

An Updated Nationwide Epidemiology of Primary Brain Tumors in Republic of Korea, 2013

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Background This report aims to provide accurate nationwide epidemiologic data on primary brain and central nervous system (CNS) tumors in the Republic of Korea. We updated the data by analyzing primary brain and CNS tumors diagnosed in 2013 using the data from the national cancer incidence database.

Methods Data on primary brain and CNS tumors diagnosed in 2013 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 11,827 patients were diagnosed with primary brain and CNS tumors in 2013. Brain and CNS tumors occurred in females more often than in males (female:male, 1.70:1). The most common tumor was meningioma (37.3%). Pituitary tumors (18.0%), gliomas (12.7%), and nerve sheath tumors (12.3%) followed in incidence. Glioblastomas accounted for 41.8% of all gliomas. In children (<19 years), sellar region tumors (pituitary and craniopharyngioma), embryonal/primitive/medulloblastoma, and germ cell tumors were the most common tumors.

Conclusion This study should provide valuable information regarding the primary brain tumor epidemiology in Republic of Korea.

Key Words Epidemiology; Brain; Central nervous system; Tumors; Registries; Korea.

INTRODUCTION

Primary brain tumors include any tumors arising in the brain. Primary brain tumors can start from brain cells, meninges, nerves, or glands [1]. Although brain tumor is a rare disease, the incidence of brain tumors is gradually increasing worldwide due to the development of diagnostic technologies and the increased frequency of imaging tests [2-4]. The prog-

nosis of malignant brain tumors is poor due to its histologic characteristics, however, some benign tumors are located in inoperable areas, and these tumors have similar bad prognosis and require the same economic burden as malignant brain tumors.

The Korea Central Cancer Registry (KCCR) started in 1980, and they collected malignant tumors only, excluding benign and borderline tumors. In order to collect benign and borderline brain tumors, the KCCR modified their registration guideline in corporation with the Brain Tumors Registration Committee of the Korean Brain Tumor Society in 2004, and started to register non-malignant brain tumors from year 2005 [5]. The scope of brain tumors included tumors of the

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meninges, pituitary gland, pineal gland and nerves, as defined in the International Classification of Diseases for Oncology, third edition (ICD-O-3). The first epidemiologic article of primary brain and central nervous system (CNS) tumors of the year of 2005 was published in 2010 [6], and the second paper of year 2010 was published in 2013 [7].

Many registries, such as the Central Brain Tumor Registry of the United States (CBTRUS) and surveillance epidemiology and end results program in USA, collect and disseminate the epidemiology of brain tumor [3,8-12]. Due to increase of screening with imaging testing, the incidence of brain tumor is increasing and the frequency of tumor diagnosis is chang-

Table 1. Incidence rates of primary brain and CNS tumors by histology and sex, Republic of Korea, 2013

Histology	Male			Female			Total				
	n	CR	ASR	n	CR	ASR	n	%	Age*	CR	ASR
Tumors of neuroepithelial tissue	848	3.35	2.98	761	3.01	2.69	1,609	13.6	52.0	3.18	2.82
Pilocytic astrocytoma	25	0.10	0.15	25	0.10	0.19	50	0.4	12.5	0.10	0.17
Diffuse astrocytoma	2	0.01	0.01	1	0.00	0.01	3	0.0	29.0	0.01	0.01
Anaplastic astrocytoma	54	0.21	0.18	40	0.16	0.11	94	0.8	53.0	0.19	0.15
Unique astrocytoma variants	18	0.07	0.07	16	0.06	0.08	34	0.3	30.5	0.07	0.07
Astrocytoma, NOS	65	0.26	0.22	45	0.18	0.14	110	0.9	47.5	0.22	0.18
Glioblastoma	344	1.36	0.99	285	1.13	0.78	629	5.3	61.0	1.24	0.87
Oligodendroglioma	47	0.19	0.15	40	0.16	0.12	87	0.7	47.0	0.17	0.14
Anaplastic oligodendroglioma	28	0.11	0.08	31	0.12	0.09	59	0.5	52.0	0.12	0.08
Ependymoma/anaplastic ependymoma	34	0.13	0.14	47	0.19	0.15	81	0.7	46.0	0.16	0.15
Ependymoma variants	11	0.04	0.04	15	0.06	0.05	26	0.2	47.0	0.05	0.04
Mixed glioma	25	0.10	0.08	22	0.09	0.07	47	0.4	44.0	0.09	0.07
Glioma malignant, NOS	84	0.33	0.32	76	0.30	0.25	160	1.4	50.0	0.32	0.28
Choroid plexus	9	0.04	0.06	11	0.04	0.05	20	0.2	33.0	0.04	0.05
Neuroepithelial	12	0.05	0.04	9	0.04	0.02	21	0.2	54.0	0.04	0.03
Non-malignant and malignant neuronal/ glial, neuronal and mixed	51	0.20	0.21	54	0.21	0.26	105	0.9	29.0	0.21	0.24
Pineal parenchymal	13	0.05	0.05	9	0.04	0.03	22	0.2	37.5	0.04	0.04
Embryonal/primitive/medulloblastoma	26	0.10	0.21	35	0.14	0.30	61	0.5	5.0	0.12	0.25
Tumors of cranial and spinal nerves	674	2.67	1.95	780	3.09	2.10	1,454	12.3	54.0	2.88	2.02
Nerve sheath, non-malignant and malignant	674	2.67	1.95	780	3.09	2.10	1,454	12.3	54.0	2.88	2.02
Other tumors of cranial and spinal nerves	-	-	-	-	-	-	-	-	-	-	-
Tumors of meninges	996	3.94	2.77	3,485	13.79	8.36	4,481	37.9	61.0	8.86	5.68
Meningioma	954	3.77	2.61	3,455	13.67	8.26	4,409	37.3	61.0	8.72	5.55
Other mesenchymal, non-malignant and malignant	42	0.17	0.16	30	0.12	0.10	72	0.6	45.0	0.14	0.13
Lymphomas and hemopoietic neoplasms	124	0.49	0.34	97	0.38	0.25	221	1.9	63.0	0.44	0.29
Lymphoma	124	0.49	0.34	97	0.38	0.25	221	1.9	63.0	0.44	0.29
Germ cell tumors, and cysts	92	0.36	0.48	35	0.14	0.18	127	1.1	18.0	0.25	0.34
Germ cell tumors, cysts and heterotopias	92	0.36	0.48	35	0.14	0.18	127	1.1	18.0	0.25	0.34
Tumors of sellar region	911	3.60	2.68	1,366	5.40	4.31	2,277	19.3	50.0	4.50	3.45
Pituitary	835	3.30	2.42	1,291	5.11	4.05	2,126	18.0	50.0	4.20	3.20
Craniopharyngioma	76	0.30	0.26	75	0.30	0.26	151	1.3	45.0	0.30	0.26
Local extensions from regional tumors	6	0.02	0.02	10	0.04	0.03	16	0.1	44.5	0.03	0.02
Chordoma/chondrosarcoma	6	0.02	0.02	10	0.04	0.03	16	0.1	44.5	0.03	0.02
Unclassified tumors	735	2.91	2.36	907	3.59	2.57	1,642	13.9	53.0	3.25	2.46
Hemangioma	199	0.79	0.64	239	0.95	0.76	438	3.7	48.0	0.87	0.69
Hemangioblastoma	67	0.27	0.20	45	0.18	0.13	112	0.9	48.5	0.22	0.17
Neoplasm, unspecified	457	1.81	1.48	613	2.43	1.64	1,070	9.0	56.5	2.12	1.56
All others	12	0.05	0.05	10	0.04	0.04	22	0.2	55.0	0.04	0.04
Total	4,386	17.34	13.58	7,441	29.44	20.49	11,827	100.0	56.0	23.39	17.09

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

ing with time, so the recent changes would be reflected in this paper. This report aims to provide the updated nationwide brain tumor incidence in the Republic of Korea.

MATERIALS AND METHODS

Brain tumor registration

A total of 11,827 brain and CNS patients were registered in 2013 from 396 hospitals. Basic information such as the demographic characteristics of patients, date of diagnosis, tools of diagnosis, topography, and histological type according to the ICD-O-3 were collected by the KCCR [1].

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, craniopharyngeal duct and pineal gland (C75.1–C75.3). Their histology code was also classified by the ICD-O-3, which are divided into 3 groups: benign, uncertain whether benign or malignant (borderline), and malignant.

Histology groupings were based on the classification of the CBTRUS [3]. These groupings were broadly based on the World Health Organization categories for brain tumors. Unclassified tumors include unspecified neoplasms and all other tumors. Unspecified neoplasms refer to cases registered based on death certificates only. The tumors which classified into all other tumors were tumors that did not meet the CBTRUS criteria.

The population size used as a denominator to calculate cancer incidence was the mid-year population on 1 July 2013 with modification of the registered population released annually from the Statistics Korea [13]. 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 and it is frequently adjusted for age to age-standardized rate to a common standard population, which allows for comparison of rates across different countries with different age structures. We used Segi's world standard population as a standard population in this report [14].

RESULTS

Overall incidence

There were 11,827 newly diagnosed brain tumors from a population of 50.6 million in 2013 (Table 1). The overall crude

rate of brain tumors was 23.39 per 100,000 person-years in 2013.

The incidence of meningiomas was over 3.5 times higher in females than in males. Nerve sheath tumors, pituitary tumors, and ependymomas were also more common in females. On the other hand, germ cell tumors, gliomas (except pilocytic astrocytoma), and lymphomas were more common in males. Unclassified tumors accounted for 13.9% of all CNS tumors. The number of histological confirmed cases were 5,649 (47.8%) (Table 2). Pituitary tumors and nerve sheath tumors, accounted for 19.9% and 13.8% of all histologically confirmed tumors, respectively.

Incidence according to tumor biological behavior

The overall incidence according to biological behavior is shown in Fig. 1. Tumors classified as benign, uncertain, and malignant tumors accounted for 73.2%, 8.8%, and 18.0% of all primary CNS tumors, respectively. The incidence in males was 37.1% and the incidence in females was 62.9%. Benign tumors developed nearly twice more frequently in females than in males (M:F=2,786:5,877). In contrast, the incidences of borderline tumors were noted to be similar.

Distribution of tumors according to originating site

The incidence according to the originating site is shown in

Table 2. The numbers of total and histologically confirmed cases by histological group, Republic of Korea, 2013

Histological group	Total	Histology confirmed
	n (%)	n (%)
Meningioma	4,409 (37.3)	1,708 (30.2)
Glioma	1,506 (12.7)	1,235 (21.9)
Pituitary tumor	2,126 (18.0)	1,126 (19.9)
Nerve sheath tumor	1,454 (12.3)	780 (13.8)
Lymphoma	221 (1.9)	197 (3.5)
Germ cell tumors, cysts and heterotopias	127 (1.1)	94 (1.7)
Craniopharyngioma	151 (1.3)	100 (1.8)
Other mesenchymal, non-malignant and malignant	72 (0.6)	49 (0.9)
Embryonal/primitive/medulloblastoma	61 (0.5)	59 (1.0)
Hemangioma	438 (3.7)	110 (1.9)
Choroid plexus	20 (0.2)	13 (0.2)
Choroid/chondrosarcoma	16 (0.1)	11 (0.2)
Neoplasm, unspecified	1,070 (9.0)	58 (1.0)
All others	156 (1.3)	109 (1.9)
Total	11,827 (100.0)	5,649 (47.8)

Fig. 2. Meninges (35.2%) were the most common site of primary brain tumors, followed by the brain parenchyma (29.0%), sellar region (21.1%), and cranial and spinal nerves (14.7%). Tumors of the meninges developed more than 3 times frequently in females (Fig. 2). The sellar region tumors

showed 1.5 times incidence of males than females. The other sites showed no significant differences in incidence according to sex. The overall incidence of primary brain tumors increased with age until the sixth decade. The incidence of each site specific tumor according to age is shown in Fig. 3. Tumors

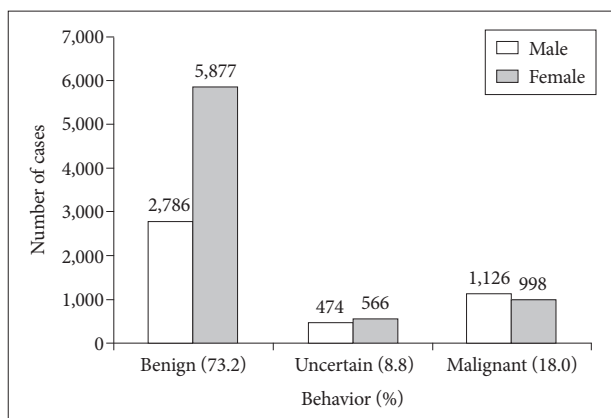


Fig. 1. Distribution of primary brain and CNS tumors according to sex and behavior, Republic of Korea, 2013. CNS, central nervous system.

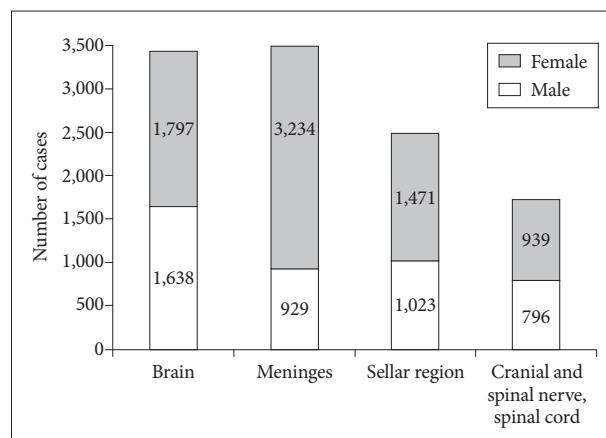


Fig. 2. Distribution of all brain and CNS tumors according to topography, Republic of Korea, 2013. CNS, central nervous system.

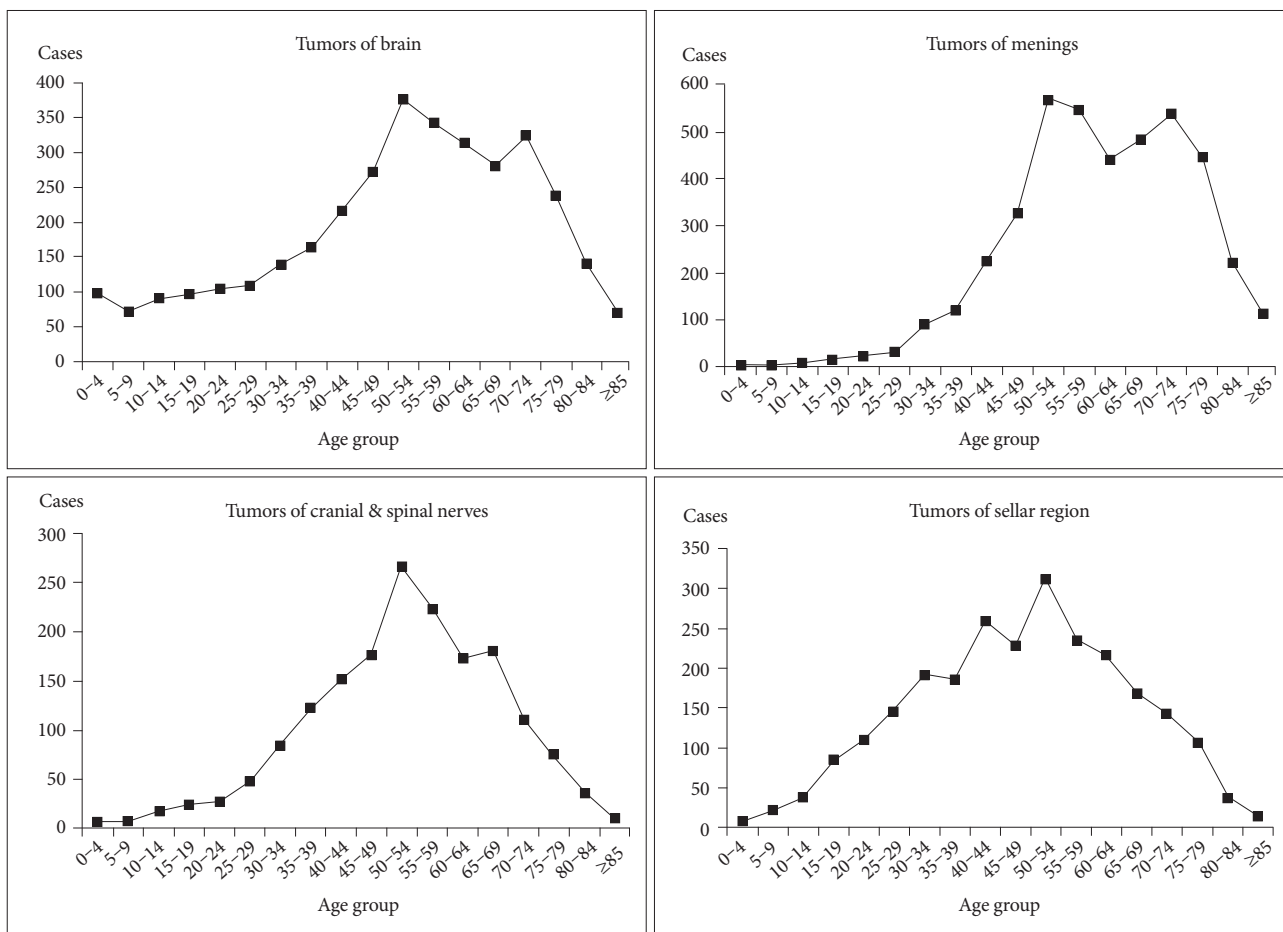


Fig. 3. Distribution of primary brain and CNS tumors according to age for selected histology, Republic of Korea, 2013. CNS, central nervous system.

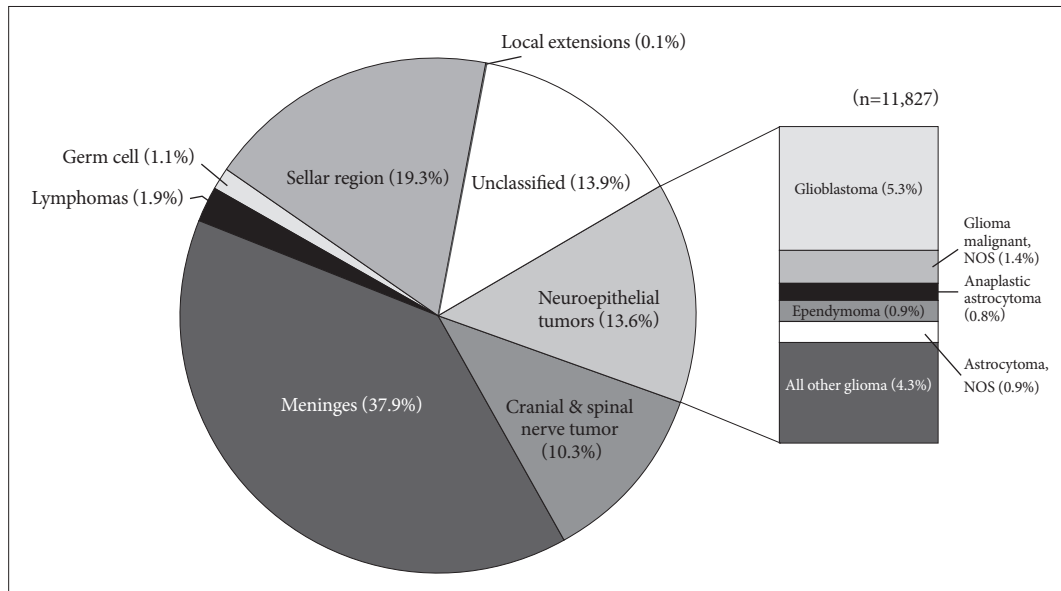


Fig. 4. Distribution of brain and CNS tumors according to the histology, Republic of Korea, 2013. NOS, not otherwise specified; CNS, central nervous system.

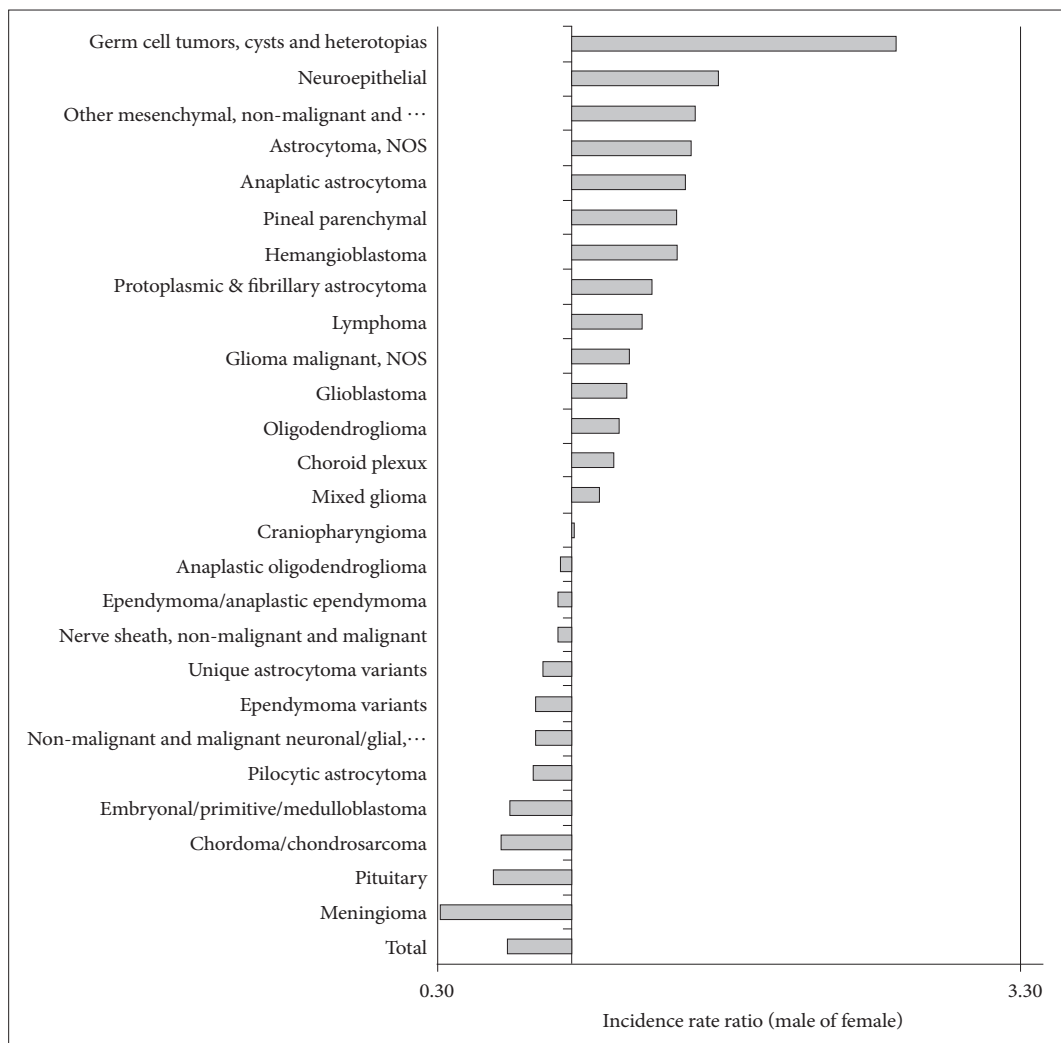


Fig. 5. Incidence according to sex and histology, Republic of Korea, 2013. NOS, not otherwise specified.

of the brain parenchyma reached a peak in the sixth decade. Tumors of the meninges seldom occurred in childhood, the incidence of which increased from the third decade and peaked in the sixth decade. Tumors of the nerves peaked in the sixth decade. Sellar tumors increased rapidly in late adolescents and peaked in the sixth decade, which decreased thereafter.

Incidence according to specific histology

Distribution of the tumors according to histology is shown

in Fig. 4 and 5. Histologically, tumors of meninges were the most common (37.9%), followed by tumors of the sellar region (19.3%) and neuroepithelial tumors (13.6%). Neuroepithelial tumors of neuroepithelial tissue were composed of astrocytic tumors, oligodendroglial tumors, ependymal tumors, choroid plexus tumors, pineal region tumors, and embryonal tumors. Most of the neuroectodermal tumors were gliomas (93.4%), which accounted for 12.7% of all primary brain tumors. Glioblastomas accounted for 5.3% of all tumors and 41.8% of all

Table 3. The numbers of total and histologically confirmed cases by histological type in gliomas, Republic of Korea, 2013

Histological group in gliomas	Total	Histology confirmed
	n (%)	n (%)
Glioblastoma	629 (41.8)	570 (46.2)
Astrocytoma, NOS	110 (7.3)	89 (7.2)
Anaplastic astrocytoma	94 (6.2)	88 (7.1)
Pilocytic astrocytoma	50 (3.3)	48 (3.9)
Ependymoma/anaplastic ependymoma/ependymoma variants	107 (7.1)	100 (8.1)
Oligodendroglioma	87 (5.8)	83 (6.7)
Anaplastic oligodendroglioma	59 (3.9)	58 (4.7)
Glioma malignant, NOS	160 (10.6)	32 (2.6)
Neuroepithelial	21 (1.4)	12 (1.0)
Mixedglioma	47 (3.1)	45 (3.6)
Uniqueastrocytomavariants	34 (2.3)	23 (1.9)
Protoplasmic & fibrillary astrocytoma	3 (0.2)	3 (0.2)
Non-malignant and malignantneuroal/glial, neuronal and mixed	105 (7.0)	84 (6.8)
Total	1,506 (100.0)	1,235 (100.0)

NOS, not otherwise specified

Table 4. Incidence rates of primary CNS tumors by histology and sex in childhood (ages 0–19), Republic of Korea, 2013

Histology	Male			Female			Total		
	n	CR	ASR	n	CR	ASR	n	CR	ASR
Tumors of neuroepithelial tissue	113	1.98	2.09	110	2.09	2.27	223	2.03	2.18
Pilocytic astrocytoma	15	0.26	0.28	21	0.40	0.43	36	0.33	0.35
Anaplastic astrocytoma	5	0.09	0.10	2	0.04	0.04	7	0.06	0.07
Astrocytoma, NOS	6	0.10	0.10	4	0.08	0.07	10	0.09	0.09
Glioblastoma	9	0.16	0.12	10	0.19	0.17	19	0.17	0.15
Ependymoma/anaplastic ependymoma	10	0.17	0.19	3	0.06	0.05	13	0.12	0.12
Glioma malignant, NOS	14	0.24	0.28	9	0.17	0.20	23	0.21	0.24
Non-malignant and malignant neuronal/glial, neuronal and mixed	14	0.24	0.23	16	0.30	0.33	30	0.27	0.28
Embryonal/primitive/medulloblastoma	22	0.38	0.48	31	0.59	0.72	53	0.48	0.60
Tumors of cranial and spinal nerves	15	0.26	0.20	13	0.25	0.22	28	0.26	0.21
Tumors of meninges	14	0.24	0.22	14	0.27	0.24	28	0.26	0.23
Lymphomas and hemopoietic neoplasms	1	0.02	0.01	3	0.06	0.04	4	0.04	0.03
Germ cell tumors, and cysts	59	1.03	0.89	13	0.25	0.26	72	0.66	0.59
Tumors of sellar region	35	0.61	0.53	73	1.39	1.15	108	0.98	0.83
Pituitary	27	0.47	0.38	62	1.18	0.95	89	0.81	0.65
Craniopharyngioma	8	0.14	0.15	11	0.21	0.20	19	0.17	0.18
Local extensions from regional tumors	-	-	-	-	-	-	-	-	-
Unclassified tumors	64	1.12	1.09	51	0.97	0.97	115	1.05	1.03
Total	301	5.27	5.03	277	5.27	5.17	578	5.27	5.10

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

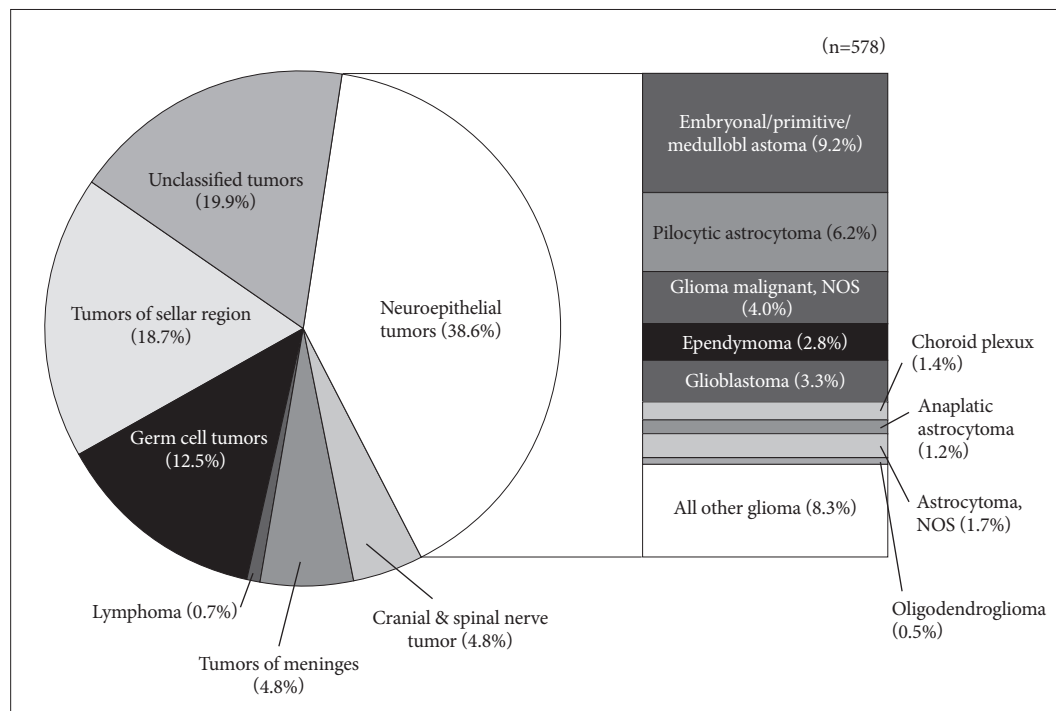


Fig. 6. Distribution of primary brain and CNS tumors according to histology in children, Republic of Korea, 2013. CNS, central nervous system; NOS, not otherwise specified.

gliomas. Among histologically confirmed cases, glioblastomas accounted for 46.2% of all gliomas (Table 3).

Childhood primary brain tumors according to histology

Distribution of tumors according to histology in childhood is shown in Table 4 and Fig. 6.

Children numbering 578 under 19 years of age were diagnosed with brain tumors in 2013, and crude rates of primary brain tumors in children was 5.27 per 100,000 person-years. The incidence was slightly higher in females (5.17) than in males (5.03). The most common histology in children included neuroepithelial tumors, germ cell tumors, and tumors of the sellar region. Neuroepithelial tumors accounted for 38.6% of all tumors in children. Embryonal/primitive/medulloblastoma was the most common tumor among neuroepithelial tumors in children. Glioblastomas accounted for only 3.3% of all primary brain tumors in children.

DISCUSSION

This is the third nationwide report on primary brain and CNS tumors, encompassing benign, borderline, and malignant tumors in the Republic of Korea. Compared to two previous reports of 2005 and 2010, crude rates for brain and CNS tumors increased from 11.7 per 100,000 in 2005 [6], to 20.1 in 2010 [7], and 23.4 in 2013. Age-standardized rates also in-

creased from 10.2 in 2005, to 15.7 in 2010, and 17.1 in 2013. The incidences of all histological types increased in 2013 compared to 2010, however, most of this increase was due to benign tumors, including tumors of the cranial nerves, meninges, and sellar. The increased frequency of MRI scans could be a main reason for benign tumors increase. Age-standardized rate of malignant brain tumors was 2.9 per 100,000, and slightly lower than the worldwide incidence rate (3.4 per 100,000), according to Globocan 2012 [15]. Among children, the age-standardized rate of brain tumors also increased from 3.72 in 2005 to 5.00 in 2010, and 5.10 in 2013.

In conclusion, we updated the nationwide statistics of brain and CNS tumors in the Republic of Korea. Updated incidence of brain tumors will help to assess disease burden, facilitate etiologic studies, and establish cancer prevention and control strategies.

Conflicts of Interest

The authors have no financial conflicts of interest.

Acknowledgments

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