

# Racial Disparities in the Incidence and Survival of Spinal Meningioma

## Abstract

**Objective:** Race is a significant prognostic factor in various cancers, including the breast. Its prognostic association with spinal meningioma has not been established, although the incidence of spinal meningioma varies by race. In this retrospective cohort study, we aimed to investigate the association of race with the incidence and survival of spinal meningioma among a large population sample. **Materials and Methods:** A comprehensive search was done in the surveillance, epidemiology, and end results database between 2000 and 2016 to identify patients with spinal meningioma. Overall and race-specific incidence were calculated. The effect of race on overall survival among these patients was determined with Kaplan–Meier curve and Cox proportional hazard models. **Results:** Of 3502 spinal meningioma patients, 82.6% were Caucasian, 7.7% were African-American, 8.8% were Asian/Pacific Islander and 0.7% were American Indian/Alaska Native. The overall age-adjusted incidence was 0.239/100,000; it was highest among Caucasian (0.249) and lowest among American Indian/Alaska Native patients (0.137). There was a race effect in overall survival in the unadjusted analysis with the worst overall survival reported for Caucasian patients, and the best reported for American Indian/Alaska Native patients. However, this relationship was insignificant in the adjusted analysis. **Conclusions:** Race was not significantly associated with overall survival among these patients. Future studies should use spinal-meningioma-specific survival as outcome to see whether there is a racial difference in survival.

**Keywords:** Incidence, race, spinal meningioma, survival

## Introduction

Spinal meningioma is a slow-growing benign tumor of the spinal cord.<sup>[1]</sup> It generally occurs outside the cord but within its dural covering. It accounts for 7.5%–12.7% of all meningiomas (cranial and spinal) and 25%–46% of spinal neoplasms.<sup>[2]</sup> Spinal meningioma typically occurs among older individuals (age: 50–70 years),<sup>[3]</sup> but in rare instances, affects children.<sup>[4]</sup> It is more prevalent among females than males (ratio 3–4.2:1).<sup>[5]</sup> Spinal meningioma can be fully surgically resected without causing any neurological damage, and patients generally have an excellent prognosis.<sup>[2]</sup>

Several factors have been identified with the prognosis of spinal meningioma. The outcomes studied include postsurgical neurological functional status, recurrence, and survival.<sup>[3,6]</sup> A recurrent tumor status, higher Ki-67 index, and poor preoperative neurological functions were associated with poor postsurgical neurological functional status.<sup>[6]</sup> On the other hand, male gender,

higher tumor grade, recurrent tumor status, and a Simpson resection III were significantly associated with meningioma recurrence.<sup>[6]</sup> Although spinal meningioma is more prevalent among females, mortality from it is higher among males.<sup>[3]</sup>

Race is a significant prognostic factor in various types of cancer.<sup>[7]</sup> In the US, African-Americans have a higher incidence and lesser survival of all malignancies combined compared to other races.<sup>[8]</sup> Race differences in susceptibility to cancers are partially due to the genomic diversity among the races. Studies have shown more genetic diversity and fewer levels of linkage disequilibrium in Africans relative to all other populations.<sup>[9]</sup> Furthermore, there are multiple single-nucleotide polymorphisms and copy number variations associated with racial diversity. In addition, a difference in DNA methylation between Europeans and Africans, which is an early step before cancer development, showed that there was an epigenetic difference by race.<sup>[10]</sup>

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All this evidence suggests that race might have a prognostic value in the case of spinal meningioma, but data are lacking in this regard. A large-scale epidemiological study indicated that the incidence was higher among the Asian Pacific Islanders, Caucasians, and Hispanics.<sup>[11]</sup> Other small-scale studies also reported a racial difference in spinal meningioma.<sup>[12]</sup>

The current study used information contained in the surveillance, epidemiology, and end results (SEER) database and aimed to assess the association between race and survival in patients with spinal meningioma.

## Materials and Methods

We obtained patients' data from the SEER database 18 registries of the US National Cancer Institute.<sup>[13]</sup> The data were extracted using SEER\*Stat software version 8.3.5.

### Ethical consideration

This was a secondary analysis of publicly available data from the SEER database. No additional ethical approval was required.

### Data collection

All patients diagnosed with spinal meningioma between 2000 and 2016 were eligible. The primary tumor sites that were considered included spinal meninges (C70.1), spinal cord (C72.0), and cauda equina (C72.1). Patients were excluded if: (1) the diagnosis of spinal meningioma was not microscopically confirmed or was made from an autopsy, (2) the primary tumor site was unknown, and (3) they did not have an active follow-up.

We also extracted data on the following variables: race (Caucasian, African-American, American Indian/Alaska Native, and Asian or Pacific islander), gender (male, female), age at diagnosis into quartiles (<52, 52–63, 64–73, and >73), marital status (divorced/separated, married or domestic partner, single, and widowed), therapy including radiation and surgery (received and did not receive), vital status, tumor type (benign, borderline malignancy, and malignant), and size (<1 cm and ≥1 cm). There were no restrictions on any of the aforementioned variables except for race; patients with unknown race were excluded from the study.

### Incidence statistics

The age-adjusted incidence rate (per 100,000) of spinal meningioma between 2000 and 2016 was calculated using the SEER\*Stat software version 8.3.5. Its frequency, percentage, and rate of incidence were also determined for each race.

### Statistical analyses

Statistical analyses were performed using R Studio version 3.2.5 software. Since variables related to patients' characteristics were all categorical, they were presented as

frequencies and percentages. Comparison of these variables across the four racial groups was made using Chi-square or Fisher's exact test, whichever was more appropriate. A Kaplan–Meier curve was used to demonstrate the overall survival probability of the different racial groups, and a log-rank test was used to compare between them. Univariable and multivariable Cox regression models were used to compare the overall survival between the different races. The Caucasian race was used as a reference in the regression models, and adjustment was performed for the following covariates: age, gender, marital status, tumor site, size, behavior, radiation, and surgery. A two-sided  $P < 0.05$  was considered statistically significant.

## Results

### Patient population and baseline characteristics

A total of 3502 patients with spinal meningioma were identified between 2000 and 2016 according to eligibility criteria. Of those, 2895 (82.7%) were Caucasian, 272 (7.8%) were African-American, 310 (8.8%) were Asian or Pacific Islanders, and 25 (0.7%) were American Indian/Alaska Native. The distribution of patients by age was <52 (23.5%), 52–63 (27.4%), 64–73 (24.3%), and >73 years (24.8%). Females were the majority overall (81%) as well as in each racial group. Almost all patients (96%) received surgical resection of their tumors, and a tiny minority (1.7%) received radiation. At last follow-up, 80.2% of the African-American patients were alive; the corresponding percentages were 85.5% for Caucasian, 89.0% for Asian or Pacific Islanders, and 96.0% for American Indian/Alaska Natives. The distribution of age, gender, marital status, surgery, and vital status were significantly different across the four racial groups [Table 1].

### Surveillance, epidemiology, and end results population-based incidence statistics

The age-adjusted rate of spinal meningioma was 0.239/100,000. The rate was highest in Caucasian patients (0.249), followed by Asian or Pacific Islander (0.23), African-American (0.173), and American Indian/Alaska Native (0.137) [Table 2].

### Race-specific survival analysis for spinal meningioma patients

The Kaplan–Meier curve showed that Caucasian patients had the worst survival rate, American Indian/Alaska Native patients had the best survival rate, and Asian or Pacific Islanders and African-American patients had the intermediate survival rate; the log-rank test showed that this difference was statistically significant ( $P = 0.03$ ) [Figure 1]. Compared to Caucasians, the overall mortality was 33% lower for African-Americans (hazard ratio [HR] = 0.67, 95% confidence interval [CI] = 0.46, 0.98), 31% lower for Asian or Pacific Islanders (HR = 0.69, 95% CI = 0.48,

**Table 1: Characteristics of the included patients stratified by race**

Predictors	Caucasian (n=2895)	African- American (n=272)	Asian or pacific islander (n=310)	American Indian/ Alaska native (n=25)	P
Age at diagnosis (%)					
<52	647 (22.3)	100 (36.8)	69 (22.3)	8 (32.0)	<0.001
52-63	774 (26.7)	82 (30.1)	91 (29.4)	12 (48.0)	
64-73	698 (24.1)	59 (21.7)	89 (28.7)	4 (16.0)	
>73	776 (26.8)	31 (11.4)	61 (19.7)	1 (4.0)	
Gender (%)					
Female	2329 (80.4)	222 (81.6)	260 (83.9)	14 (56.0)	0.007
Male	566 (19.6)	50 (18.4)	50 (16.1)	11 (44.0)	
Marital status (%)					
Divorced/separated	301 (10.4)	35 (12.9)	19 (6.1)	3 (12.0)	<0.001
Married or domestic partner	1600 (55.3)	105 (38.6)	187 (60.3)	11 (44.0)	
Single (never married)	410 (14.2)	85 (31.2)	51 (16.5)	5 (20.0)	
Unknown	172 (5.9)	17 (6.2)	14 (4.5)	4 (16.0)	
Widowed	412 (14.2)	30 (11.0)	39 (12.6)	2 (8.0)	
Site (%)					
C70.1-spinal meninges	2819 (97.4)	265 (97.4)	303 (97.7)	23 (92.0)	0.746
C72.0-spinal cord	74 (2.6)	7 (2.6)	7 (2.3)	2 (8.0)	
C72.1-cauda equina	2 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	
Size (%)					0.88
<1 cm	1500 (51.8)	139 (51.1)	156 (50.3)	10 (40.0)	
≥1 cm	5 (0.2)	1 (0.4)	1 (0.3)	0 (0.0)	
Unknown	1390 (48.0)	132 (48.5)	153 (49.4)	15 (60.0)	
Behavior (%)					
Benign	2784 (96.2)	253 (93.0)	298 (96.1)	25 (100.0)	0.232
Borderline malignancy	75 (2.6)	14 (5.1)	9 (2.9)	0 (0.0)	
Malignant	36 (1.2)	5 (1.8)	3 (1.0)	0 (0.0)	
Surgery (%)					
Not received	115 (4.0)	8 (2.9)	7 (2.3)	5 (20.0)	<0.001
Received	2780 (96.0)	264 (97.1)	303 (97.7)	20 (80.0)	
Radiation (%)					
Not received/unknown	2846 (98.3)	265 (97.4)	305 (98.4)	25 (100.0)	0.656
Received	49 (1.7)	7 (2.6)	5 (1.6)	0 (0.0)	
Vital status (%)					
Alive	2445 (84.5)	240 (88.2)	276 (89.0)	24 (96.0)	0.027
Dead	450 (15.5)	32 (11.8)	34 (11.0)	1 (4.0)	

0.99), and 80% lower for American Indian/Alaska Natives (HR = 0.20, 95% CI = 0.03, 1.46); the results were significant for all the races except American Indian/Alaska Native [unadjusted model; Table 3]. The mortality, however, was not statistically different among the racial groups after adjustment with covariates [Table 3].

## Discussion

In various types of cancer, for example, breast, colon, and leukemia, survival varies by race.<sup>[14-16]</sup> The racial effect in survival among spinal meningioma patients has been unclear. A number of factors may have contributed to this lack of clarity, such as (1) small-sized studies, (2) single-center studies, and (3) studies that included patients who received a specific type of treatment.<sup>[17-20]</sup> This study contributes to the knowledge by assessing the

race effect on survival by drawing from a large spectrum of spinal meningioma patients in a population-based database (SEER).

In this study, Caucasian patients had the worst survival rate, American Indian/Alaska Native patients had the best survival rate, and Asian/Pacific Islanders and African-American patients had an intermediate survival rate. Nevertheless, there was no race effect when the model was adjusted for covariates. There are two potential explanations behind a null finding. The mortality from spinal meningioma is very low; therefore, there were not enough outcome events to find a difference by race. This study used all-cause mortality and not cancer-specific mortality (spinal meningioma) as outcome. Due to competing causes of death, it is difficult to find an effect when all-cause mortality is used as outcome unless the

**Table 2: Population-based incidence statistics for spinal meningioma stratified by race**

	Count (%)	Rate	SE
Total	3502 (100)	0.239	0.004
Race			
Caucasian	2895 (82.667)	0.249	0.005
African-American	272 (7.767)	0.173	0.011
American Indian/Alaska native	25 (0.714)	0.137	0.029
Asian or Pacific islander	310 (8.852)	0.23	0.013

Percent is for total cases. Rates are per 100,000 and age-adjusted to the 2000 US standard population. SE – Standard error

**Table 3: Uni- and multi-variable Cox proportional hazard model for the effect of race on overall survival of spinal meningioma**

	Overall survival	
	HR (95% CI)	P
Uni-variable analysis		
Caucasian	Reference	Reference
American Indian/Alaska native	0.20 (0.03, 1.46)	0.113
Asian or pacific islander	0.69 (0.48, 0.99)	0.044
African-American	0.67 (0.46, 0.98)	0.04
Multivariable analysis*		
Caucasian	Reference	Reference
American Indian/Alaska native	0.38 (0.05, 2.69)	0.329
Asian or pacific islander	0.90 (0.63, 1.30)	0.581
African-American	0.97 (0.66, 1.43)	0.88

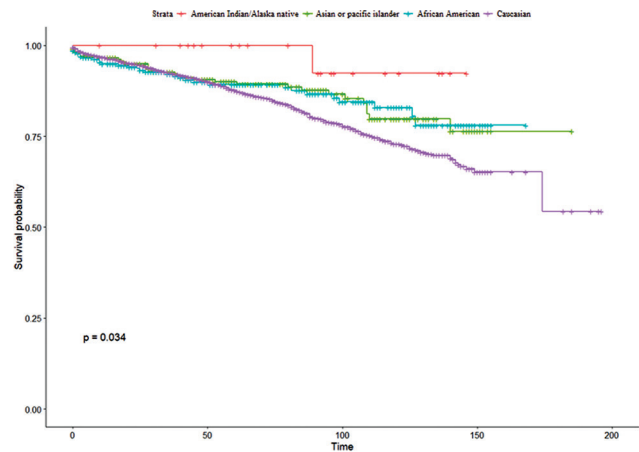
\*Covariates included in the adjusted model were age, site, size, gender, marital status, behavior, radiation, and surgery.

HR – Hazard ratio; CI – Confidence interval

disease in question is a leading cause of death,<sup>[21]</sup> which spinal meningioma may not be.

Most available studies on spinal meningioma, except one, were descriptive in nature and pertained to the incidence rates in different racial groups.<sup>[11,22]</sup> The sole study that reported prognostic estimates by race was by Maiti *et al.*<sup>[12]</sup> It enrolled 38 patients who underwent surgical resection and found no significant difference between Caucasians and African-Americans in terms of recurrence ( $P = 0.745$ ) or functional improvement ( $P = 0.606$ ) at 1-year follow-up. Although it was a small-sized study, had a short follow-up, and did not include a broad spectrum of patients, its findings were supportive of this current study.

This study's findings on spinal meningioma incidence by race were consistent with earlier published studies. The study by Kshetry *et al.* showed that Caucasian patients and Asian Pacific Islanders had the highest incidence of spinal meningioma, and African-American and American Indian/Alaskan Native individuals had a significantly lower incidence.<sup>[11]</sup> A second study found that nonHispanic Caucasians had a significantly higher incidence rate than nonHispanic African-Americans.<sup>[22]</sup> The observed racial difference in incidence might be attributed to the disparities

**Figure 1: Kaplan–Meier survival curve showing the overall survival for spinal meningioma patients based on race**

in genetic determinants (for example, polymorphisms, mutations), lifestyle, socioeconomic status, and health care access.<sup>[23]</sup>

This study had several strengths and limitations. It was a population-based study with robust sample size. The diagnosis of spinal meningioma and the outcome (survival) were ascertained by validated means. Although SEER is an important database for clinical research, the information contained in it might be subject to error (underreporting, misclassification, etc.).<sup>[24]</sup> In addition, patients might have migrated in and out of the registry areas, and the database might not have all the necessary variables. For example, the multivariate model of this study was not adjusted for several critical variables, such as surgical complications, treatment compliance, and other medical comorbidities as they were not available in the SEER database. Meningiomas have a long asymptomatic phase and are frequently underreported tumors, and therefore, potential variations in reporting are to be expected. This might have affected the incidence estimates of spinal meningioma.

## Conclusions

The incidence of spinal meningioma was highest in Caucasians, who experienced the worst survival rate, as compared to other racial groups. This racial difference in survival lost its statistical significance when the model was adjusted for covariates. Future studies should use spinal-meningioma-specific mortality as outcome to see whether there is a racial difference in survival.

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### Conflicts of interest

There are no conflicts of interest.

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