

Incidence trends, rates, and ethnic variations of primary CNS tumors in Texas from 1995 to 2013

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Abstract

Background. Although rare, primary central nervous system (CNS) tumors are associated with significant morbidity and mortality. Texas is a representative sample of the United States population given its large population, ethnic disparities, geographic variations, and socio-economic differences. This study used Texas data to determine if variations in incidence trends and rates exist among different ethnicities in Texas.

Methods. Data from the Texas Cancer Registry from 1995 to 2013 were examined. Joinpoint Regression Program software was used to obtain the incidence trends and SEER*Stat software was used to produce average annual age-adjusted incidence rates for both nonmalignant and malignant tumors in Texas from 2009 to 2013.

Results. The incidence trend of malignant primary CNS tumors in whites was stable from 1995 to 2002, after which the annual percent change decreased by 0.99% through 2013 (95% CI, -1.4, -0.5; $P = .04$). Blacks and Asian/Pacific Islanders showed unchanged incidence trends from 1995 to 2013. Hispanics had an annual percent change of -0.83 (95% CI, -1.4, -0.2; $P = .009$) per year from 1995 through 2013. From 2009 to 2013, the incidence rates of nonmalignant and malignant primary CNS tumors were highest among blacks, followed by whites, Hispanics, Asians, and American Indians/Alaskan Natives.

Conclusions. Consistent with the 2016 Central Brain Tumor Registry of the United States report, the black population in Texas showed the highest total incidence of CNS tumors of any other race studied. Many factors have been proposed to account for the observed differences in incidence rate including geography, socioeconomic factors, and poverty factors, although the evidence for these external factors is lacking.

Key words

brain tumors | CNS tumors | ethnicity | incidence | Texas

Although contributing to only about 3% of new cancer diagnoses worldwide, primary CNS tumors are a diverse group of tumors that can lead to significant social and neuro-cognitive consequences in the life of the patient and family.^{1–3} Likewise, the prognosis of patients with primary CNS tumors remains poor with an approximate 33.7% 5-year relative survival rate.⁴ Often the disease burden depends on the tumor grade and its location.² In this paper, we will examine the incidence trends of malignant primary

CNS tumors in Texas from 1995 to 2013 and also look at the incidence rates of both malignant and nonmalignant CNS tumors from 2009 to 2013. The population size of the state of Texas and its diversity, ethnic disparities, geographic variations and socio-demographic differences make it an ideal sample to compare to the United States population. Looking at how incidence rates vary from one ethnic group to another will give insight about the potential impact of external factors on these tumors.

Materials and Methods

The dataset was obtained from the Texas Cancer Registry of the Texas Department of Health and Human Services.⁵ Data contained incidence of both malignant and nonmalignant primary CNS tumors among Texas residents from 1995 to 2013. Individual-level data from the United States Department of Veteran Affairs and nonresidents were not included. Population estimates were age adjusted to the 2000 United States (US) standard population census and were obtained from the Surveillance, Epidemiology, and End Results (SEER) program of the National Cancer Institute.⁶

The SEER*Stat 8.3.2 statistical software package was used to analyze the data to yield average annual age-adjusted incidence rates, confidence intervals, and standard error of the estimates for both malignant and nonmalignant tumors diagnosed in Texas from 2009 to 2013. Doing so enabled comparison with the Central Brain Tumor Registry of the United States (CBTRUS) report from the same time period.⁷ Joinpoint Regression 4.4.0.0 software was used to obtain the incidence trends of malignant primary CNS tumors from 1995 to 2013. Joinpoint software, produced by the National Cancer Institute, utilized the multiple line segment model to find the line of best fit among brain tumor datasets that analyzed changes in tumor trends. The level of significance was calculated using the Monte Carlo permutation technique.⁸ It should be noted that data from nonmalignant tumors was not routinely collected until after the Benign Tumor Act went into action in 2004.⁹ Therefore, only trends of malignant primary CNS tumors were calculated from 1995 to 2013. All other incident rates included both malignant and nonmalignant primary CNS tumors over a 5-year period from 2009 to 2013.

Data on primary CNS tumors were selected by primary site using the International Classification of Diseases (ICD-O-3) defined by the World Health Organization (WHO). In keeping this study consistent with CBTRUS analysis, the same primary sites were studied in our analysis, including the following: nasal cavity (C30.0), cerebral meninges (C70.0), spinal meninges (C70.1), meninges (C70.9), cerebrum (C71.0), frontal lobe (C71.1), temporal lobe (C71.2), parietal lobe (C71.3), occipital lobe (C71.4), ventricle (C71.5), cerebellum (C71.6), brain stem (C71.7), overlapping lesion of the brain (C71.8), brain (C71.9), spinal cord (C72.0), cauda equina (C72.1), olfactory nerve (C72.2), optic nerve (C72.3), acoustic nerve (C72.4), cranial nerve (C72.5), overlapping lesion of brain and CNS (C72.8), nervous system (C72.9), pituitary gland (C75.1), craniopharyngeal duct (C75.2), and pineal gland (C75.3).

The data of each tumor were then recorded from diagnosed CNS tumors from the 7 main regions of Texas. Each region of Texas represents a different predominant geography, and each of the largest Texas cities are found within a different region. These regions are the Panhandle, West Texas, North Texas, East Texas, South Texas, Central Texas, and the Upper Gulf Coast.¹⁰

Level of poverty was categorized by percentages with 100% poverty meaning total poverty. The poverty variable

in the dataset was the census tract poverty indicator which has been frequently used in cancer studies to measure the relationship between socioeconomic status and cancers. We examined the relationship between primary CNS tumors and poverty levels by geographic regions and ethnicity. The divisions in poverty level (0% to <5%, 5% to <10%, 10% to <20%, and >20% poverty) were predefined at the time of data collection (Fig. 3 and 4).

Results

Incidence Rates by Ethnicity

The overall age-adjusted average annual incidence rate of both malignant and non-malignant primary CNS tumors in Texas from 2009 to 2013 is 24.91 (95% CI, 24.62, 25.19) per 100,000 population of the 2000 US standard population. Across all races, females had a higher age-adjusted incidence rate of 27.68 when compared to the incidence rates among males (21.91). From 2009 to 2013, the incidence rate of malignant and nonmalignant tumors were highest among blacks (26.35), whites (24.82), and Hispanics (22.35). Incidence rates were lowest among Asians (17.06) and American Indians/Alaskan natives (8.19) (Table 1).

Average incidence rate of tumor types varied among the different ethnicities studied. Blacks showed higher incidence rates of meningiomas (11.37) and pituitary adenomas/carcinomas (7.09) per 100,000 population of the 2000 US standard population. Whites were found to have the highest incidence rates of astrocytomas (4.52), unspecified intracranial/intraspinal neoplasms (1.78), mixed gliomas (0.60), ependymomas (0.46), and oligodendrogliomas (0.31). Hispanics showed the highest incidence rates among lymphomas (0.60).

Incidence Rates by Region

The highest age-adjusted average annual incidence rates per 100,000 population were seen in the Texas Panhandle region (29.80), North Texas (27.90), and West Texas (25.60). South Texas had the overall lowest incidence rate of 21.80. By tumor type, the Panhandle region was found to have the highest incidence rates of meningiomas (11.22), pituitary adenomas/carcinomas (4.62), unspecified intracranial/intraspinal neoplasms (2.69), and astrocytomas (4.76), versus any other region in Texas. Central Texas had the highest incidence rates of ependymomas (0.56) and oligodendrogliomas (0.34). The Upper Gulf Coast region showed the highest incidence rates of lymphomas (0.53) (Table 2).

Incidence Rates by Behavior

Of all primary CNS tumors, approximately 30% were malignant. The overall age-adjusted average annual incidence rates for malignant primary CNS tumors was 7.35 (95% CI, 7.20, 7.51), and for non-malignant brain tumors, the incidence rate was 15.78 (95% CI, 15.68, 16.01) per 100,000 population age-adjusted to the 2000 United States standard population (Table 1). For malignant tumors, males

Table 1 Average annual age-adjusted incidence rate per 100,000 population stratified by behavior and race in Texas from 2009 to 2013

	Total			Malignant			Borderline			Nonmalignant		
	Count	Rate	95% CI	Count	Rate	95% CI	Count	Rate	95% CI	Count	Rate	95% CI
All races	30356	24.91	24.61–25.19	9101	7.35	7.20–7.51	2146	1.75	1.67–1.82	19077	15.78	15.68–16.01
White	25448	24.83	24.52–25.14	8057	7.76	7.59–7.93	1770	1.73	1.65–1.81	15591	15.31	15.07–15.56
Black	3552	26.35	25.45–27.28	727	5.01	4.63–5.40	286	2.02	1.78–2.28	2538	19.32	18.53–20.12
Hispanic	7831	22.35	21.82–22.89	2289	6.01	5.75–6.29	634	1.68	1.54–1.83	4899	14.63	14.20–15.08
AI/AN	79	8.19	6.26–10.49	23	2.45	1.43–3.87	4	0.47	0.10–1.25	52	5.28	3.79–7.12
A/PI	756	17.06	15.74–18.47	200	4.36	3.71–5.08	46	0.99	0.70–1.36	509	11.67	10.57–12.86

Abbreviations: AI/AN, American Indian/Alaska Native; A/PI, Asian/Pacific Islander

Total count of each row may not add up to 100% due to omitted “in-situ” histologic classification

Table 2 The average annual age-adjusted incidence rate (malignant and nonmalignant) per 100,000 population and frequency of primary CNS tumors by ICD-03/WHO 2008 morphology in Texas State by geographic regions (2009 to 2013)

Morphology	Panhandle	North Texas	East Texas	Upper Gulf Coast	South Texas	West Texas	Central Texas
	Rate (Count) 95% CI	Rate (Count) 95% CI	Rate (Count) 95% CI	Rate (Count) 95% CI	Rate (Count) 95% CI	Rate (Count) 95% CI	Rate (Count) 95% CI
All primary brain and CNS tumors	29.8 (647) 27.5–32.2	27.9 (9176) 27.3–28.5	23.7 (2516) 22.8–24.7	25.3 (7120) 24.7–25.9	21.8 (4384) 21.2–22.5	25.7 (2746) 24.7–26.6	22.6 (3194) 21.8–23.4
Ependymomas	0.29 (6) 0.10–0.53	0.45 (155) 0.38–0.52	0.31 (31) 0.21–0.44	0.39 (123) 0.32–0.47	0.36 (76) 0.28–0.45	0.44 (47) 0.32–0.58	0.56 (83) 0.44–0.70
Astrocytomas	4.76 (106) 3.89–5.76	4.15 (1394) 3.93–4.38	4.18 (444) 3.79–4.60	4.28 (1252) 4.04–4.53	4.10 (842) 3.82–4.39	4.17 (454) 3.79–4.58	4.72 (670) 4.36–5.09
Other gliomas	0.61 (13) 0.32–1.04	1.16 (406) 1.05–1.28	0.75 (72) 0.58–0.94	0.84 (252) 0.74–0.95	0.70 (140) 0.59–0.82	0.88 (94) 0.71–1.08	0.88 (123) 0.73–1.05
Oligodendrogliomas	0.20 (4) 0.06–0.52	0.32 (117) 0.27–0.39	0.26 (24) 0.16–0.39	0.31 (91) 0.25–0.38	0.20 (38) 0.14–0.38	0.28 (28) 0.19–0.41	0.34 (50) 0.25–0.45
Mixed and unspecified gliomas	0.35 (8) 0.15–0.70	0.80 (278) 0.71–0.91	0.47 (46) 0.34–0.62	0.49 (149) 0.41–0.58	0.49 (100) 0.40–0.60	0.59 (71) 0.46–0.76	0.52 (74) 0.41–0.66
Other specified intracranial/intraspinal neoplasms	15.92 (343) 14.26–17.72	15.43 (4960) 14.99–15.87	11.51 (1242) 10.86–12.18	13.46 (3678) 13.01–13.92	10.89 (2160) 10.43–11.36	12.81 (1365) 12.14–13.52	10.39 (1450) 9.85–10.95
Pituitary adenomas and carcinomas	4.62 (99) 3.74–5.63	4.09 (1391) 3.87–4.31	2.65 (217) 2.34–3.0	3.49 (1018) 3.27–3.71	3.43 (686) 3.17–3.70	2.92 (311) 2.60–3.27	2.31 (338) 2.06–2.57
Meningiomas	11.22 (242) 9.82–12.74	10.88 (3402) 10.51–11.27	8.55 (943) 8.0–9.13	9.48 (2507) 9.10–9.88	7.09 (1395) 6.72–7.48	9.37 (997) 8.78–9.98	7.75 (1062) 7.28–8.44
Unspecified intracranial and intraspinal neoplasms	2.69 (59) 2.04–3.48	1.54 (489) 1.41–1.69	2.33 (246) 2.05–2.65	1.72 (462) 1.56–1.89	1.77 (353) 1.59–1.97	2.22 (238) 1.94–2.52	1.46 (198) 1.26–1.68
Lymphomas and reticuloendothelial neoplasms	0.29 (6) 0.11–0.63	0.46 (152) 0.39–0.55	0.39 (44) 0.28–0.53	0.53 (144) 0.44–0.62	0.51 (99) 0.42–0.63	0.42 (44) 0.30–0.56	0.50 (67) 0.38–0.63

Abbreviations: ICD-03, International Classification of Diseases-Oncology 3; WHO, World Health Organization

are seen to have a higher incidence rate when compared to females at 8.41 versus 6.25. For nonmalignant tumors, females had a higher incidence rate of 19.71 compared to the male incidence rate of 11.75.

Incidence Trends in Texas

For the general population, the incidence trends of malignant primary CNS tumors have been stable with a nonsignificant annual percent change (APC) from 1995 to 2002. Beginning in 2002 and extending until 2013, there was a significant decrease in incidence trend in the general

population, with APC = -1.12 (95% CI, -1.6, -0.7; $P = .004$). Beginning in 2001, the incidence trend of primary CNS tumors in males started to decrease, with an average APC of -0.98 (95% CI, -1.5, -0.4; $P = .017$). Beginning in 2003, the incidence trend of primary CNS tumors in females started to decrease, with an average APC of -1.32 (95% CI, -1.9, -0.7; $P = .006$). The trend curve in males is higher than females demonstrating a higher incidence of malignant primary CNS tumors in males (Fig. 1).

Beginning in 2002, the incidence trend in whites of malignant primary CNS tumors decreased by 1% per year. This incidence trend continued to decrease through

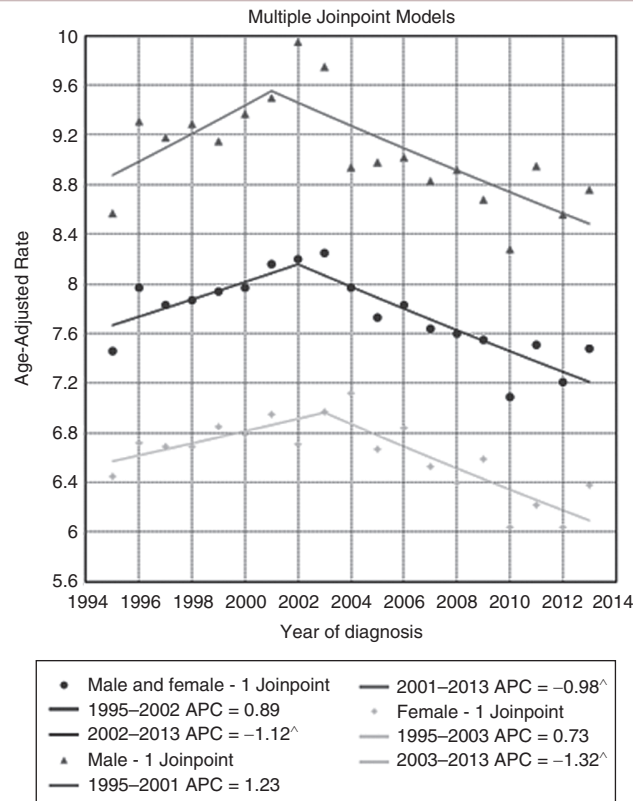


Fig. 1 Trends in incidence of malignant primary CNS tumors in Texas by gender from 1995 to 2013.

2013 (95% CI, -1.4, -0.5; $P = .004$). For blacks and Asian/Pacific Islanders, the incidence rates were relatively stable from 1995 through 2013 without a significant change in trend. Hispanics had a constant trend throughout with the incidence rate decreasing at 0.83% per year from 1995 through 2013, APC = -0.83 (95% CI, -1.4, -0.2; $P = .009$) (Fig. 2).

Grade of Tumor Versus Socioeconomic Status

For all tumors (malignant and nonmalignant) there was an observed variation in socioeconomic status of patients from one region of Texas to another (Fig. 3). Poverty levels were highest in South and West Texas; 48.72% of patients in South Texas and 42.21% of patients in West Texas were at greater than 20% of poverty level. Forty-eight percent of patients in East Texas and 34.57% of patients in Central Texas were at the 10% to 20% poverty level. Patients in the Panhandle region, North Texas, and Upper Gulf Coast regions had a wide spread in the different socioeconomic levels (Fig. 3). With regards to ethnicity, a higher proportion of Hispanic and black patients were at higher poverty levels: 53.01% and 45.36%, respectively, compared to white patients, who were averagely spread along the socioeconomic spectrum (Fig. 3).

Discussion

Texas Versus the United States

Texas and the United States share many characteristics, most notably, the demographics in the major metropolitan areas of Texas are similar to those of the United States.¹¹ Select regions of Texas also correspond to the major population demographics found in different regions of the United States. For example, the US Census Bureau reveals that the majority of the population in South and West Texas is made up of the Hispanic population as is the Southwestern and Western regions of the United States.¹² The Upper Gulf Coast and East Texas regions correspond to the Southeast region of the United States with the highest percentage of black population.¹²

From 2009 to 2013, the average annual age-adjusted incidence rate for primary CNS tumors (malignant and nonmalignant) in Texas was 24.91 per 100,000 population, which is slightly higher than the national average of 22.36 per 100,000 population as seen in the 2016 CBTRUS report.⁷ Approximately 30% of the primary CNS tumors diagnosed in Texas were malignant (7.37 versus 16.15 for nonmalignant tumors per 100,000 US population). This is likewise consistent with the 2016 CBTRUS report for the same period of study.⁷ Males had a higher incidence

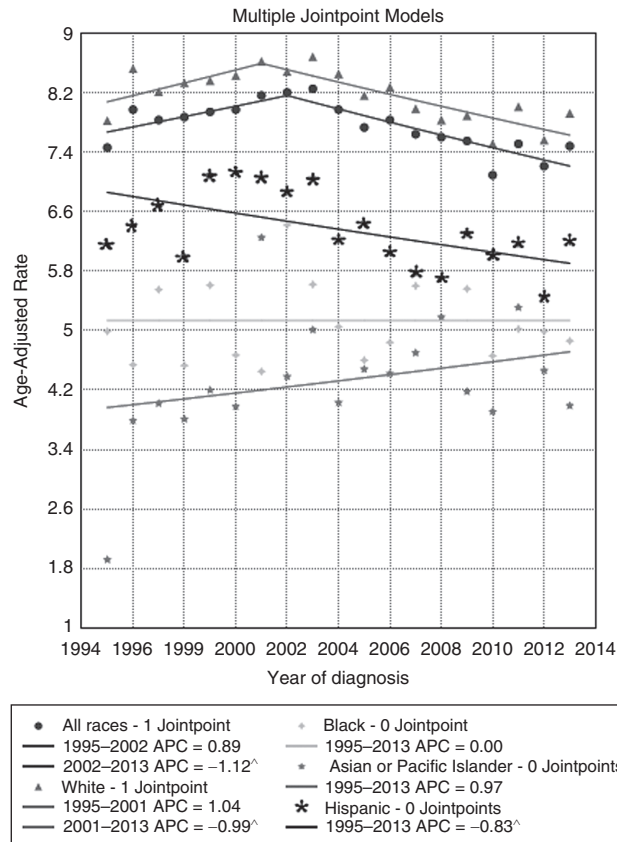


Fig. 2 Trends in incidence of malignant primary CNS tumors in Texas by ethnicity from 1995 to 2013.

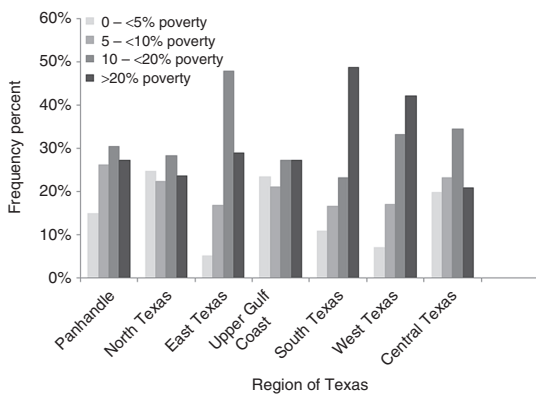


Fig. 3 Frequency of primary CNS tumors (malignant and nonmalignant) by poverty level in Texas from 2009 to 2013.

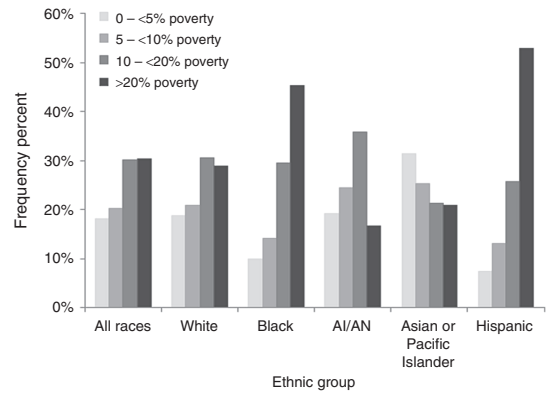


Fig. 4 Frequency of primary CNS tumors (malignant and nonmalignant) by poverty level among different ethnic groups in Texas from 2009 to 2013.

rate of malignant tumors at 8.41 per 100,000 US population compared to females at 6.25 per 100,000 US population. Females, though, had a combined higher incidence rate of both malignant and nonmalignant tumors at

27.68 compared to 21.19 for males per 100,000 US population. A known hormone dependence of meningiomas could account for the male-to-female differences seen in incidence.¹³

Trends by Race

When investigating primary CNS tumors by race, there are many unique differences among incidence rates, incidence trends, and susceptibility to certain tumor types.^{14–17} As seen in [Table 1](#), the incidence rate of malignant primary CNS tumors is highest in the white population in Texas when compared to other ethnicities. Regions of Texas with the highest percentage of whites include the Panhandle, North Texas, and Central Texas. In a similar fashion, data from the United States as a whole revealed whites to have the overall highest incidence rates for brain tumors, namely gliomas.¹⁸ The CBTRUS Report also revealed that blacks have higher incidence rates when compared to other races studied for pituitary tumors, meningiomas (malignant and nonmalignant), and craniopharyngiomas.⁷ The higher rate of pituitary tumors and meningiomas among blacks in the United States is consistent with our findings (7.09 and 11.37 per 100,000 US population, respectively).

One possible reason for the observed differences seen among different races has to do with the socioeconomic status and presence of adequate health insurance coverage. Blacks were found to have lower socioeconomic status and lack of health insurance coverage when compared to other races.^{19,20} Interpretation of these differences by socioeconomic differences and race may have its problems though, as patients with little to no access to health care may lead to underreporting of incidence.¹⁸ This fact could explain why the Panhandle and North Texas, regions with a lower level of poverty, report a higher incidence of primary CNS tumors ([Fig. 3](#)).

Trends by Texas Region

The highest incidence rates of malignant and nonmalignant CNS tumors in Texas were seen in the Texas Panhandle (29.8) followed by North Texas (27.9) per 100,000 US population. Given the majority white population demographic in these regions, this may suggest increased access to health care leading to increased screening. Furthermore, environmental influences in view of the construction and intense oil and gas activities going on in this region may also contribute to an increased incidence of primary CNS tumors in this area.^{21,22} However, large scale research studies have shown that many common environmental, workplace, and toxin exposures have not proven to have a significant effect on incidence rates of primary CNS tumors.¹⁸

Our data represent a decrease in incidence trends of malignant primary CNS tumors in all reported ethnicities (except Asian or Pacific Islander) in the state of Texas. These observations are consistent with reports by the National Cancer Institute.²³ Even though part of the incidence has been attributed to improved screening, it is possible that demographic transition of southern states (which have the highest growth rates in the nation) might have affected the temporal trends of diseases, including brain tumors, responsible for a declining incidence rate. Other important factors that may potentially contribute to observed changes are improved quality of life, significant reduction in tobacco consumption, awareness and trends of healthy life style benefits (exercise, diet), and better control of environmental health.

Conclusion

Consistent with the 2016 CBTRUS report, it is seen that the black population and females in Texas have the highest incidence rate of primary malignant and non-malignant CNS tumors when compared to other races and males, respectively. When subdividing by malignant tumors only, whites and males were found to have the highest rates in each category of these tumors. Regions of Texas, such as the Panhandle and North Texas, with a higher percentage of white population, reported an increased incidence of primary CNS tumors. Although no clear external factors were seen to directly contribute to primary CNS tumor incidence, long term prospective studies particularly ones that focus on the black population are needed to study specific risk factors and disparities of incidence.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Acknowledgement

Cancer data have been provided by the Texas Cancer Registry, Cancer Epidemiology and Surveillance Branch, Texas Department of State Health Services, P.O Box 149347, Austin, Texas 78756.

Conflict of interest: The authors declare no conflicts of interest.

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