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Epidemiology of Primary Intracranial Neoplasms: A Single-Institute Cross-Sectional Study in Iran

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Abstract

Background: Primary central nervous system (CNS) tumors represent a diverse group of neoplasms with variable histologic features and clinical behavior. In Iran, the lack of a robust cancer registry has limited comprehensive epidemiological evaluations. This study aimed to assess the distribution, histopathological subtypes, and demographic characteristics of primary intracranial tumors diagnosed at a major referral center in Tehran.

Methods: This retrospective cross-sectional study reviewed 1603 histologically confirmed primary CNS tumor cases diagnosed at Loghman-e-Hakim Hospital in Tehran, Iran, from 2010 to 2017. Demographic data, tumor location, histopathologic classification, and the World Health Organization (WHO) grade were extracted from pathology reports. Tumors were classified based on the 2007 and 2016 WHO CNS tumor classifications. Statistical analysis was performed using SPSS Version 23, employing chi-square and t tests with a significance level set at $P < 0.05$.

Results: The mean age of patients was 42.9 ± 17.4 years, with a slight female predominance (52.5%). The most common tumor groups were gliomas (38%) and meningiomas (37.9%). Glioblastoma (14.6%) and transitional meningioma (14.2%) were the most prevalent subtypes. Meningiomas were significantly more frequent in females (odds ratio, 3.14; 95% CI, 2.54-3.89; P < 0.001), while gliomas and embryonal tumors were more common in males. The age distribution showed that gliomas peaked in the 20-40-year-old group, whereas meningiomas were most frequent in patients aged 41-60 years. A statistically significant variation in tumor distribution by age was observed for several tumor types. An increasing trend in CNS tumor diagnoses was noted over the study period, especially for gliomas and meningiomas.

Conclusion: This study provides a comprehensive overview of the epidemiological and histopathological profile of CNS tumors in a single-center Iranian cohort. The findings are consistent with global trends, particularly in the sex- and age-specific distributions of gliomas and meningiomas. The increasing incidence observed underscores the need for enhanced surveillance and a national cancer registry to improve data accuracy and healthcare planning.

Keywords: Central Nervous System, Intracranial, Neoplasm, Epidemiology

Conflicts of Interest: *None declared*
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Introduction

Although a significant portion of the central nervous system (CNS) neoplasms are metastatic (about one-

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↑What is "already known" in this topic:
Primary central nervous system (CNS) tumors represent a diverse group of neoplasms with varying histologic subtypes, age and sex distributions, and clinical behaviors. Global data suggest gliomas and meningiomas are among the most common types. However, in many countries, including Iran, epidemiologic patterns are less well-defined due to limited national cancer registries and population-based data.

→What this article adds:
This single-center study provides one of the most comprehensive reviews of histologically confirmed primary intracranial tumors in Iran. By analyzing 1603 cases over a 7-year period, it highlights the distribution of tumor types, subtypes, and their associations with age and sex. The findings also reveal temporal trends and support the need for enhanced surveillance and nationwide registry efforts to better understand the burden of CNS tumors in the region.

fourth), the most common tumors originating from this site are primary (1). Unlike the child population, primary CNS tumors are rare in adults and account for only 1% to 2% of all neoplasms (2). They consist of a heterogeneous spectrum of tumors and can show a malignant, benign, or uncertain behavior (3). Worldwide, the age-adjusted annual incidence of malignant brain neoplasms is 5.57 per 100,000 population, with considerable variability between geographic regions. Europe and Canada have the highest incidence rates, and Southeast Asia, India, and East Asia have the lowest. The Middle East, including Iran, has been reported to have an annual incidence rate of 4.21 per 100,000 population (4), although some nationwide studies in Iran estimated it to be 2.73 (5). These significant differences could be related to the poor registry system in our region. From another perspective, the primary CNS tumors are very diverse in terms of histopathological features, clinical behavior, and outcomes (3, 6). These tumors can be divided into 29 histologic groups and 143 subtypes according to the 2016 World Health Organization (WHO) classification (3). In the most recent update of the WHO classification, 104 tumor types and 168 subtypes can be recognized (7). The increase in tumor types is due to newly recognized entities, molecular subtypes, and reclassification of some existing tumors. In this regard, meningioma is the most common histology among primary brain neoplasms, including 40.8% of all brain tumors based on the Central Brain Tumor Registry of the United States (CBTRUS), followed by pituitary tumors (17.2%) and glioblastoma (14.2%) (8). In a small report from Golestan, Iran, glioblastoma, followed by diffuse astrocytoma and malignant meningioma, were the most prevalent primary malignant CNS tumors (9). Primary spinal cord tumors are very rare in the adult population and can be intramedullary or extramedullary. Meningiomas, nerve sheath tumors, and ependymomas are the most common primary tumors of the spinal cord in adults, together accounting for >85% of all cases (8).

Because of the poor cancer registry system in Iran, we conducted this study to investigate the frequency of different histologic subtypes of CNS tumors submitted to our referral pathology department, while accounting for patient age, sex, and tumor histopathological features.

Methods

We retrospectively reviewed all cases with confirmed diagnoses of CNS tumors submitted to the pathology department at Loghman-e-Hakim Hospital, Tehran, Iran, from 2010 to 2017 (7 years). We included all patients who underwent neurosurgical resection or biopsy of CNS lesions and whose tumors were diagnosed as primary CNS neoplasms based on histopathologic criteria. Exclusion criteria included metastatic tumors, incomplete pathology records, and non-neoplastic conditions. We extracted available data on patients' sex, age at diagnosis, date of surgery, location, pathologic classification, and tumor histologic grade from hospital medical records. The diagnosis in all cases was made on routine histopathological examination and, if needed, on immunohistochemistry, based on the WHO classification of CNS tumors (4th edition, 2007, and its updated version, 2016). Arteriovenous malformation was included in our report as a primary CNS neoplasm, while pituitary adenomas were excluded. To minimize selection bias, we included all consecutive eligible cases submitted to the pathology department over the defined 7-year period. No formal sample size calculation was performed due to the planned descriptive design. To reduce inter-observer variability, all cases were reviewed by a single expert pathologist to ensure consistent classification and histopathologic interpretation. Statistical analyses were conducted using SPSS version 23 (Chicago, IL, USA). Chi-square tests were used for categorical variables, while Student's t tests were applied to continuous variables. $P < 0.05$ was considered statistically significant.

Results

A total of 1603 patients were included in the present study, with a mean age of 42.9 ± 17.4 years (range, 1-94 years). The patient population was slightly skewed toward females, who accounted for 52.5% of cases, while males accounted for 47.5%. In terms of tumor distribution, gliomas were the most common diagnosis, representing 38% (609 cases) of all tumors, followed closely by meningiomas at 37.9% (608 cases). Schwannomas and vascular tumors, accounting for 9.5% and 4.2% of the cases, respectively, were the most common diagnoses. WHO tumor grading applied to 1337 cases, with Grade 1 tumors accounting for 48.3%, Grade 2 for 22.5%, Grade 3 for 7.7%, and Grade 4 for 21.5%. Figure 1 shows the distribution of tumor diagnoses across the study population.

Among gliomas, glioblastoma was the most common subtype, accounting for 38.4% of cases, while transitional meningioma was the most common meningioma subtype, accounting for 37.3%. Arteriovenous malformation was the predominant vascular tumor (58.2%), and classic medulloblastoma was the most diagnosed embryonal tumor (82.1%). Among neuronal and mesenchymal tumors, central neurocytoma, ganglioglioma (each 38.5%), and hemangioblastoma (70.8%) were the most frequent, respectively. Melanocytoma was the only melanocytic tumor, while intermediate differentiation tumors (63.6%) and germinoma, along with mature teratoma (each 50%), were the most common pineal and germ cell tumors, respectively. Table 1 presents the detailed distribution of subtypes for each CNS tumor group. Notably, schwannoma, craniopharyngioma, and choroid plexus tumor had no subtypes.

Distribution of Tumor Diagnoses by Sex

The sex distribution of the study participants reveals a distinct pattern in the occurrence of different tumor types. Males were more frequently diagnosed with specific tumor types, including gliomas (360 males vs 249 females), craniopharyngiomas (28 males vs 18 females), and embryonal tumors (28 males vs 11 females), suggesting a higher prevalence of these tumors in males. In contrast, tumors like meningiomas (423 female vs 185 male) were notably more common in females, highlighting a sex-specific tendency for certain central nervous system neoplasms. Other tumor types, such as schwannomas and neuronal tumors, showed relatively balanced sex distribu-

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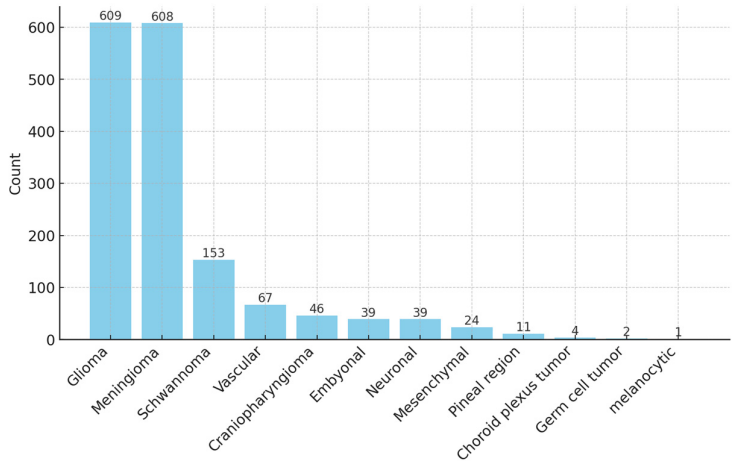

Figure 1. Tumor Diagnosis Distribution

Table 1. Tumor Subtypes Distribution

Tumor Group	Subtype	Number (Percent of all cases)
Gliomas	GBM (Glioblastoma Multiforme)	234 (14.6%)
	Diffuse Astrocytoma	144 (9.0%)
	Pilocytic Astrocytoma	55 (3.4%)
	Oligodendroglioma	54 (3.4%)
	Ependymoma	41 (2.6%)
	Oligoastrocytoma	39 (2.4%)
	Gliosarcoma	10 (0.6%)
	Myxopapillary Ependymoma	10 (0.6%)
	SGA (Subependymal Giant Cell Astrocytoma)	6 (0.4%)
	Pilomyxoid Astrocytoma	5 (0.3%)
	PXA (Pleomorphic Xanthoastrocytoma)	5 (0.3%)
	Subependymoma	5 (0.3%)
	Angiocentric Glioma	1 (0.06%)
Meningiomas	Transitional	227 (14.2%)
	Meningothelial	165 (10.3%)
	Atypical (brain invasion)	72 (4.5%)
	Fibrous	58 (3.6%)
	Angiomatous	27 (1.7%)
	Microcystic	16 (1.0%)
	Secretory	13 (0.8%)
	Anaplastic	10 (0.6%)
	Psammomatous	9 (0.6%)
	Metaplastic	5 (0.3%)
	Clear cell	3 (0.2%)
	Lymphoplasmacytic	2 (0.1%)
	Chordoid	1 (0.06%)
Vascular Tumors	AVM (Arteriovenous Malformation)	39 (2.4%)
	Cavernous	28 (1.7%)
Embryonal Tumors	Medulloblastoma (Classic)	32 (2.0%)
	Medulloblastoma (Desmoplastic)	3 (0.2%)
	PNET (Primitive Neuroectodermal Tumor)	1 (0.06%)
	Neuroblastoma	1 (0.06%)
	Ependymoblastoma	1 (0.06%)
	Medulloblastoma (Large cell)	1 (0.06%)
Neuronal Tumors	Central Neurocytoma	15 (0.9%)
	Ganglioglioma	15 (0.9%)
	DNT (Dysembryoplastic Neuroepithelial Tumor)	7 (0.4%)
	DIA-DIG (Desmoplastic Infantile Ganglioglioma/Astrocytoma)	1 (0.06%)
	Dysplastic Gangliocytoma of the Cerebellum	1 (0.06%)
Mesenchymal Tumors	Hemangioblastoma	17 (1.1%)
	Hemangiopericytoma	7 (0.4%)
Melanocytic Tumors	Melanocytoma	1 (0.06%)
Pineal Tumors	Intermediate Differentiation Tumor	7 (0.4%)
	Pineoblastoma	3 (0.2%)
	Pineocytoma	1 (0.06%)
Germ Cell Tumors	Germinoma	1 (0.06%)
	Mature Teratoma	1 (0.06%)

tions, with only slight differences in the number of male and female cases. We conducted chi-square tests to assess

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statistical significance in the sex distribution of tumor diagnoses. We calculated odds ratios (OR) to quantify the strength of the association between sex and each tumor type. Meningiomas were notably more common in females, with an OR of 3.14 (95% CI, 2.54-3.89; $P < 0.001$), indicating a higher likelihood of diagnosis in females. In contrast, gliomas, craniopharyngiomas, and embryonal tumors were more frequently diagnosed in males. Specifically, gliomas showed a male predominance (OR, 1.49; 95% CI, 1.25-1.77; $P < 0.001$), as did craniopharyngiomas (OR, 1.67; 95% CI, 1.03-2.70; $P = 0.035$) and embryonal tumors (OR, 2.89; 95% CI, 1.56-5.35; $P < 0.001$). Vascular tumors also had a higher incidence in males, although the difference was not statistically significant (OR, 2.04; 95% CI, 0.99-4.18; $P = 0.053$).

Distribution of Tumor Diagnoses by Age Groups

The distribution of tumor diagnoses across age groups demonstrates distinct patterns for different types of central nervous system neoplasms. Gliomas were most frequently diagnosed in patients aged 20 to 40 years, with a notable peak in this age group (277 cases). Meningiomas showed a high frequency in the 41-60 age range (308 cases), reflecting the older age predilection for this tumor type. In contrast, embryonal tumors were predominantly diagnosed in younger patients, with the majority (20 cases) diagnosed at <20 years of age. Table 2 shows the detailed distribution of tumor diagnoses by age groups. It also presents the results of chi-square tests evaluating whether the distribution of brain tumor diagnoses varies significantly across 4 age groups (<20, 20-40, 41-60, and >60 years). Tumor types such as meningioma, embryonal tumors, gliomas, craniopharyngiomas, vascular tumors, neuronal tumors, and germ cell tumors showed statistically significant differences in distribution across age groups ($P < 0.001$). In contrast, schwannomas, mesenchymal tumors, choroid plexus tumors, melanocytic tumors, and pineal region tumors did not exhibit statistically significant variation.

Adjusted Logistic Regression Results (Age and Sex)

Multivariable logistic regression, adjusting for age and sex, showed that gliomas were significantly more common in males (OR, 2.08; 95% CI, 1.69-2.56; P < 0.001) and occurred at younger ages (OR per year, 0.98; 95% CI, 0.97-0.99; $P < 0.001$). In contrast, meningiomas were strongly associated with increasing age (OR per year, 1.06; 95% CI, 1.05-1.07; $P < 0.001$) and were less common in males (OR, 0.28; 95% CI, 0.22-0.35; $P < 0.001$), corresponding to approximately 3.6-fold higher odds in females. Embryonal tumors showed a strong association with younger age (OR per year, 0.90; 95% CI, 0.87-0.92; $P < 0.001$) and a modest male predominance (OR, 2.18; 95% CI, 1.04-4.57; $P = 0.038$). Vascular tumors also occurred more often in males (OR, 2.13; 95% CI, 1.26-3.59; $P = 0.005$) and at slightly younger ages (OR per year, 0.97; 95% CI, 0.95-0.98; $P < 0.001$). Craniopharyngiomas and neuronal tumors were associated with younger age (both $P < 0.001$), but sex was not a significant predictor in adjusted models ($P = 0.19$ and $P = 0.95$, respectively). Germ cell tumors were too infrequent to support a stable multivariable model; only descriptive results are reported.

Trend of CNS Tumor Diagnoses Over the Years

The number of brain tumor cases showed a generally increasing trend over the years, with a gradual rise in annual diagnoses throughout the study period. Figure 2 shows the overall increasing trend in brain tumor diagnoses over the years.

Among the various brain tumor types diagnosed over the study period, gliomas, meningiomas, and schwannomas emerged as the most prevalent and dynamically changing categories. Gliomas consistently accounted for the largest proportion of cases each year, maintaining a stable range of 35% to 46% of all diagnoses. Meningiomas showed a noticeable upward trend, particularly during the early 2011s, peaking at over half of the annual cases in 2015. Schwannomas, while less frequent overall, exhibited distinct peaks, most notably in 2012, when they represented >20% of brain tumor cases. In contrast, other tumor types—including embryonal, vascular, mesenchymal, and germ cell tumors—were diagnosed infrequently and showed no significant temporal variation. These findings suggest a stable burden of gliomas, an increasing trend in meningioma detection, and episodic spikes in schwannoma diagnoses, with other tumor types remaining relatively

Table 2. Distribution of Tumor Diagnoses by Age Groups

Diagnosis	<20 (years)	20-40 (years)	41-60 (years)	>60 (years)	Total	Chi-square	p-value	95% CI
Choroid Plexus Tumor	1	2	0	1	4	2.96	0.397	0.00–0.50
Craniopharyngioma	14	19	13	0	46	33.54	<0.001	0.00–0.41
Embryonal	20	18	1	0	39	98.77	<0.001	0.00–0.51
Germ Cell Tumor	2	0	0	0	2	20.26	<0.001	0.00–1.00
Glioma	69	277	171	92	609	39.01	<0.001	0.11–0.45
Meningioma	10	111	308	179	608	155.30	<0.001	0.02–0.51
Mesenchymal	2	14	6	2	24	5.92	0.116	0.08–0.58
Neuronal	10	20	9	0	39	24.18	<0.001	0.00–0.51
Pineal region	1	5	4	1	11	0.85	0.837	0.09–0.45
Schwannoma	7	60	65	21	153	7.03	0.071	0.05–0.42
Vascular	8	40	18	1	67	24.35	<0.001	0.01–0.60
Melanocytic	0	0	1	0	1	1.69	0.639	0.00–1.00
Total	144	566	596	297	1603			

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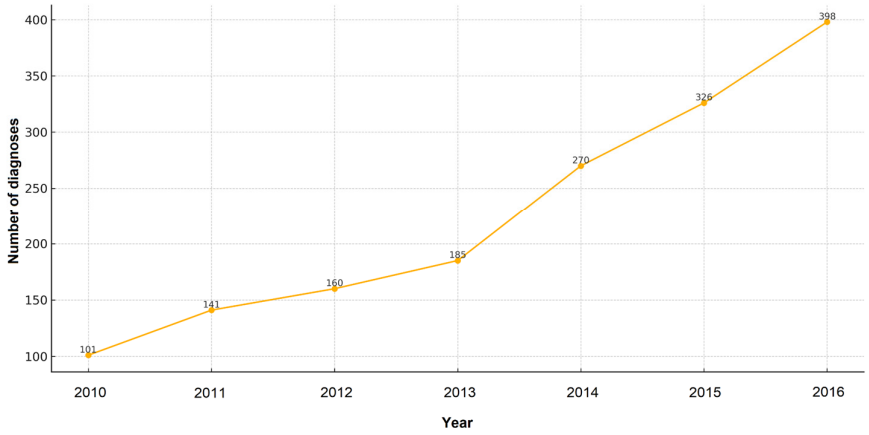

Figure 2. Annual incidence of histologically confirmed primary CNS tumors (2010-2017)

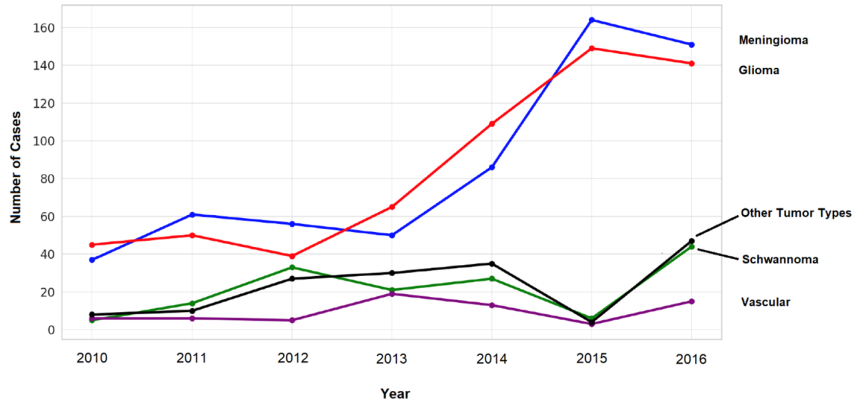

Figure 3. Annual incidence trends of major CNS tumor types (2010–2017)

rare and static over the decades. Figure 3 illustrates the annual incidence of different tumor types, highlighting changes in their relative frequencies over time.

The observed increase in tumor diagnoses over time may be influenced by several factors—including advancements in diagnostic imaging, heightened clinical awareness, and improved pathology reporting within the center. However, these trends should be interpreted with caution, as they may also reflect changes in referral patterns rather than true epidemiological shifts. Given the single-center design and the absence of a national cancer registry, the data may underrepresent cases from other regions or institutions, limiting generalizability and population-level incidence estimates.

Discussion

Our study aimed to assess the distribution and histopathological features of CNS tumors in a cohort of patients from Loghman-e-Hakim Hospital in Tehran, Iran, spanning from 2010 to 2017. We observed significant differences in tumor distribution, demographic factors, and tumor trends compared with studies from other regions. Here, we compare our results with the findings from global and regional research, exploring similarities and differences in the incidence of specific CNS tumor types and their associated trends. In our study, gliomas (38.0%) and meningiomas (37.9%) were the most common CNS tumor types, consistent with patterns observed in other studies. For instance, a large-scale study from England analyzing primary brain tumors between 1995 and 2017 found gliomas to be the most frequent tumor type, with meningiomas as the second most common (10). Similarly, a multicenter study conducted in neighboring Lebanon, involving 695 patients, reported a comparable distribution pattern, with gliomas and meningiomas being the most frequently diagnosed primary brain tumors. Specifically, glioblastomas were among the most commonly identified glioma subtypes, and meningiomas were the most common benign tumors, accounting for 29.6% of all brain tumor cases (11). Our study revealed notable sex-based differences in CNS tumor types. Meningiomas were significantly more common in females, aligning with global epidemiological patterns (8). This observation is consistent with findings by Leece et al, who reported a pronounced female predominance in meningiomas across multiple international cancer registries (4). Some studies suggest that hormonal factors may influence meningioma development, as these tumors are observed to occur about

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twice as often in women compared with men (12). In our cohort, the results suggest an even stronger sex association (approximately 3.6-fold higher odds in females) than that reported in many Western populations, potentially reflecting regional genetic, hormonal, or environmental influences. Conversely, gliomas were more frequently diagnosed in males, mirroring trends observed in other international and regional studies (8). This male predominance has also been highlighted in studies from Iran. For instance, in a retrospective multicenter study assessing CNS tumor prevalence across Iran, gliomas dominated among males, confirming our findings (13). This male predominance may be linked to genetic, hormonal, and environmental factors, although the exact etiology remains unclear. The age distribution of CNS tumors in our study showed gliomas predominating in the 20-40 year age group, consistent with other studies, including those by Jazayeri et al (5) and Mehrazin et al (14), which also reported that gliomas were more frequently diagnosed in younger adults. Our study also reported a notable peak of meningiomas in the 41-60 year age group, along with a substantial incidence in individuals >60 years, reflecting the established age-related predilection for this tumor type, as observed in previous studies (10, 14). Embryonal tumors, which are typically more common in children and adolescents, were also found predominantly in the <20-year group, as observed in other global and regional studies (4, 15). This finding aligns with the general understanding that embryonal tumors, such as medulloblastomas, are rare in adults but remain a significant concern in the pediatric population. Our study revealed an increasing trend in the number of CNS tumor diagnoses over the years, particularly for gliomas and meningiomas. This trend is not unique to our cohort; studies from various countries, including the United Kingdom and the most recent report from Iran, have observed similar increases in brain tumor diagnoses over time (10, 16). This phenomenon may be attributed to a combination of factors, including improvements in diagnostic imaging, greater awareness of CNS tumors, and better reporting systems. It is also possible that the increased incidence reflects actual rises in tumor prevalence, possibly due to environmental or lifestyle factors, although this remains speculative. While the increasing trend in gliomas aligns with findings from several global studies, the rising incidence of meningiomas in our cohort stands out. Meningiomas have been steadily increasing in incidence in several countries, as observed by Wanis et al (10) and Ho et al (17). Still, this trend has been particularly noticeable in countries with well-established cancer registries. Our study may reflect this global trend; however, the lack of a robust cancer registry system in Iran limits our ability to assess this increase fully. Despite the valuable insights our study provides, several limitations need to be acknowledged. First, the absence of a national cancer registry in Iran poses challenges in accurately assessing the true incidence and prevalence of CNS tumors. As a result, cases from smaller medical centers or rural areas may be underrepresented. Another significant limitation concerns the evolution of diagnostic criteria over the study period. Since our samples span 2010 to 2017, diagnoses were based on earlier editions of the WHO Classification of CNS tumors. Specifically, the 2007 and early 2016 versions were used for diagnosis before the widespread adoption of molecular parameters introduced in late 2016 and, especially, the 2021 WHO CNS classification. Consequently, the lack of molecular profiling in earlier diagnoses may have led to misclassification or underdifferentiation of certain tumor types, particularly gliomas and embryonal tumors, which are now more precisely defined based on genetic markers.

Conclusion

Our study provides a comprehensive analysis of the distribution and histopathological characteristics of CNS tumors in a large cohort from Tehran, Iran. The findings generally align with international trends, particularly in the distribution of gliomas and meningiomas, the sex-specific prevalence, and the age-related predilection for specific tumor types. The increasing trend of CNS tumor diagnoses over the years is consistent with global studies. However, the limitations of local registries and data-collection systems in Iran necessitate caution in interpreting this trend. Further research with a broader geographic scope and more extensive data collection is needed to confirm these findings and explore the underlying causes of the observed trends.

Authors' Contributions

The authors contributed equally to this work.

Ethical Considerations

This study was approved by the local scientific and ethical committee with the ethical approval code of IR.SBMU.MSP.REC.1398.1009.

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None.

Conflict of Interests

The authors declare that they have no competing interests.

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