors; they were less likely to receive a radical surgical resection than non-Hispanic Whites.

Previous studies on racial differences in brain tumor survival found a survival advantage to Black brain cancer patients [10, 28–30]. A large SEER registry-based study found that the 5-year survival for Blacks with glioblastomas was significantly higher than that for Whites (32.8% vs. 26.8%) [10]. However, another registry-based study found the age-adjusted mortality rate in Whites to be about 1.8 times higher than in Blacks [30]. Using the data from a regional cancer registry in Texas, Nizamutdinov et al. [28] found that compared to Whites, Black patients had a much higher survival rate from glioblastoma (47.4% vs. 7.3%). These studies are limited in the extent to which they controlled only for age and demographic characteristics without adjustment for tumor and treatment specific variables. Ostrom et al. recently found lower relative survival rates among non-Hispanic Whites over 34 years of age as compared to other racial groups [31]. While they were able to control for surgery and stratified by histology, they did not adjust for any other tumor-specific variables such as size or location.

Our study showed better 5-year brain cancer-specific survival for non-Hispanic Black patients than non-Hispanic Whites disappeared after adjusting for tumor and treatment variables, as well as demographic characteristics. Several large SEER based studies on glioblastomas adjusted for tumor characteristics and treatment variables comparable to the ones included in our study and had similar findings [14, 15]. Some studies found worse survival among non-Hispanic Black patients as compared to non-Hispanic Whites. Using SEER data to evaluate supratentorial low-grade gliomas, Claus et al. found a 30% all-cause survival benefit for White patients [21]. However, this study was primarily focused on patterns of treatment modalities and survival by age. We were able to evaluate cancer-specific survival while incorporating more tumor-specific variables, including tumor histology and location, and type of surgery. Barnholtz-Sloan and colleagues' large SEER base analysis determined Black patients to be at a 13% increased risk of death compared to Whites with eleven specific types of brain tumors [12]. In a later study focusing on a small population of older glioblastoma patients from the linked SEER Medicare database, Barnholtz-Sloan et al. found no racial differences in survival [13]. Unlike our study, these studies were limited to fewer histology types than our study, used only supratentorial tumors [21], or defined location based only on the ICD-O primary site codes rather than in relation to the clinically significant cerebellar tentorium [12].

We showed that non-Hispanic Blacks were more likely to have infratentorial tumors or tumors in overlapping or unspecified regions than non-Hispanic Whites. To our knowledge, no research has described the distribution of tumor location (supratentorial vs. infratentorial) by race. Given that supratentorial tumors are associated with worse survival than those in other sites [18, 32], not controlling for tumor location might be a factor explaining better survival in some previous studies [12, 21]. Tumor location was adjusted for in our study. However, racial disparity in tumor location and its effects on survival warrants future studies.

This is the first study showing that non-Hispanic Blacks had significantly higher odds of having a tumor of unknown size or grade. Non-Hispanic Blacks may have less access to the health care systems and thus did not have their tumors measured and graded. Poorer follow-up and heavier reliance on lower quality healthcare reducing the chance of determining tumor grade or size due to less access to medical care with sufficient clinical and technological resources has been observed for racial minority cancer patients [1, 33–35].

The non-Hispanic Blacks in this study were found to be less likely to receive a gross total resection of the tumor, which is the recommended surgical treatment when feasible [36]. Studies examining racial disparities in receipt of surgery type for other cancers have noted differences with Blacks and other racial minorities are typically less likely than their White counterparts to receive the recommended type of surgical cancer treatments [37–40]. Studies examining racial disparities in extent of initial surgical treatments for brain cancer in particular are sparse, but two studies did find that Black patients have lower odds of receiving surgical resection [21, 41]. This study provides evidence for racial disparities in the type of brain cancer surgery received.

This study was able to contribute new information to the issue of racial disparities in brain cancer survival by using cancer-specific survival rather than relative or all-cause survival. It has been shown that the two methods of quantifying survival provide similar results, usually with slightly higher estimates of cause-specific survival [42, 43]. Given the small impact of cause of death misclassification on the calculation of hazard ratios in conjunction with SEER's uses of an algorithm which reduces the impact of cause of death misclassification [42, 44], the choice of cancer-specific survival is appropriate and superior to all-cause calculation methods.

This study's strength is in using brain cancer-specific death as the outcome and assessing the potential effects of tumor and treatment variables, based on the large SEER database. However, there are some limitations. Although we controlled for more confounding variables in this study than many previous studies, there might be residual confounding by variables not included in SEER data, such as specific treatments and comorbidities important factors for brain cancer prognosis [45, 46]. Other databases with relevant information may be used in future studies.

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## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

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