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A retrospective epidemiological study of the World Health Organization (WHO)-classified primary brain and other Central Nervous System (CNS) tumors from a tertiary health care center in Northeast India

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Abstract

Background Brain and other central nervous systems (CNS) tumors are a heterogeneous group of neoplasms that are prevalent in all age groups and gender. The study aimed to investigate the pattern of distribution of World Health Organization (WHO) classified primary brain and other CNS tumors among different age groups and gender at a tertiary care center in Northeast India. This is the first study of CNS tumors from this region of the country. The data obtained can be useful for correct diagnosis, timely treatment, and management of CNS tumors in this area. It can also provide relevant information concerning research and funding for this disease. Data collection was done retrospectively from January 1996 to March 2022. Distribution frequency as per age, gender, histopathology type, and tumor location was estimated. Data analysis was performed using the SPSS software.

Results A total of 1441 primary brain and other CNS tumors were examined in the study. There were 232 pediatric cases (16.1%) and 1209 adult cases (83.9%). The ratio of males to females was 1.4. The majority of the cases in the overall cohort were meningiomas ($n=346$; 24%). Among the pediatric cohort, the maximum occurrence of gliomas, glioneuronal, and neuronal tumors ($n=68$; 29.3%) was seen while meningiomas ($n=336$; 27.8%) showed the highest prevalence in the adult cohort. There were 248 other distinct cases of CNS (17.2%) of which 62 (26.7%) were identified within the pediatric cohort and the remaining 186 (15.4%) were detected among the adult population. Most of the tumor sites was supratentorial areas ($n=759$; 52.7%) with the next being spinal cord ($n=258$; 18%).

Conclusion This is the first study from Northeast India that highlights the prevalence of WHO-classified CNS tumors. With newer and advanced health care and diagnostic facilities, there is an increased incidence of CNS tumors in developing countries. Our study may help in understanding the epidemiological aspects and highlight the need for research, funding, and maintenance of a hospital-based tumor registry for this particular ailment.

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Keywords Age, Frequency, Gender, Histopathology, Central nervous system tumors

Background

Primary brain and other central nervous systems (CNS) tumors comprise a heterogeneous group of malignant and non-malignant neoplasms [1]. They are found to be prevalent in both children and adults and account for less than 2% of all neoplasms [1]. About 5–10 individuals per 100,000 populations are affected by brain and other CNS tumors in India which constitute approximately 2% of all malignant neoplasms [2, 3]. The causes of CNS tumors are unknown. However, certain risk factors that can increase the likelihood of this disease include family history, genetic factors, radiation exposure, stress, and a weakened immune system [4]. The signs and symptoms of CNS tumors vary according to tumor size and location [5]. The symptoms that are commonly seen are blurred vision, headache, gait imbalance, seizures, nausea, and vomiting. They may develop gradually over time or might occur abruptly. Diagnosis is usually done by neuro-radiological imaging tests that include a computed tomography (CT) scan and/or magnetic resonance imaging (MRI) and histopathological tests such as a biopsy [5]. The World Health Organization (WHO) classification of CNS tumors has been the most widely accepted practice for classifying CNS tumors. A few important changes about grading, specific entities, and terminology has been incorporated in the 5th (2021) revised edition of CNS WHO classification [6].

Epidemiological studies play a crucial role in determining the distribution and identifying the contributing risk factors as well as the etiological agents of different diseases [7]. Such descriptive studies are important for accurate disease prevention, management, and control [7]. A few epidemiological studies for various brain tumors have been conducted in different parts of India [8–10]. However, there is a dearth of such studies from the Northeast region of the country. The present study is aimed at understanding the epidemiological aspects of all WHO-classified primary brain and other CNS tumors with regards to age, gender, tumor type, and tumor location from a tertiary health care center in Northeast India. This will give an insight into the prevalence of CNS tumors in the Indian population.

Also, the data will be helpful in the development and maintenance of a CNS tumor registry in future which might be beneficial for the pathologists and neurosurgeons of this region. Such a hospital-based registry can aid in understanding disease etiology, early diagnosis, and accurate treatment of CNS tumors from this region. It can provide important information to the hospital administration and the policymakers for the best treatment plans that are required for the patients. This epidemiological study also provides updated data on cancer prevalence in the Indian population and therefore, can be a part of population-based cancer registries (PBCRs).

Methods

A single-centric retrospective cohort study was performed. All CNS cases between zero to > 70 years of age diagnosed in the neurosurgery department of our hospital during the 26 years from 1996 to 2022 were investigated. A total of 1441 cases were included in the study. Tumor biopsies were performed and the reports were examined. Clinical details about patient age, gender, histopathological diagnosis, and tumor location were collected from the biopsy reports and analyzed. The samples were fixed in 4% formalin, embedded in paraffin, sectioned, and stained with hematoxylin and eosin (H&E). The H&E slides were viewed under the microscope for examination of the histological features. All the cases were re-classified according to the revised CNS WHO 2021 classification. The cases were arbitrarily segregated into eight groups: 1–9 years, 10–19 years, 20–29 years, 30–39 years, 40–49 years, 50–59 years, 60–60 years, and > 70 years. Frequencies of distribution as per age, gender, histopathology, and tumor location were determined for all the cases. Data analysis was performed using the SPSS software version 17 [11].

Results

The present study consisted of WHO-classified primary brain and other CNS tumor cases as well as some other distinct cases of CNS from January 1996 to March 2022 that were diagnosed at the departments of neurosurgery and pathology of our hospital (Table 1). There were a total of 1441 cases that comprised 232 pediatric (16.1%) and 1209 adult patients (83.9%). The pediatric cohort consisted of 148 males (63.8%) and 84 females (36%) with a male/female ratio of 1.8. In the adult cohort, there were

Table 1 Primary brain and other CNS tumor cases from 1996 to 2022

	Pediatric cases	Adult cases
Total (*n*; %)	232 (16.1%)	1209 (83.9%)
Male (*n*; %)	148 (63.8%)	688 (57%)
Female (*n*; %)	84 (36%)	521 (43.1%)
M: F ratio	1.8	1.3

688 males (57%) and 521 females (43.1%) and the male/female ratio was 1.3.

The age and gender wise distribution of WHO-classified primary brain and other CNS tumors are shown in Table 2. Upon age wise distribution, it was observed that the cases showed the highest proportion in the sixth decade ($n=317$; 22%) followed by fifth ($n=313$; 21.7%) and fourth decades ($n=217$; 15.1%). Gender wise distribution analysis revealed that the proportion of males ($n=836$; 58%) was more than the females ($n=605$; 42%) with the male/female ratio being 1.4.

Overall in the cohort, meningiomas ($n=346$; 24%) showed the largest proportion followed by gliomas, glioneuronal tumors, and neuronal tumors ($n=326$; 22.6%), cranial and para spinal nerve tumors ($n=198$; 13.7%), tumors of the seller region ($n=101$; 7%), and mesenchymal, non-meningothelial tumors ($n=78$; 5.4%) in that order. Metastases ($n=57$; 4%), embryonal tumors ($n=38$; 2.6%), ependymal tumors ($n=36$; 2.5%), choroid plexus tumors ($n=6$; 0.4%), pineal tumors ($n=4$; 0.3%), and germ cell tumors ($n=3$; 0.2%) were also detected. There were no hematolymphoid tumor cases during our study period. Other CNS cases ($n=248$) constituted 17.2%. Table 3 gives a description about the histological wise distribution of all CNS cases of the overall cohort of our study. Most of the tumors showed male predilection except meningiomas and tumors of the seller region where the M: F ratio was 0.6 and 0.9 respectively.

Gliomas, glioneuronal tumors, and neuronal tumors ($n=59$; 25.4%) were the most prevalent among the classified tumors within the pediatric population followed by tumors of the seller region ($n=21$; 9.1%), embryonal tumors ($n=24$; 10.3%), ependymal tumors ($n=18$; 7.8%), mesenchymal, non-meningothelial tumors ($n=16$; 6.9%), cranial and para spinal nerve tumors ($n=12$; 5.2%), and meningiomas ($n=10$; 4.3%) (Fig. 1). Overall, these tumors constituted about 69% of all pediatric CNS cases. Pineal tumors ($n=4$; 1.7%), choroid plexus tumors ($n=3$; 1.3%), germ call tumors (n = 2; 0.9%), and metastases ($n=1$; 0.4%) represented only 4.3% of all tumors within

Table 2 Age and gender wise distribution of primary brain and other CNS tumors from 1996 to 2022

Age range (years)	Male	Frequency (%)	Female	Frequency (%)	Ratio	Total (*N*)	Frequency (%)
0–10	53	66.3	27	33.8	1.0	80	5.6
11–18	95	62.5	57	37.5	1.7	152	10.5
19–29	110	64.3	61	35.7	1.8	171	11.9
30–39	135	62.2	82	37.8	1.7	217	15.1
40–49	161	51.4	152	48.6	1.1	313	21.7
50–59	184	58	133	41.9	1.4	317	22.0
60–69	83	52.9	74	47.1	1.1	157	11.0
> 70	15	44.1	19	55.9	0.8	34	2.4

Table 3 Histological wise distribution of primary brain and other CNS tumors from 1996 to 2022

Histopathology type	Age range (years)	Male	Frequency (%)	Female	Frequency (%)	Ratio	Total (*n*)	Frequency (%)
Gliomas, glioneuronal tumors, and neuronal tumors	$0–70^+$	221	67.8	105	32.2	2.1	326	22.6
Ependymal tumors	$0–70^+$	21	58.3	15	41.7	1.4	36	2.5
Choroid plexus tumors	$0–70^+$	4	66.7	2	33.3	2.0	6	0.4
Embryonal tumors	$0–70^+$	27	71.1	11	28.9	2.5	38	2.6
Pineal tumors	$0–70^+$	3	75	1	25	3	4	0.3
Cranial and para spinal nerve tumors	$0–70^+$	128	64.6	70	35.3	1.8	198	13.7
Meningiomas	$0–70^+$	123	35.5	223	64.5	0.6	346	24.0
Mesenchymal, non-meningothelial tumors	$0–70^+$	49	62.8	29	37.2	1.7	78	5.4
Hematolymphoid tumors	$0–70^+$	0	0	0	0	0	0	0
Germ cell tumors	$0–70^+$	2	66.7	1	33.3	2	3	0.2
Tumors of the seller region	$0–70^+$	49	48.5	52	51.5	0.9	101	7.0
Metastases	$0–70^+$	37	64.9	20	35.1	1.9	57	4.0
Others	$0–70^+$	172	69.3	76	30.7	2.3	248	17.2

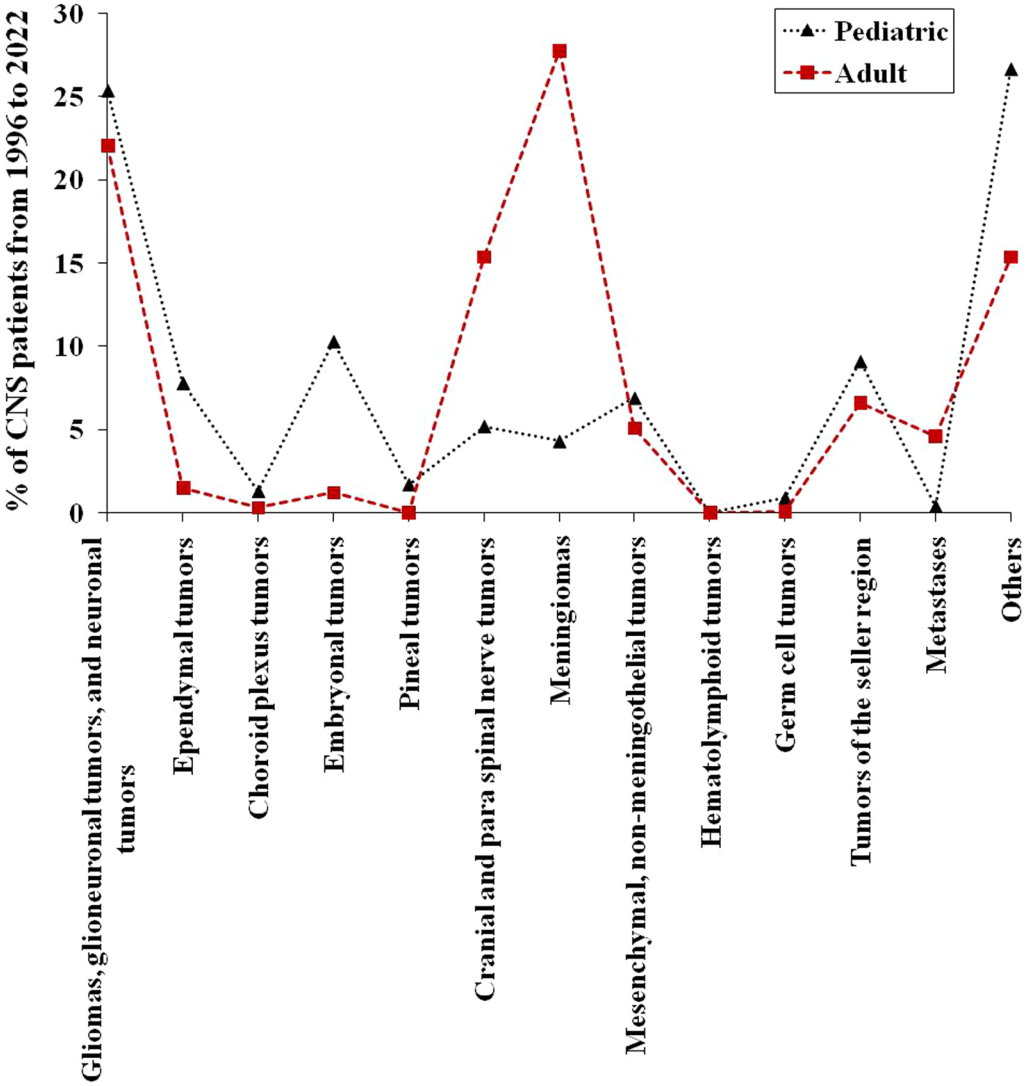

Fig. 1 Histological distribution of CNS cases in pediatric and adult group

the pediatric cohort (Fig. 1). However, it was noted that about 26.7% ($n=62$) of the pediatric cases were the auxiliary cases of CNS. The histological wise distribution of all pediatric CNS cases is shown in Table 4.

The maximum proportion among the classified tumors in the adult cohort was noted to be the meningiomas ($n=336$; 27.8%) with the next being gliomas, glioneuronal tumors, and neuronal tumors ($n=267$; 22.1%) followed by cranial and para spinal nerve tumors ($n=186$; 15.4%) (Fig. 1). Together, they represented about 65.3% of the overall adult CNS cases. Approximately, 19% ($n=228$) of the cases were comprised of germ cell tumors ($n=1$; 0.08%), choroid plexus tumors ($n=3$; 0.3%), embryonal tumors ($n=14$; 1.2%), ependymal tumors ($n=18$; 1.5%), metastases ($n=56$; 4.6%) mesenchymal, non-meningothelial tumors ($n=62$; 5.1%), and tumors of the seller region ($n=80$; 6.6%) (Fig. 1). There were no adult pineal tumor cases during the period of study. The auxiliary cases in general represented about 15.4% ($n=186$) of the adult CNS cases.

The histological wise distribution of all adult CNS cases is indicated in Table 4. Histological distribution of gliomas, glioneuronal tumors, and neuronal tumors within the overall cohort was also analyzed (Figs. 2, 3). It was observed that in both pediatric and adult groups, astrocytoma grade 2 was the most common glioma comprising 23.7% and 35.2% respectively. Astrocytoma grade 1 (20.3%), astrocytoma grade 3 (6.8%), astrocytoma grade 4 (1.7%), glioblastoma (1.7%), mixed oligodendroastrocytoma (historical; 1.7%), oligodendroglioma (17%),

Table 4 Histopathological wise distribution of primary brain and other CNS tumors in pediatric and adult patients

Histopathological type	Pediatric cohort		Total (*N*)	Frequency (%)	Adult cohort		Total (*N*)	Frequency (%)
	Male	Female			Male	Female		
Gliomas, glioneuronal tumors, and neuronal tumors	38	21	59	25.4	183	84	267	22.1
Ependymal tumors	10	8	18	7.8	11	7	18	1.5
Choroid plexus tumors	2	1	3	1.3	2	1	3	0.3
Embryonal tumors	17	7	24	10.3	10	4	14	1.2
Pineal tumors	3	1	4	1.7	0	0	0	0
Cranial and para spinal nerve tumors	6	6	12	5.2	122	64	186	15.4
Meningiomas	8	2	10	4.3	115	221	336	27.8
Mesenchymal, non-meningothelial tumors	7	9	16	6.9	42	20	62	5.1
Hematolymphoid tumors	0	0	0	0.0	0	0	0	0.0
Germ cell tumors	2	0	2	0.9	0	1	1	0.08
Tumors of the seller region	11	10	21	9.1	38	42	80	6.6
Metastases	1	0	1	0.4	36	20	56	4.6
Others	43	19	62	26.7	129	57	186	15.4

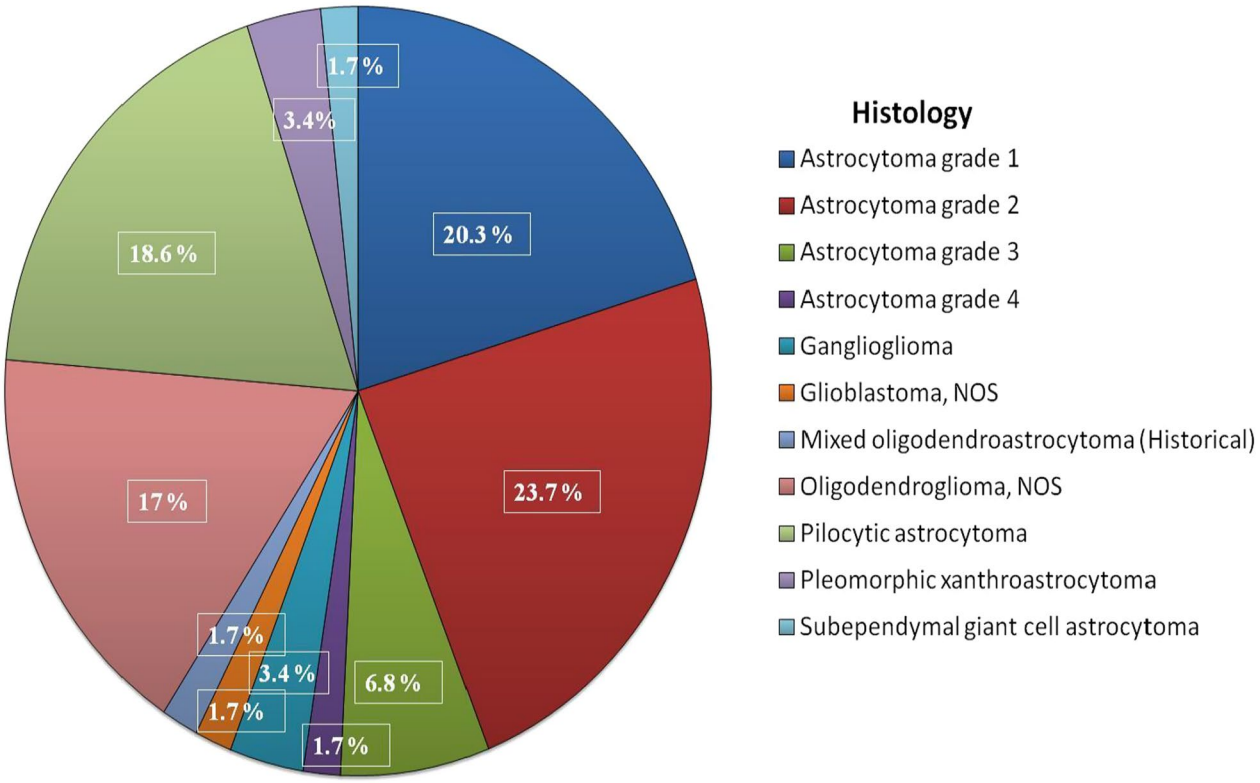

Fig. 2 Histological distribution of gliomas, glioneuronal tumors, and neuronal tumors in the pediatric cohort

pilocytic astrocytoma (18.6%), pleomorphic xanthroastrocytoma (3.4%), and subependymal giant cell astrocytoma (1.7%) were the other gliomas seen within the pediatric population of our study. Similarly, glial tumors that were observed within the adult group consisted of astrocytoma grade 1 (3.8%), astrocytoma grade 3 (16.1%), astrocytoma grade 4 (4.1%), diffuse astrocytoma (1.5%), gemistocytic astrocytoma (historical; 2.3%), glioblastoma (14.6%), mixed oligodendroastrocytoma (historical; 2%), oligodendroglioma (16.5%), pilocytic astrocytoma

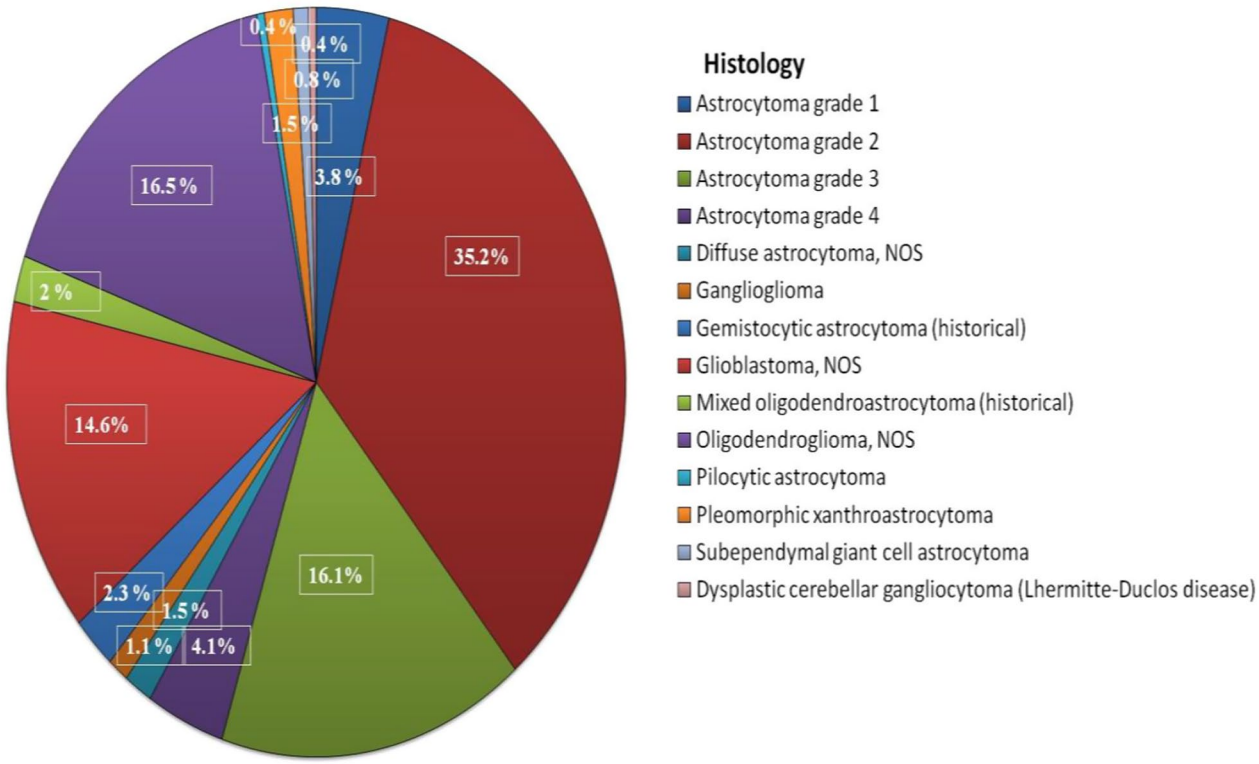

Fig. 3 Histological distribution of gliomas, glioneuronal tumors, and neuronal tumors in the adult cohort

(0.4%), pleomorphic xanthroastrocytoma (1.5%), and subependymal giant cell astrocytoma (0.8%). Among the glioneuronal and neuronal tumors, ganglioglioma was seen in 3.4% of the pediatric group and 1.1% of the adult group while Dysplastic cerebellar gangliocytoma (Lhermitte-Duclos disease) was noted in 0.4% adult population. Histological distribution of the remaining CNS tumor categories in the pediatric and adult population is provided in Additional file 1: Figs. S1 and S2. Table 5 describes the prevalence of pediatric primary CNS tumors across different health centres of India. We also compared our data with the various studies from different countries of the world and are shown in Table 6.

The distribution of all the CNS cases as per location within the cohort was further analyzed (Fig. 4). There were 759 CNS cases (52.7%) that were located in supratentorial areas, of which 172 cases (22.7%) were localized at the frontal lobe, 92 (12.1%) at the parietal lobe, and 81 were detected at the temporal lobe (12.1%). Another 212 cases (14.7%) were from the infratentorial compartment with 95 (44.8%) of them arising from the cerebellum. 263 cases were localized at the spinal cord (18.3%). Unspecified sites accounted for 14.4% cases ($n=207$).

Discussion

The developed countries have dedicated cancer databases from which information can be retrieved that can subsequently help in predicting the incidence rates of different types of cancers and designing effective treatment plans to combat the disease [12–15]. However, information from the western cancer registries cannot be applied directly to developing countries due to various reasons that include different clinical presentations, disease

Table 5 Comparison of primary CNS tumors within the pediatric population across different centres

	AIIMS	CSMMU	CMC	GB Pant	NIMHANS	PGIMER	TMH	SMS	Our study
Study period	2002–2007	2003–2007	1990–2007	2003–2007	2010–2014	2003–2007	2006–2007	2013–2019	1996–2022
Total pediatric tumors	819	137	1297	378	694	369	288	548	170 (Excluding the other cases)

Table 6 Comparison of primary CNS tumors within the pediatric population with the various studies of the world

Study	Study period	Country	Age (yrs)	M:F	Total pediatric primary CNS tumors	ST:IT	Pilocytic astrocytoma (%)	Medulloblastoma (%)	Oligodendroglioma (%)	Craniopharyngioma (%)	Ependymoma (%)
Kaatsch et al. 2001 [23]	1990–1999	Germany	< 15	ND	3268	ND	ND	18.1	1.1	4.4	10.4
Rosemberg and Fujiwara 2005 [24]	1974–2003	Brazil	< 22	1.2:1	1195	1.9:1	17.5	10.1	0.9	9.8	7.8
Raaschou-Nielsen et al. 2006 [25]	1980–1996	Denmark	< 15	1.2:1	626	1:0.7	10.5	ND	ND	ND	9.3
Ahmed et al. 2007 [26]	1989–1998	Pakistan	< 15	2.5:1	81	1:0.5	14.8	48.2	1.2	ND	9.9
Zhou et al. 2008 [27]	2001–2005	China	< 18	1.6:1	1485	1.6:1	1	13.5	1.1	17	4.3
Kaderali et al. 2009 [28]	1980–2008	Canada	< 20	1.3:1	1866	ND	5.9	10.6	1.7	6.8	4.9
Karkouri et al. 2010 [29]	2003–2007	Morocco	< 20	1.07:1	542	ND	17.3	29	1.7	6.6	7.6
Makino et al. 2010 [30]	1989–2008	Japan	< 15	1.3:1	210	ND	ND	10	ND	10.5	4.8
El-Gaidi 2011 [31]	2005–2008	Egypt	< 15	1.06:1	451	1:0.9	19.3	18.8	1.6	11.3	8.2
Azad et al. 2015 [32]	2009–2014	Nepal	< 18	1.6:1	39	ND	16.7	16.7	2.8	5.6	19.4
Present study	1996–2022	India	< 18	1.8:1	170	3.6:1	6.5	10.6	6	9.4	10.6

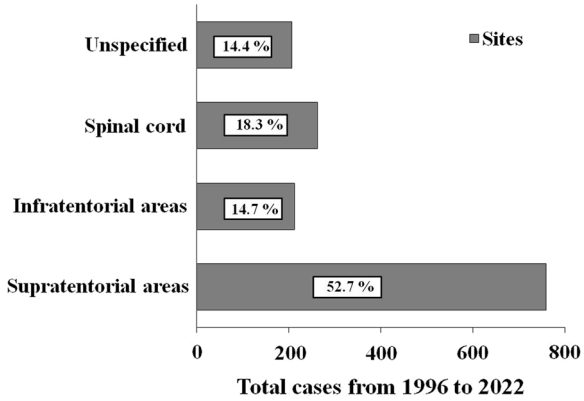

Fig. 4 Site wise distribution of CNS cases

progressions, and treatment outcomes. Thus, there is a marked difference in the cancer registries for developed and developing countries. A few epidemiological studies on brain tumors have been carried out in India by some of the major institutes including All India Institute of Medical Sciences (AIIMS), Delhi, National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore, Tata Memorial Hospital (TMH), Mumbai, and Sawai ManSingh College (SMS), Jaipur while some other studies have focused solely on tumor cases within the pediatric population [8, 9, 16–19]. There is lack of such epidemiological studies on CNS tumors from Northeast India.

Therefore, this study is the first from the Northeast Indian population regarding the spectrum of primary brain and other CNS tumor cases. The earlier studies have been dedicated only to the WHO-classified primary intracranial tumors. Nevertheless, our study has taken into consideration both the WHO classified and other distinctive cases of CNS. We noted both similarities and differences between our data and that of other Indian registries as well as the international brain tumor registry- the Central Brain Tumor Registry of the United States (CBTRUS) [20].

During the last 26 years, a total of 1441 CNS tumors and other distinct cases were diagnosed in our hospital with an age range of 0 to > 70 yrs. There were a total of 232 pediatric patients (16.1%) and 1209 adult patients (83.9%). On further analyzing the demographics in our study, it was noted that the percentage of males and females affected were 58 and 42% respectively.

This result was similar to NIMHANS and SMS data on primary intracranial tumors. However, CBTRUS data showed 42 and 58% affected male and female percentages respectively. One reason for such inverse data from India could be due to less awareness and literacy among the females as compared to the male counterparts which subsequently leads to delay in seeking medical care [19]. We also looked for CNS tumor distribution by age for the overall cohort. The maximum proportion of cases was noted in the sixth decade which was followed closely by the fifth decade. There was a slight difference in our result when compared with the Indian registries (NIMHANS, SMS, and TMH). This could be a result of considering the entire spectrum of CNS cases in our study.

We analyzed the histological pattern for the cases and noted that meningiomas showed the highest distribution in the entire cohort and showed a female predominance. This result showed similarity with the NIMHANS, SMS, and CBTRUS data. As suggested in previous studies the increased preponderance might have arisen due to the presence of sex hormone receptors in meningiomas which in turn increase the disease risk in females [21, 22]. We also observed female predilection in the case of the tumors of the seller region. The remaining CNS tumors include gliomas, glioneuronal, and neuronal tumors, ependymal tumors, choroid plexus tumors, embryonal tumors, pineal tumors, cranial and para spinal nerve tumors, mesenchymal, non-meningothelial tumors, germ cell tumors, metastases, and the unclassified cases showed male predilection which denoted similarity with NIMHANS, SMS, and CBTRUS data.

Tumors of our pediatric cohort (0–18 years) constituted 16.1% which matched with the SMS (15.1%) and NIMHANS (16.2%) data. In the CBTRUS report, pediatric tumors (0–19 years) comprised 6.6% of the overall CNS tumors. One possible explanation for this is that there are a considerable percentage of young people in India as compared to the US population [19]. In our pediatric cohort, gliomas, glioneuronal, and neuronal tumors constituted the maximum proportion (34.7%) among the WHO-classified primary brain and other CNS tumors ($n = 170$) followed by embryonal (14.1%) and ependymal tumors (12.8%). Only the gliomas, glioneuronal, and neuronal tumors showed equitable results with the SMS report (37.9%) and the study performed by Jain et al. (34.7%) [17]. There were slight variations in embryonal tumor frequency percentage between our data and that of SMS (20.8%) and Jain et al. (22.4%) data. Meningiomas were the most common (35%) among the primary brain and other CNS tumors ($n = 961$) in the adult population of our study followed by gliomas, glioneuronal, and neuronal tumors (27.7%). Increased frequency percentage of meningiomas was seen in our study as compared to NIMHANS (23.2%) and SMS cohort (23.1%). This could be due to the consideration of spinal tumors in our cohort. The percentage of other distinct CNS cases in our pediatric and adult cohort equals 26.7% and 15.4% respectively. This included arteriovenous malformations (AVM), meningoencephelocele, cysticercosis, lipoma,

orbital lesions, intracranial cyst, eosinophilic granuloma, osteoid osteoma of skull and bone, mucinous mucocoele, plasmacytoma, epithelial hemangioendothelioma, Non-Hodgkin's lymphoma, fibrous dysplasia, intracranial epidermoid cyst, tuberculosis, cerebral abscess, and giant cell tumor.

Studies from different regions of the world showed a male predominance in pediatric primary CNS tumors which was similar to our study. More tumors in the supratentorial location were seen in our series. High frequency of pilocytic astrocytoma was seen in different studies but this was not observed in our study series. The frequency of medulloblastoma was comparable to various other studies although some studies showed high frequency. Our study reported increased incidence of oligodendroglioma in comparison with other series. Frequencies of craniopharyngioma and ependymoma were comparable to most studies. We also analyzed the individual glial tumors of our cohort. It was noted that astrocytoma grade 2 was most common in both pediatric (23.7%) and adult (35.2%) populations.

Our analyzed data showed variation from the SMS cohort where pilocytic astrocytomas (47.8%) were the most common in the pediatric cohort while glioblastomas (44.3%) showed the highest prevalence in the adult group. The supratentorial tumors (52.7%) were more than the infratentorial tumors (14.7%) in our study. The percentage of spinal tumors was 18.3% and over 14.4% of the sites were not specified.

CNS tumors are heterogeneous neoplasms with different etiology, histological features, prognosis, and outcome. Irrespective of age, CNS tumors are on the rise globally. Therefore, effective preventive and protective measures need to be implemented to reduce CNS disease incidence.

Multifactorial risk factors are associated with CNS tumors. Variations in age, gender, race, histopathology type, and geographical locations make the etiology of CNS tumors complex. Epidemiological studies are indispensable tools for a better understanding of the etiology, incidence, prognosis, and outcomes of CNS tumors. Our study has given a brief outlook on the diverse brain and other CNS tumor cases that are registered in our hospital. However, this study is of limited use. More collaborative studies with various health centers across the country need to be carried out about the incidence of CNS tumors.

Although the data obtained from our study has generated some interesting insights into the prevalence of primary brain and other CNS tumors from Northeast India, however, it also has certain limitations that need to be considered. It is a single-centric tertiary hospital-based study. As such it may not reflect the profile of the entire community. In general, the data was collected retrospectively. We were unable to consider a few factors such as socioeconomic status, follow-up on survivality, treatment modalities, etc. due to irrational reasons.

In summary, the present study aimed to evaluate prevalence patterns of all the CNS cases in both pediatric and adult Indian populations with regards to distribution as per age, gender, histopathology, and tumor location. It was also an attempt from our side to do a hospital-based tumor registry to provide effective and essential information for tracking cancer prevalence and cancer care plans of our institute which could eventually be a part of PBCS.

Conclusion

In conclusion, this is the first study from Northeast India that highlights the prevalence of primary brain and other CNS tumor cases across all age groups and gender. This single hospital-based study gives relevant information about the distribution of diverse CNS tumors within the Indian population of the Northeast. There is an increased incidence of CNS cases in developing countries due to advanced diagnostic and better healthcare facilities. Within the pediatric population of our study, gliomas, glioneuronal, and neuronal tumors were the most common tumors while meningiomas were highly prevalent in the adult cohort. The supratentorial compartment of the brain was the common tumor site. In conclusion, this study provides useful insights into the epidemiological aspects of all CNS cases from this region and highlights the need for the maintenance of a hospital-based tumor registry, conducting research, and generating funds for all CNS ailments.

Abbreviations

AIIMS	All India Institute of Medical Sciences
CBTRUS	Central Brain Tumor Registry of the United States
CNS	Central nervous system
CT	Computed tomography
MRI	Magnetic resonance imaging
NIMHANS	National Institute of Mental Health and Neurosciences
PBCR	Population based cancer registries
SMS	Sawai ManSingh College
TMH	Tata Memorial Hospital
WHO	World Health Organization

Supplementary Information

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Additional file 1. Supplementary figures.

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Author contributions
Concepts, design, and literature: NB, ALB, BS, and SA. Data acquisition: BS, AB, and SA. Data analysis: NB, NJB, IH, BS, AB, and SA. Statistical analysis: AB. Manuscript preparation: AB. Manuscript review and editing: NB, NJB, IH, BS, and SA. Guarantor: SA. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are not publicly available due [not applicable] but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the ethics committee of GNRC Hospitals.

Consent for publication
The inform consent was taken from all the patients for publication (as per our department policy we take such consent from all the patients at time of admission).

Competing interests
The authors declare that they have no competing interests.

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