

# An Updated Nationwide Epidemiology of Primary Brain Tumors in Republic of Korea

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## Objective

The aim of this report is to provide accurate nationwide epidemiologic data on primary brain and central nervous system (CNS) tumors in Republic of Korea. In 2010, we had reported first nationwide epidemiologic data on primary brain tumors diagnosed in 2005. In this report, we updated the data by analyzing primary brain and CNS tumors diagnosed in 2010 using the data from national cancer incidence database.

## Methods

Data on primary brain and CNS tumors diagnosed in 2010 were collected from the Korean Central Cancer Registry. Crude and age-standardized rates were calculated in terms of gender, age, and histological type.

## Results

A total of 10,004 patients diagnosed with primary brain and CNS tumors in 2010 were included in this study. Brain and CNS tumors occurred in females more often than in males (female to male, 1.59 : 1). The most common tumor was meningioma (35.5%). Pituitary tumors (18.7%), gliomas (15.1%), and nerve sheath tumors (10.3%) were followed in incidence. Glioblastoma accounted for 34.6% of all gliomas. In children (<20 years), sellar region tumors (pituitary and craniopharyngioma), embryonal/primitive/medulloblastoma, and germ cell tumors were the most common tumors.

## Conclusion

Data from this study should provide valuable information regarding the primary brain tumors epidemiology in Republic of Korea.

## Key Words

Epidemiology; Brain; Central nervous system; Tumor; Registry; Korea.

## INTRODUCTION

Primary brain and central nervous system (CNS) tumors are not common. However, the incidence of brain and CNS tumors has increased gradually [1-3]. These tumors may result in mental alteration and neurologic deficits, and the social burden of brain tumors is just as large as that of other tumors. An accurate understanding of the epidemiology is needed to facilitate early detection and treatment. Many countries have established brain tumor registries, and their descriptive epidemiology have been reported [1,2,4-7].

The Korean Ministry of Health and Welfare started a nationwide, hospital-based cancer registry (Korea Central Cancer Registry, KCCR) in 1980. In 2005, the first national cancer incidence between 1999 and 2001 were reported by the KCCR [8]. The KCCR database was especially useful for showing trends of cancer occurrence in Republic of Korea. However, it only provided the incidence of malignant brain tumors,

excluding benign and borderline tumors.

Since benign brain tumors can recur and may be inoperable, non-malignant brain tumors may impose the same cost on the society in terms of medical care and case fatality as malignant brain tumors.

In order to include benign and borderline tumors of the brain and CNS, the KCCR revised its criteria for cancer registration in 2004, and started national collection of nonmalignant brain tumors since 2005. As a result, there was a first nationwide epidemiologic report in 2010 by analyzing registered tumors in 2005 [9]. In this report, we updated the data by analyzing primary brain and CNS tumors diagnosed in 2010 using the data from the KCCR.

The objective of this report is to provide an accurate nationwide incidence of primary malignant and nonmalignant brain tumors in Korean by sex, age group, topography and histological type.

**Table 1.** Incidence rates of primary brain and CNS tumors by histology and sex, Republic of Korea, 2010

Histology	Male			Female			Total				
	N	CR	ASR	N	CR	ASR	N	%	Age*	CR	ASR
Tumors of neuroepithelial tissue	823	3.30	3.15	689	2.77	2.49	1,512	15.1	48.2	3.03	2.81
Pilocytic astrocytoma	34	0.14	0.17	36	0.14	0.19	70	0.7	15.4	0.14	0.18
Diffuse astrocytoma	5	0.02	0.02	4	0.02	0.01	9	0.1	54.7	0.02	0.02
Anaplastic astrocytoma	72	0.29	0.23	51	0.20	0.16	123	1.2	47.7	0.25	0.20
Unique astrocytoma variants	11	0.04	0.04	14	0.06	0.05	25	0.2	44.8	0.05	0.05
Astrocytoma, NOS	54	0.22	0.20	51	0.20	0.18	105	1.0	43.9	0.21	0.19
Glioblastoma	287	1.15	0.89	236	0.95	0.67	523	5.2	60.1	1.05	0.77
Oligodendroglioma	27	0.11	0.09	32	0.13	0.11	59	0.6	45.7	0.12	0.10
Anaplastic oligodendroglioma	29	0.12	0.09	20	0.08	0.07	49	0.5	48.2	0.10	0.07
Ependymoma/anaplastic ependymoma	46	0.18	0.18	44	0.18	0.18	90	0.9	43.4	0.18	0.18
Ependymoma variants	9	0.04	0.04	7	0.03	0.03	16	0.2	30.7	0.03	0.03
Mixed glioma	24	0.10	0.07	18	0.07	0.05	42	0.4	45.6	0.08	0.06
Glioma malignant, NOS	72	0.29	0.28	65	0.26	0.23	137	1.4	42.3	0.27	0.25
Choroid plexus	14	0.06	0.10	11	0.04	0.06	25	0.2	18.5	0.05	0.08
Neuroepithelial	15	0.06	0.06	11	0.04	0.04	26	0.3	53.2	0.05	0.05
Non-malignant and malignant neuronal/glial, neuronal and mixed	62	0.25	0.27	51	0.20	0.24	113	1.1	24.9	0.23	0.26
Pineal parenchymal	10	0.04	0.05	10	0.04	0.03	20	0.2	45.6	0.04	0.04
Embryonal/primitive/medulloblastoma	52	0.21	0.36	28	0.11	0.20	80	0.8	8.6	0.16	0.28
Tumors of cranial and spinal nerves	466	1.87	1.45	569	2.28	1.69	1,035	10.3	52.6	2.07	1.57
Nerve sheath, non-malignant and malignant	466	1.87	1.45	569	2.28	1.69	1,035	10.3	52.6	2.07	1.57
Other tumors of cranial and spinal nerves	-	-	-	-	-	-	-	-	-	-	-
Tumors of meninges	888	3.56	2.79	2,866	11.51	7.71	3,754	37.5	60.0	7.53	5.35
Meningioma	781	3.13	2.44	2,769	11.12	7.39	3,550	35.5	60.5	7.12	5.02
Other mesenchymal, non-malignant and malignant	28	0.11	0.10	35	0.14	0.13	63	0.6	40.1	0.13	0.11
Hemangioblastoma	79	0.32	0.25	62	0.25	0.19	141	1.4	49.0	0.28	0.22
Lymphomas and hemopoietic neoplasms	95	0.38	0.30	67	0.27	0.18	162	1.6	61.7	0.32	0.24
Lymphoma	95	0.38	0.30	67	0.27	0.18	162	1.6	61.7	0.32	0.24

Table 1. Continued

Histology	Male			Female			Total				
	N	CR	ASR	N	CR	ASR	N	%	Age*	CR	ASR
Germ cell tumors, and cysts	66	0.26	0.33	20	0.08	0.11	86	0.9	16.8	0.17	0.23
Germ cell tumors, cysts and heterotopias	66	0.26	0.33	20	0.08	0.11	86	0.9	16.8	0.17	0.23
Tumors of sellar region	899	3.60	2.85	1,104	4.43	3.57	2,003	20.0	48.9	4.02	3.17
Pituitary	833	3.34	2.61	1,040	4.18	3.31	1,873	18.7	49.2	3.76	2.92
Craniopharyngioma	66	0.26	0.24	64	0.26	0.26	130	1.3	42.9	0.26	0.25
Local extensions from regional tumors	4	0.02	0.01	4	0.02	0.02	8	0.1	48.8	0.02	0.01
Chordoma/chondrosarcoma	4	0.02	0.01	4	0.02	0.02	8	0.1	48.8	0.02	0.01
Unclassified tumors	620	2.48	2.13	824	3.31	2.39	1,444	14.4	55.0	2.89	2.27
Hemangioma	80	0.32	0.30	77	0.31	0.26	157	1.6	44.0	0.31	0.28
Neoplasm, unspecified	531	2.13	1.79	741	2.98	2.09	1,272	12.7	56.9	2.55	1.95
All others	9	0.04	0.03	6	0.02	0.04	15	0.1	31.8	0.03	0.03
Total	3,861	15.46	13.01	6,143	24.67	18.16	10,004	100.0	54.4	20.06	15.65

\*Median age at diagnosis. CNS: central nervous system, CR: crude rate, ASR: age-standardized rate, NOS: not otherwise specified

## MATERIALS AND METHODS

### Brain tumor registration

A total of 10,004 brain and CNS patients diagnosed in 2010 were registered by 352 hospitals. Basic information such as the demographic characteristics of patients, date of diagnosis, tools of diagnosis, topography and histological type according to the International Classification of Diseases for Oncology, third edition (ICD-O-3) were collected by the KCCR [10].

### Data processing

Primary brain and CNS tumors with the following ICD-O-3 codes were included in the analysis: brain (C71.0-C71.9), meninges (C70.0-C70.9), spinal cord, cranial nerves and other parts of the CNS (C72.0-C72.9), and pituitary gland, cranio-pharyngeal duct and pineal gland (C75.1-C75.3). Their behavior was also classified by the ICD-O-3 code, which are divided into 3 groups: benign, uncertain whether benign or malignant, and malignant. Tumors with behavior codes (fifth digit ICD-O morphology) 0, 1 and 3, respectively, were also included. Histology groupings were based on the classification of the Central Brain Tumor Registry of the United States (CBTRUS) [2]. These groupings were broadly based on the World Health Organization categories for brain tumors.

The population size used as a denominator to calculate cancer incidence was the midyear population on 1 July. In this report, we modified the registered population released annually from the national statistics office to obtain the midyear population [11]. Childhood tumors were defined as those diagnosed in patients less than 19 years of age.

### Statistical analysis

Incidence measures the occurrence of newly diagnosed cases of disease. Crude rate is the rate of disease in an entire population. Crude rate is frequently adjusted for age to age-standardized rate to a common standard population, which allows for rate comparisons across regions with different age structures. We used world standard population as a standard population in this report [12].

## RESULTS

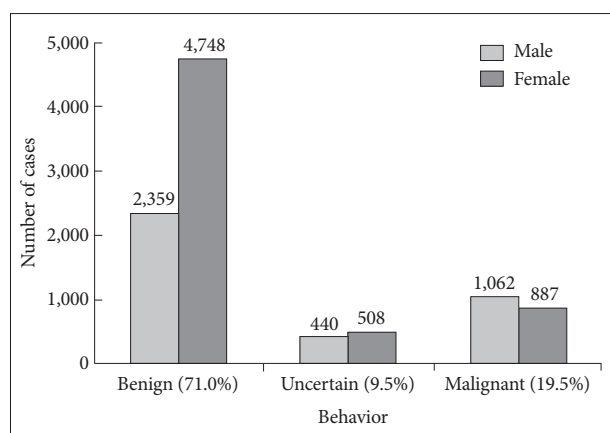
### Overall incidence

There were 10,004 newly diagnosed brain tumors from a population of 49.9 million in 2010 (Table 1, Fig. 5). Among them, 601 (6.0%) developed in children under 19 years of age. Brain tumors are the second most common tumors in children. The overall crude rate of brain tumors in Republic of Korea was 20.06 per 100,000 person-years in 2010, and the rate in children was 5.16 per 100,000 person-years. Tumors

classified as benign, uncertain whether benign or malignant, and malignant tumors accounted for 71.0%, 9.5%, and 19.5% of all primary CNS tumors, respectively (Fig. 1). Histological confirmation was achieved in 52.1% (5,208 cases). The number of total and histologically confirmed cases is listed in descending order of frequency in Table 2.

### Incidence according to tumor biological behavior

The overall incidence according to biological behavior was shown in Fig. 1. The incidence in males was 38.6% and the incidence in females was 61.4%. The incidence of benign tumors was 71.0%. Benign tumors developed nearly twice more frequently in females than in males (M : F=2,359 : 4,748). In contrast, the incidences of uncertain and malignant tumors were noted to be similar.

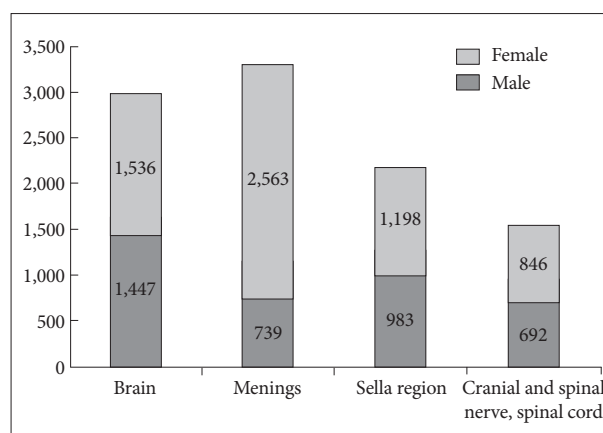


**Fig. 1.** Distribution of primary Brain and CNS tumors according to sex and behavior, Republic of Korea, 2010. CNS: central nervous system.

### Distribution of tumors according to the originating site

The incidence according to the originating site was shown in Fig. 2. Meninges (33.0%) were the most common site of primary brain tumors, followed by the brain parenchyma (29.8%), sellar region (21.8%), and cranial and spinal nerves (15.4%). Tumors of the meninges developed 3 times more frequently in females (Fig. 2). The other sites showed no significant differences in incidence according to sex.

The overall incidence of primary brain tumors increased with age until the seventh decade. The incidence of each site-specific tumor according to age is shown in Fig. 3. Tumors of the brain parenchyma reached a peak in the seventh decade. Tumors of meninges seldom occurred in childhood, the incidence of which increased in the third decade and peaked in the

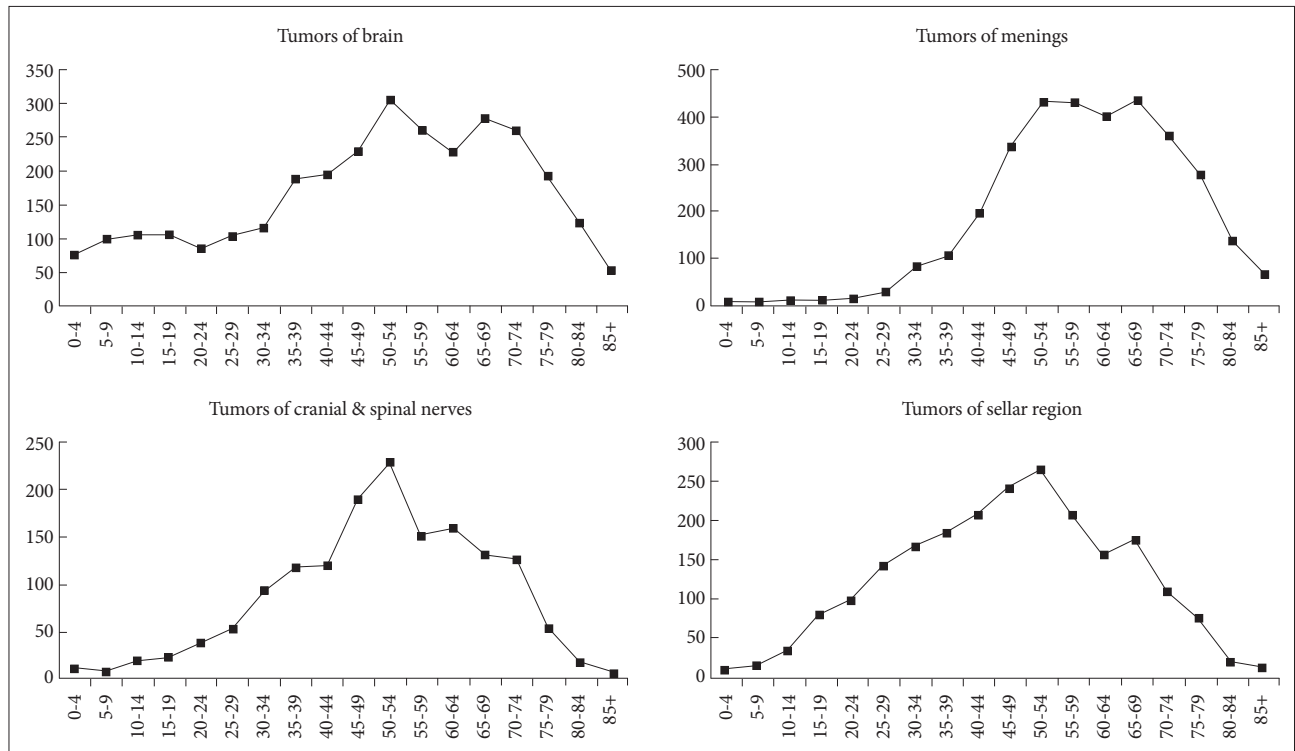


**Fig. 2.** Distribution of all Brain and CNS tumors according to the topography, Republic of Korea, 2010. CNS: central nervous system.

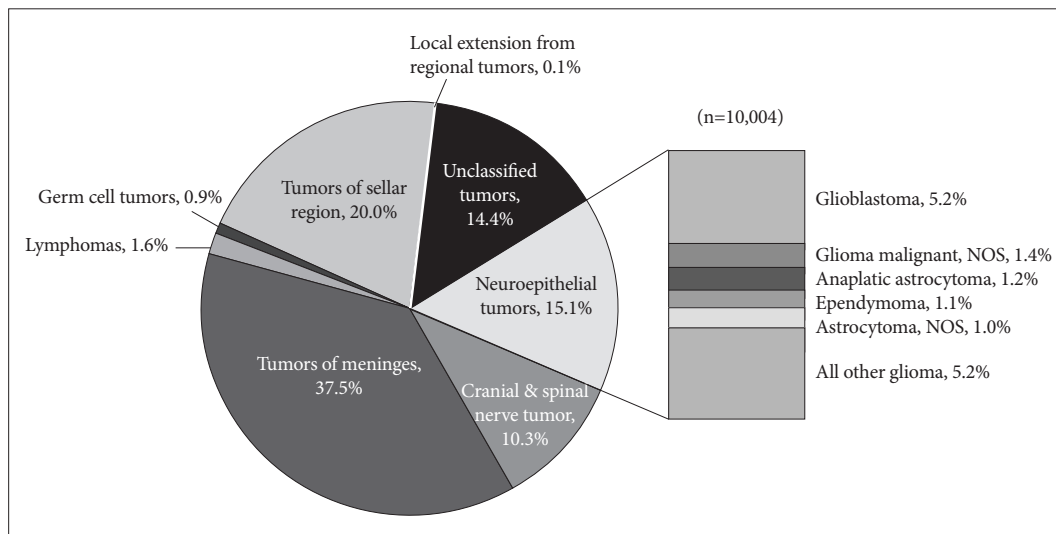
**Table 2.** The numbers of total and histologically confirmed cases by histological group, Republic of Korea, 2010

Histological group	Total count		Histology (+)	
	N	%	N	%
Meningioma	3,691	36.9	1,703	32.7
Glioma	1,873	18.7	1,054	20.2
Pituitary tumor	1,387	13.9	1,167	22.4
Nerve sheath tumor	1,035	10.4	668	12.8
Lymphoma	162	1.6	147	2.8
Germ cell tumors, cysts and heterotopias	157	1.6	74	1.4
Craniopharyngioma	130	1.3	97	1.9
Other mesenchymal, non-malignant and malignant	86	0.9	75	1.4
Embryonal/primitive/medulloblastoma	80	0.8	76	1.5
Hemangioma	63	0.6	39	0.7
Choroid plexus	25	0.3	18	0.3
Chordoma/chondrosarcoma	8	0.1	8	0.2
Neoplasm, unspecified	1,272	12.7	57	1.1
All others	35	0.4	25	0.5
Total	10,004	100.0	5,208	100.0

Histology (+): histologically confirmed cases



**Fig. 3.** Distribution of primary brain and CNS tumors according to age for selected histology, Republic of Korea, 2010. CNS: central nervous system.



**Fig. 4.** Distribution of brain and CNS tumors according to the topography and histology, Republic of Korea, 2010. CNS: central nervous system, NOS: not otherwise specified.

seventh decade. Tumors of the nerves peaked in the sixth decade. Sellar tumors increased rapidly in late adolescents and peaked in the fifth decade, which decreased thereafter.

### Incidence according to specific histology

Distribution of the tumors according to histology was shown in Fig. 4. Histologically, tumors of meninges were the

most common (37.5%). Tumors of sellar region (20.0%) and neuroepithelial tumors (15.1%) were followed. Neuroepithelial tumors were composed of glioma, ganglioneuroma, neurocytoma, primitive neuroectodermal tumor, pineal tumor and retinoblastoma. Most of the neuroectodermal tumors were gliomas (91.7%), which accounted for 15.1% of all primary brain tumors. Glioblastoma accounted for 5.2% of all tumors

and 34.4% of all gliomas. Among histologically confirmed cases, glioblastoma accounted for 40.6% of all gliomas (Table 3). Sellar tumors and nerve sheath tumors, which were confirmed by pathologists, accounted for 20.2% and 12.8%, respectively, of all tumors.

The overall incidence according to gender and histology are presented in Fig. 1. The incidence of meningioma was almost three times higher in females than in males. Nerve sheath tumor, pituitary tumor and pilocytic astrocytoma were also more common in females. On the other hand, germ cell tu-

**Table 3.** The numbers of total and histologically confirmed cases by histological type in gliomas, Republic of Korea, 2010

Histological group in gliomas	Total count		Histology (+)	
	N	%	N	%
Glioblastoma	523	37.7	474	40.6
Astrocytoma, NOS	105	7.6	83	7.1
Anaplastic astrocytoma	123	8.9	118	10.1
Pilocytic astrocytoma	70	5.1	67	5.7
Ependymoma/anaplastic ependymoma	106	7.6	97	8.3
Oligodendroglioma	59	4.3	52	4.5
Anaplastic oligodendroglioma	49	3.5	47	4.0
Glioma malignant, NOS	137	9.9	36	3.1
Neuroepithelial	26	1.9	19	1.6
Mixed glioma	42	3.0	42	3.6
Unique astrocytoma variants	25	1.8	19	1.6
Protoplasmic & fibrillary astrocytoma	9	0.7	9	0.8
Non-malignant and malignant neuronal/glia, neuronal and mixed	113	8.2	104	8.9
Total	1,387	100.0	1,167	100.0

Histology (+): histologically confirmed cases. NOS: not otherwise specified

**Table 4.** Incidence rates of primary CNS tumors by histology and sex in childhood (Ages 0-19), Republic of Korea, 2010

Histology	Male			Female			Total		
	N	CR	ASR	N	CR	ASR	N	CR	ASR
Tumors of neuroepithelial tissue	160	2.62	2.76	113	2.04	2.06	273	2.34	2.42
Pilocytic astrocytoma	22	0.36	0.34	21	0.38	0.35	43	0.37	0.34
Anaplastic astrocytoma	9	0.15	0.12	4	0.07	0.06	13	0.11	0.09
Astrocytoma, NOS	8	0.13	0.14	5	0.09	0.11	13	0.11	0.13
Glioblastoma	10	0.16	0.13	8	0.14	0.14	18	0.15	0.14
Ependymoma/anaplastic ependymoma	9	0.15	0.17	10	0.18	0.19	19	0.16	0.18
Glioma malignant, NOS	16	0.26	0.27	10	0.18	0.16	26	0.22	0.22
Non-malignant and malignant neuronal/glia, neuronal and mixed	21	0.34	0.33	21	0.38	0.34	42	0.36	0.33
Embryonal/primitive/medulloblastoma	40	0.66	0.79	21	0.38	0.45	61	0.52	0.63
Tumors of cranial and spinal nerves	15	0.25	0.23	10	0.18	0.17	25	0.21	0.20
Tumors of meninges	16	0.26	0.23	19	0.34	0.32	35	0.30	0.27
Lymphomas and hemopoietic neoplasms	3	0.05	0.06	1	0.02	0.01	4	0.03	0.04
Germ cell tumors, and cysts	45	0.74	0.60	12	0.22	0.21	57	0.49	0.42
Tumors of sellar region	39	0.64	0.55	58	1.05	0.88	97	0.83	0.71
Pituitary	26	0.43	0.33	39	0.70	0.54	65	0.56	0.43
Craniopharyngioma	13	0.21	0.22	19	0.34	0.34	32	0.27	0.28
Local extensions from regional tumors	-	-	-	2	0.04	0.03	2	0.02	0.02
Unclassified tumors	57	0.93	0.96	51	0.92	0.88	108	0.93	0.92
Total	335	5.49	5.39	266	4.80	4.57	601	5.16	5.00

CNS: central nervous system, CR: crude rate, ASR: age-standardized rate, NOS: not otherwise specified

mor, glioma (except pilocytic astrocytoma) and lymphoma were more common in males.

We classified tumors according to CBTRUS. Unclassified

tumors include unspecified neoplasms and all other tumors. Unspecified neoplasms refer to cases registered based on death certificates only. We did not have any specific data other

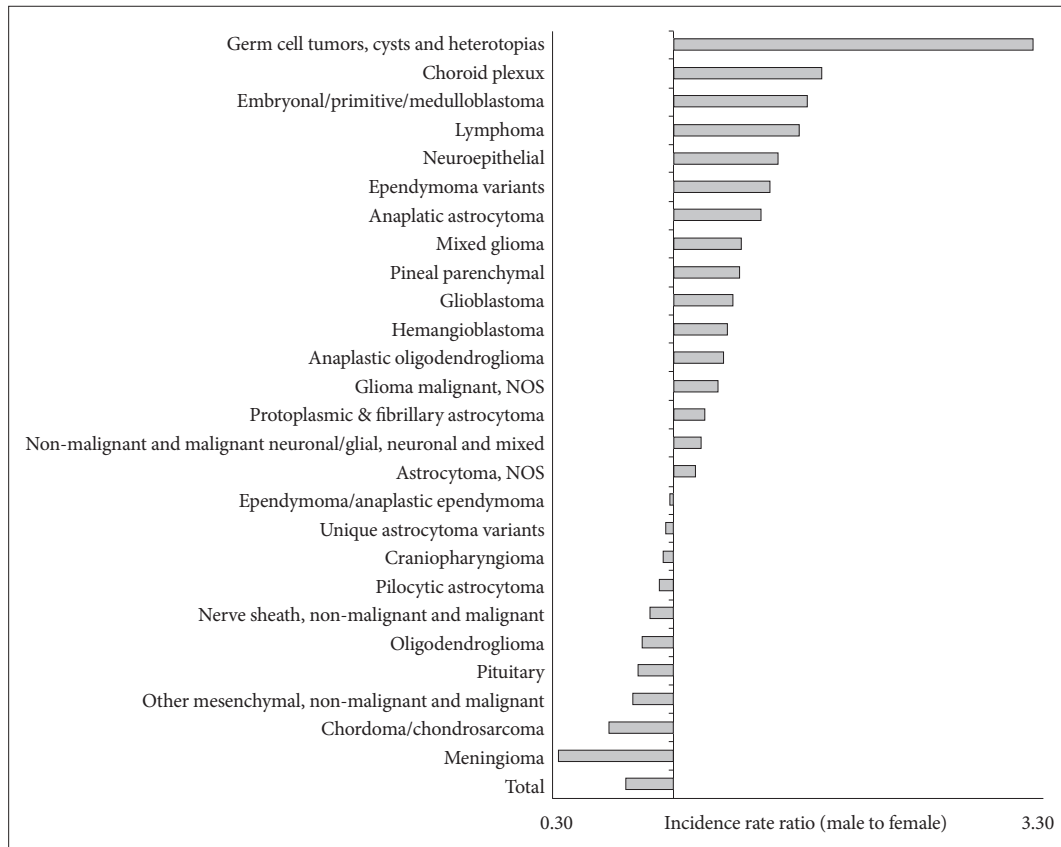


Fig. 5. Incidence according to sex and histology, Republic of Korea, 2010. NOS: not otherwise specified.

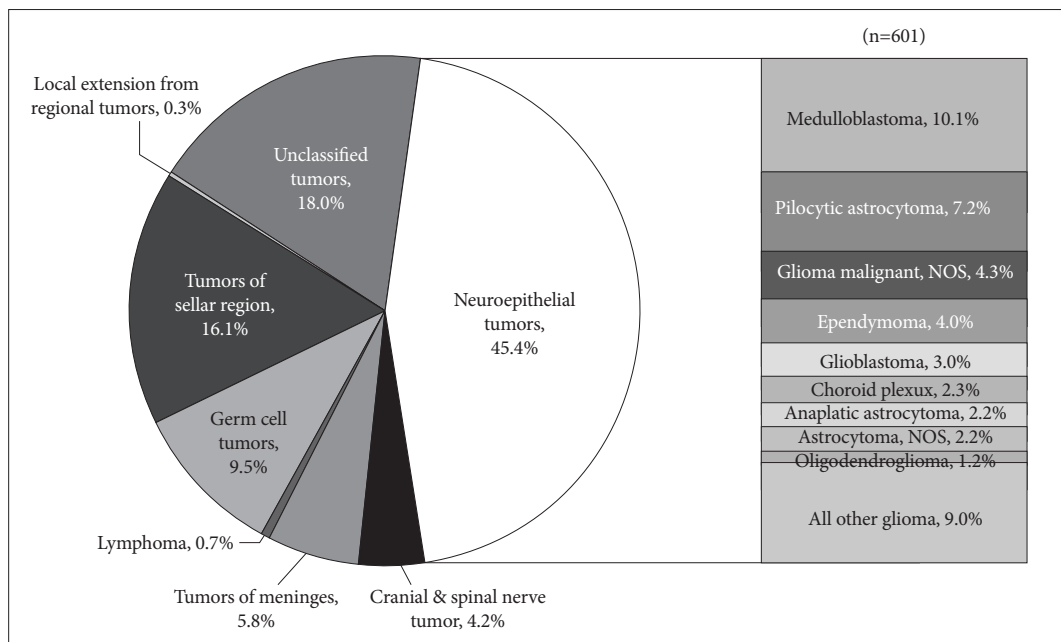


Fig. 6. Distribution of primary brain and CNS tumors according to the topography and histology in children, Republic of Korea, 2010. CNS: central nervous system, NOS: not otherwise specified.



than neoplasm in those cases. The tumors which classified into all other tumors were tumors that did not meet CBTRUS criteria. Unclassified tumors accounted for 14.4% of all CNS tumors. The detail was described in Table 1.

### Distribution of childhood primary brain tumors according to histology

Distribution of tumors according to histology in childhood was shown in Table 4 and Fig. 6. The most common histology in children included neuroepithelial tumors, tumors of sellar region and germ cell tumors. Neuroepithelial tumors accounted for 45.4% of all tumors in children. Medulloblastoma was the most common tumor among neuroepithelial tumors in children. Glioblastoma accounted for only 3% of all primary brain tumors in children.

### Incidence in children according to age and histology

The age-standardized incidence in children according to histology was shown in Table 4. The incidence of primary brain tumors was 5.0 per 100,000 person-years. The incidence was slightly higher in males (5.39) than in females (4.57).

## DISCUSSION

This is second nationwide report on primary brain and CNS tumors, encompassing benign, borderline and malignant tumors in Republic of Korea. The overall crude rate for brain and CNS tumors in Republic of Korea was 11.69 per 100,000 person-years in 2005, and the crude rate in children was 3.63 per 100,000 person-years [9]. In 2010, those were 20.06 per 100,000 person-years and 5.16 per 100,000 person-years, respectively. Tumors of neuroepithelial tissue were increased from 599 to 823 cases. Tumors of cranial nerves were increased from 272 to 466 cases. Tumors of meninges were increased from 453 to 888 cases. Tumors of sellar region were increased from 403 to 899 cases. The incidences of all histological type were increased in 2010 compared with those of 2005. However, the main cause of steep increase in the incidences of brain tumors was benign tumors. It may be caused by early detection due to inclusion of brain MRI for routine screening test in Republic of Korea. And it seemed to be also due to that medical administrators were more accustomed to register be-

nign tumors because five years have passed since registration of benign tumors started in 2005.

In conclusion, we updated nationwide statistics of brain and CNS tumors in Republic of Korea. These data base are mandatory for facilitating etiologic studies, establishing awareness of the disease, and ultimately, for the control of tumors.

### Conflicts of Interest

The authors have no financial conflicts of interest.

### Acknowledgments

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