

## Malignant primary brain and other central nervous system tumors diagnosed in Canada from 2009 to 2013

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### Abstract

**Background.** We present a national surveillance report on malignant primary brain and other central nervous system (CNS) tumors diagnosed in the Canadian population in 2009–2013.

**Methods.** Patients were identified through the Canadian Cancer Registry, an administrative dataset that includes cancer incidence data from all provinces/territories in Canada. Tumor types were classified by site and histology using the definitions from the Central Brain Tumor Registry of the United States (CBTRUS). Incidence rates (IRs) and 95% confidence intervals (CIs) were calculated per 100 000 person-years (py) and age-standardized to the 2011 Canadian population for comparisons within Canada and to the 2000 United States population for comparisons with the US.

**Results.** Overall, 12 515 malignant brain and other CNS tumors were diagnosed in the Canadian population in 2009–2013 (IR: 8.71/100 000 py; 95% CI: 8.56, 8.86); 7085 were among males (IR: 10.06/100 000 py; 95% CI: 9.82, 10.29) and 5430 among females (IR: 7.41/100 000 py; 95% CI: 7.22, 7.61). Of these, 12 115 were classifiable according to histological subgroups defined by CBTRUS. The most common histology was glioblastoma (IR: 4.06/100 000 py; 95% CI: 3.95, 4.16). Among those aged 0–19 years, 1130 malignant brain and CNS tumors were diagnosed in 2009–2013 (IR: 3.36/100 000 py; 95% CI: 3.16, 3.56). The most common histology among the pediatric population was embryonal tumor (IR: 0.74/100 000 py; 95% CI: 0.65, 0.84).

**Conclusions.** These data represent an initial detailed report on the frequency and distribution of primary malignant brain and other CNS tumors diagnosed in the Canadian population in 2009–2013. The reported distributions of tumor diagnoses by sex and age reflected expected patterns based on the literature from similar populations. A report incorporating data on nonmalignant primary brain tumors is forthcoming.

### Key Points

1. The rate of diagnoses was higher among males relative to females.
2. The relationship between age category and rate of diagnosis varied by histological subtype.
3. There was no clear relationship between geographic region within Canada and rate of diagnosis.

## Importance of the study

To date, comprehensive surveillance reports focused on primary malignant brain tumors in the Canadian population have not been produced. Data on the frequency and distribution of these tumors is needed to identify subpopulations at high risk, assess clinical outcomes for patients, and to develop effective

policies or plans for efficient resource allocation. Additionally, comprehensive surveillance reports on these tumors in the Canadian population permits comparison with other populations for which these frequencies are routinely reported, such as that of the United States.

Primary malignant brain tumors are those originating in the brain or central nervous system (CNS). These tumors are rare, particularly when tumor subtype/histology is considered. In routine surveillance reports released by the Canadian Cancer Society, the incidence of these tumors among the Canadian population is reported for all tumors originating in the brain or other CNS sites combined.<sup>1</sup> However, given the degree of variation in severity across histological subtypes of these tumors, combining all brain or other CNS tumors into a single category for reporting purposes is of limited utility in the effort to improve the efficiency of etiologic research, resource allocation, and patient outcomes. The Canadian Brain Tumour Registry (CBTR) project was initiated by a committee of the Brain Tumour Foundation of Canada with the aim of enhancing infrastructure for surveillance and clinical research to improve health care decisions and outcomes for brain tumor patients in support of Bill M235, passed in 2007.<sup>2</sup> We present a comprehensive national surveillance report on malignant primary brain and other CNS tumors diagnosed in the Canadian population from 2009 to 2013. This report expands available national information by characterizing the occurrence of cancers by histology, sex, age at diagnosis, and region for the pediatric and adult primary brain tumor patient population.

## Methods

### Data Source

Patients diagnosed with malignant primary brain and other CNS tumors between 2009 and 2013 were identified through the Canadian Cancer Registry (CCR). Ethics approval for this research was obtained from the Health Research Ethics Board of Alberta, Cancer Committee. The CCR is an administrative dataset that includes information on cancer incidence from all 13 provinces/territories in Canada.<sup>3</sup> The CCR is a collaborative effort between Statistics Canada and each provincial/territorial cancer registry. Error detection and quality control assurance methods are described by Statistics Canada.<sup>3</sup> Primary cancer diagnoses are coded using the ICD-O3 system. The CCR contains separate variables for anatomical site, histologic features, and behavior. Demographic characteristics of each patient include: age at diagnosis, sex, and location of residence (province, postal code, census tract).<sup>3</sup> The full 5 years of data were available for 9 provinces and 3 territories, and 2 years of data were available for Quebec (2009, 2010). More recent data from Quebec was unavailable due

to delays in data submissions to Statistics Canada as a result of changes in the methods used to identify and register cases.

### Brain and CNS Tumor Definition and Classification

Primary tumors occurring in the brain and other CNS were defined as those occurring at the following ICD-O3 sites: C700-C709, C710-C719, C720-C729, C751-C753, and C300. All tumors included in the analysis were assigned behavior code 3, representing malignant. Major histological types were classified by site and histology using 2 definitions: those of the Central Brain Tumor Registry of the United States (CBTRUS)<sup>4</sup> and of the International Classification of Childhood Cancer (ICCC).<sup>5</sup>

### Statistical Analysis

Counts were rounded to the nearest 5, in accordance with Statistics Canada guidelines for reporting and disclosure.<sup>3</sup> Incidence rates (IRs) and 95% CIs were calculated per 100 000 person-years (py) and standardized to the 2011 Canadian census population age distribution for comparisons within Canada. The 2011 census population was assumed to be constant across the 5-year period for all provinces and territories. The province- and territory-specific population from the 2011 census was multiplied by 5 to reflect the 5-year period for which data were available for provinces and territories other than Quebec. The 2011 census population of Quebec was multiplied by 2 to reflect the 2 years of data on malignant brain tumor incidence in this province. IRs and 95% CIs were calculated for total tumor diagnoses as defined by site and a combination of site and histology, as well as for specific histological subgroups. The extent to which tumor subtypes were broken down into finer groupings depended on the number of cases. Case numbers less than 5 were suppressed or combined with similar histological groupings in accordance with Statistics Canada guidelines.

IRs were estimated for the entire Canadian population and stratified by geographic region, sex, and age category. Incidence rate ratios (IRRs) and corresponding 95% CIs were estimated for contrasts of interest (including sex and age categories). The pediatric population was defined as patients aged 19 years and younger. IRs and 95% CIs were estimated for 5-year intervals of age among the pediatric patient population and 10-year intervals of age among the adult population ( $\geq 20$  y). Age was also classified according

to the National Cancer Institute (NCI) definitions: children are those aged 0–14 years, adolescents and young adults are aged 15–39 years, and adults are those aged ≥40 years.<sup>4</sup>

To compare IRs estimated in Canada with those estimated in the United States, data on the rate of malignant primary brain and other CNS tumor diagnoses in the US population between 2009 and 2013 were obtained from CBTRUS surveillance reports.<sup>4</sup> To facilitate this comparison, IRs estimated in Canadian provinces were standardized to the 2000 US population age distribution.

## Results

Overall, 12515 malignant brain and other CNS tumors were diagnosed in the Canadian population from 2009 to 2013 (IR: 8.71; 95% CI: 8.56, 8.86). Tumors predominantly originated in the frontal lobe (24.9% [95% CI: 24.1%, 25.7%] of tumors classified by site). IRs and 95% CIs for brain tumors by site are shown in [Table 1](#). Of diagnosed malignant tumors, 12515 were classifiable according to histological subgroups defined by CBTRUS. Incidence rates and 95% CIs for histological subgroups are shown in [Table 2](#). Tumors originating in neuroepithelial tissue were the most commonly diagnosed (81.3% [95% CI: 80.6%,

92.0%] of tumors classified by site and histology). Of these tumors, the most commonly diagnosed histological subtype was glioblastoma (59.2% [95% CI: 58.2%, 60.2%] of neuroepithelial tumors), followed by malignant glioma not otherwise specified (NOS) (6.9% [95% CI: 6.4%, 7.4%] of neuroepithelial tumors) and diffuse astrocytoma (6.3% [95% CI: 5.8%, 6.8%] of neuroepithelial tumors).

## Incidence Rates by Sex

Of brain and other CNS tumors diagnosed between 2009 and 2013, males accounted for 7085 (IR: 10.06 per 100000 py; 95% CI: 9.82, 10.29) and females for 5430 (IR: 7.41 per 100000 py; 95% CI: 7.22, 7.61). The rate of malignant tumor diagnoses was higher among males relative to females for all sites other than the cerebral and spinal meninges (C700-C709) ([Table 1](#)). Similarly, while the distribution of diagnosis frequencies across histological subtypes was similar for males and females, the rate of diagnoses was higher among males for each histological classification other than unclassified tumors and tumors of the meninges, with an overall IRR of 1.35 (95% CI: 1.30, 1.40) ([Table 2](#)). Those histological categories where this sex difference is unlikely to be due to random variation are noted in [Table 1](#) by non-overlapping CIs shown in italics.

**Table 1** Five-year total cases and incidence rates for brain and other CNS tumors by site and sex, 2009–2013, per 100000 per year, adjusted for the 2011 Canadian census age distribution

ICD-03 Code	Site	Total			Male			Female		
		5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI
C710	Cerebrum	730	0.51	0.47, 0.55	405	0.57	0.52, 0.63	325	0.44	0.40, 0.50
C711-C714	Frontal, temporal, parietal, and occipital lobes of the brain	6925	4.82	4.71, 4.93	3990	5.66	5.49, 5.84	2935	4.01	3.86, 4.16
<i>C711</i>	<i>Frontal lobe</i>	<i>3115</i>	<i>2.17</i>	<i>2.09, 2.25</i>	<i>1705</i>	<i>2.42</i>	<i>2.31, 2.54</i>	<i>1410</i>	<i>1.93</i>	<i>1.83, 2.03</i>
<i>C712</i>	<i>Temporal lobe</i>	<i>2195</i>	<i>1.53</i>	<i>1.46, 1.59</i>	<i>1340</i>	<i>1.90</i>	<i>1.80, 2.01</i>	<i>855</i>	<i>1.17</i>	<i>1.09, 1.25</i>
<i>C713</i>	<i>Parietal lobe</i>	<i>1310</i>	<i>0.91</i>	<i>0.86, 0.96</i>	<i>765</i>	<i>1.09</i>	<i>1.01, 1.17</i>	<i>545</i>	<i>0.74</i>	<i>0.68, 0.81</i>
<i>C714</i>	<i>Occipital lobe</i>	<i>305</i>	<i>0.21</i>	<i>0.19, 0.24</i>	<i>180</i>	<i>0.26</i>	<i>0.22, 0.30</i>	<i>125</i>	<i>0.17</i>	<i>0.14, 0.20</i>
C715	Ventricle	165	0.11	0.10, 0.13	85	0.12	0.10, 0.15	80	0.11	0.09, 0.14
C716	Cerebellum	445	0.31	0.28, 0.34	260	0.37	0.33, 0.42	185	0.25	0.22, 0.29
C717	Brainstem	395	0.27	0.25, 0.30	215	0.31	0.27, 0.35	180	0.25	0.21, 0.28
C718-C719	Other brain	2285	1.59	1.53, 1.66	1245	1.77	1.67, 1.87	1040	1.42	1.34, 1.51
C720-C721	Spinal cord and cauda equina	250	0.17	0.15, 0.20	145	0.21	0.17, 0.24	105	0.14	0.12, 0.17
C722-C725	Cranial nerves	90	0.06	0.05, 0.08	45	0.06	0.05, 0.09	45	0.06	0.04, 0.08
C728-C729	Other nervous system	105	0.07	0.06, 0.09	65	0.09	0.07, 0.12	40	0.05	0.04, 0.07
C700-C709	Meninges (cerebral and spinal)	250	0.17	0.15, 0.20	120	0.17	0.14, 0.20	130	0.18	0.15, 0.21
C751-C752	Pituitary and craniopharyngeal duct	85	0.06	0.05, 0.07	45	0.06	0.05, 0.09	40	0.05	0.04, 0.07
C753	Pineal	100	0.07	0.06, 0.08	65	0.09	0.07, 0.12	35	0.05	0.03, 0.07
C300	Olfactory tumors of the nasal cavity	690	0.48	0.45, 0.52	400	0.57	0.51, 0.63	290	0.40	0.35, 0.44
<b>Total</b>		<b>12515</b>	<b>8.71</b>	<b>8.56, 8.86</b>	<b>7085</b>	<b>10.06</b>	<b>9.82, 10.29</b>	<b>5430</b>	<b>7.41</b>	<b>7.22, 7.61</b>

**Table 2** Five-year total cases and incidence rates for brain and other CNS tumors by histology group and sex, 2009–2013, per 100 000 per year, adjusted for the 2011 Canadian census age distribution

Histology	Total			Male			Female		
	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI
<b>Tumors of neuroepithelial tissue</b>	<b>9850</b>	<b>6.86</b>	<b>6.72, 6.99</b>	<b>5690</b>	<b>8.08</b>	<b>7.87, 8.29</b>	<b>4160</b>	<b>5.68</b>	<b>5.51, 5.86</b>
Pilocytic astrocytoma	380	0.26	0.24, 0.29	210	0.30	0.26, 0.34	170	0.23	0.20, 0.27
Diffuse astrocytoma	620	0.43	0.40, 0.47	365	0.52	0.47, 0.57	255	0.35	0.31, 0.39
Anaplastic astrocytoma	430	0.30	0.27, 0.33	230	0.33	0.29, 0.37	200	0.27	0.24, 0.31
Unique astrocytoma variants	85	0.06	0.05, 0.07	50	0.07	0.05, 0.09	35	0.05	0.03, 0.07
Glioblastoma	5830	4.06	3.95, 4.16	3460	4.91	4.75, 5.08	2370	3.24	3.11, 3.37
Oligodendroglioma	360	0.25	0.23, 0.28	190	0.27	0.23, 0.31	170	0.23	0.20, 0.27
Anaplastic oligodendroglioma	290	0.20	0.18, 0.23	165	0.23	0.20, 0.27	125	0.17	0.14, 0.20
Oligoastrocytic tumors	400	0.28	0.25, 0.31	220	0.31	0.27, 0.36	180	0.25	0.21, 0.28
Ependymal tumors	335	0.23	0.21, 0.26	185	0.26	0.23, 0.30	150	0.20	0.17, 0.24
Glioma malignant, NOS	675	0.47	0.44, 0.5	360	0.51	0.46, 0.57	315	0.43	0.38, 0.48
Neuronal and mixed neuronal-glioma tumors	80	0.06	0.04, 0.07	45	0.06	0.05, 0.09	35	0.05	0.03, 0.07
Tumors of the pineal region	40	0.03	0.02, 0.04	20	0.03	0.02, 0.04	20	0.03	0.02, 0.04
Embryonal tumors	315	0.22	0.20, 0.25	185	0.26	0.23, 0.30	130	0.18	0.15, 0.21
Other neuroepithelial tumors	10	0.01	0.003, 0.01	5	0.01	0.002, 0.02	5	0.01	0.002, 0.02
<b>Tumors of cranial and spinal nerves</b>	<b>25</b>	<b>0.02</b>	<b>0.01, 0.03</b>	<b>10</b>	<b>0.01</b>	<b>0.01, 0.03</b>	<b>15</b>	<b>0.02</b>	<b>0.01, 0.03</b>
<b>Tumors of meninges</b>	<b>385</b>	<b>0.27</b>	<b>0.24, 0.30</b>	<b>190</b>	<b>0.27</b>	<b>0.23, 0.31</b>	<b>195</b>	<b>0.27</b>	<b>0.23, 0.31</b>
Meningioma	185	0.13	0.11, 0.15	85	0.12	0.10, 0.15	100	0.14	0.11, 0.17
Mesenchymal tumors	80	0.06	0.04, 0.07	50	0.07	0.05, 0.09	30	0.04	0.03, 0.06
Primary melanocytic lesions	75	0.05	0.04, 0.07	30	0.04	0.03, 0.06	45	0.06	0.04, 0.08
Other neoplasms related to the meninges	45	0.03	0.02, 0.04	25	0.04	0.02, 0.05	20	0.03	0.02, 0.04
<b>Lymphomas and hematopoietic neoplasms</b>	<b>610</b>	<b>0.42</b>	<b>0.39, 0.46</b>	<b>345</b>	<b>0.49</b>	<b>0.44, 0.54</b>	<b>265</b>	<b>0.36</b>	<b>0.32, 0.41</b>
Lymphoma	585	0.41	0.38, 0.44	335	0.48	0.43, 0.53	250	0.34	0.30, 0.39
Other hematopoietic neoplasms	25	0.02	0.01, 0.03	10	0.01	0.01, 0.03	15	0.02	0.01, 0.03
<b>Germ cell tumors, cysts and heterotopias</b>	<b>130</b>	<b>0.09</b>	<b>0.08, 0.11</b>	<b>100</b>	<b>0.14</b>	<b>0.12, 0.17</b>	<b>30</b>	<b>0.04</b>	<b>0.03, 0.06</b>
<b>Tumors of the sellar region</b>	<b>40</b>	<b>0.03</b>	<b>0.02, 0.04</b>	<b>25</b>	<b>0.04</b>	<b>0.02, 0.05</b>	<b>15</b>	<b>0.02</b>	<b>0.01, 0.03</b>
<b>Unclassified tumors</b>	<b>1075</b>	<b>0.75</b>	<b>0.70, 0.80</b>	<b>485</b>	<b>0.69</b>	<b>0.63, 0.75</b>	<b>590</b>	<b>0.81</b>	<b>0.74, 0.87</b>
<b>Total</b>	<b>12,115</b>	<b>8.43</b>	<b>8.28, 8.58</b>	<b>6845</b>	<b>9.72</b>	<b>9.49, 9.95</b>	<b>5270</b>	<b>7.20</b>	<b>7.00, 7.39</b>

### Incidence Rates by Age

IRs and 95% CIs of histological subtypes stratified by age are shown in [Tables 3–4](#) and [Supplementary Tables 1–2](#). Neuroepithelial tumors were the most commonly diagnosed subtype in all age groups ([Tables 3–4](#) and [Supplementary Tables 1–2](#)). Among patients aged 20 years or older, the incidence of neuroepithelial tumors increased with increasing age category ([Table 3](#)). IRRs for incremental increases in age category were: 35–44 versus 20–35 years, 1.45 (95% CI: 1.32, 1.59); 45–54 versus 35–44 years, 1.50 (95% CI: 1.39, 1.63); 55–64 versus 45–54 years, 1.85 (95% CI: 1.74, 1.96); and 65 and older versus 55–64 years, 1.65 (95% CI: 1.58, 1.74).

Overall, 1130 malignant brain and CNS tumors were diagnosed in the Canadian pediatric population (ages 0–19 y) in 2009–2013 (IR: 3.36 per 100 000 py; 95% CI: 3.16, 3.56) ([Tables 3](#) and [4](#)). Tumors originating in the neuroepithelial tissue were the most commonly diagnosed subtype in this subset of the population ([Tables 3, 4](#)). The incidence of malignant neuroepithelial tumor diagnoses decreased with increasing age category among those aged 19 years and younger. IRRs for incremental increases in age category were: 5–9 versus 0–4 years, 0.88 (95% CI: 0.75, 1.03); 10–14 versus 5–9 years, 0.66 (95% CI: 0.55, 0.80); and 15–19 versus 10–14 years, 0.89 (95% CI: 0.72, 1.09). This trend is likely driven by the incidence of malignant embryonal tumor diagnoses, which is highest

**Table 3** Incidence rates for brain and other CNS tumors by histology group and age at diagnosis, 2009–2013, per 100 000 per year, adjusted for the 2011 Canadian census age distribution

Histology	0–19 Years		20–34 Years		35–44 Years		45–54 Years		55–64 Years		65+ Years	
	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI
<b>Tumors of neuroepithelial tissue</b>	<b>2.77</b>	<b>3.14, 2.77</b>	<b>2.94</b>	<b>2.74, 3.15</b>	<b>4.32</b>	<b>4.03, 4.62</b>	<b>6.41</b>	<b>6.09, 6.75</b>	<b>11.82</b>	<b>11.34, 12.33</b>	<b>16.9</b>	<b>16.34, 17.46</b>
Pilocytic astrocytoma	0.64	0.83, 0.64	0.21	0.16, 0.28	0.13	0.01, 0.06	0.11	0.07, 0.16	0.08	0.04, 0.13	0.02	0.01, 0.06
Diffuse astrocytoma	0.16	0.26, 0.16	0.34	0.27, 0.41	0.44	0.35, 0.54	0.44	0.36, 0.53	0.62	0.51, 0.74	0.76	0.65, 0.89
Anaplastic astrocytoma	0.06	0.13, 0.06	0.30	0.24, 0.37	0.31	0.24, 0.40	0.35	0.28, 0.44	0.40	0.32, 0.50	0.5	0.41, 0.61
Unique astrocytoma variants	0.02	0.07, 0.02	0.05	0.03, 0.09	0.05	0.02, 0.09	0.04	0.02, 0.08	0.05	0.03, 0.10	0.12	0.08, 0.18
Glioblastoma	0.12	0.21, 0.12	0.52	0.44, 0.61	1.54	1.37, 1.73	3.83	3.58, 4.09	8.88	8.46, 9.32	13.34	12.85, 13.84
Oligodendroglioma	0.01	0.05, 0.01	0.29	0.23, 0.36	0.46	0.37, 0.57	0.35	0.28, 0.44	0.35	0.27, 0.44	0.14	0.10, 0.20
Anaplastic oligodendroglioma			0.16	0.12, 0.22	0.28	0.21, 0.37	0.33	0.26, 0.41	0.29	0.22, 0.38	0.26	0.20, 0.34
Oligoastrocytic tumors			0.37	0.31, 0.45	0.49	0.40, 0.60	0.33	0.26, 0.41	0.40	0.32, 0.50	0.24	0.18, 0.32
Ependymal tumors	0.24	0.36, 0.24	0.16	0.12, 0.22	0.18	0.13, 0.25	0.22	0.16, 0.29	0.27	0.20, 0.35	0.24	0.18, 0.32
Glioma malignant, NOS	0.45	0.60, 0.45	0.27	0.21, 0.34	0.31	0.24, 0.40	0.33	0.26, 0.41	0.35	0.27, 0.44	1.1	0.96, 1.25
Embryonal tumors	0.65	0.84, 0.65	0.20	0.15, 0.26	0.08	0.04, 0.13	0.02	0.01, 0.05	0.03	0.01, 0.06	0.02	0.01, 0.06
Other neuroepithelial	0.05	0.11, 0.05	0.07	0.04, 0.11	0.05	0.02, 0.09	0.07	0.04, 0.11	0.11	0.07, 0.17	0.14	0.10, 0.20
<b>Tumors of meninges</b>	<b>0.01</b>	<b>0.05, 0.01</b>	<b>0.11</b>	<b>0.07, 0.15</b>	<b>0.21</b>	<b>0.15, 0.28</b>	<b>0.26</b>	<b>0.20, 0.34</b>	<b>0.37</b>	<b>0.29, 0.47</b>	<b>0.79</b>	<b>0.67, 0.92</b>
Meningioma			0.04	0.02, 0.07	0.08	0.04, 0.13	0.15	0.11, 0.21	0.21	0.15, 0.29	0.41	0.32, 0.50
Mesenchymal tumors			0.05	0.03, 0.09	0.05	0.02, 0.09	0.07	0.04, 0.11	0.05	0.03, 0.10	0.07	0.04, 0.12
Other neoplasms related to meninges			0.02	0.01, 0.04	0.08	0.04, 0.13	0.04	0.02, 0.08	0.11	0.07, 0.17	0.31	0.24, 0.40
<b>Lymphomas and hematopoietic neoplasms</b>	<b>0.19</b>	<b>0.30, 0.19</b>	<b>0.07</b>	<b>0.04, 0.11</b>	<b>0.13</b>	<b>0.08, 0.19</b>	<b>0.33</b>	<b>0.26, 0.41</b>	<b>0.83</b>	<b>0.70, 0.97</b>	<b>1.53</b>	<b>1.36, 1.70</b>
<b>Tumors of the sellar region</b>			<b>0.18</b>	<b>0.13, 0.24</b>	<b>0.26</b>	<b>0.19, 0.34</b>	<b>0.39</b>	<b>0.32, 0.48</b>	<b>0.67</b>	<b>0.56, 0.80</b>	<b>3.44</b>	<b>3.19, 3.70</b>
<b>Unclassified tumors</b>	<b>0.00</b>	<b>0.03, 0.00</b>	<b>0.12</b>	<b>0.09, 0.17</b>	<b>0.05</b>	<b>0.02, 0.09</b>	<b>0.07</b>	<b>0.04, 0.11</b>	<b>0.08</b>	<b>0.04, 0.13</b>	<b>0.14</b>	<b>0.10, 0.20</b>
<b>Total</b>	<b>3.36</b>	<b>3.16, 3.56</b>	<b>3.42</b>	<b>3.21, 3.64</b>	<b>4.96</b>	<b>4.66, 5.29</b>	<b>7.46</b>	<b>7.11, 7.82</b>	<b>13.78</b>	<b>13.25, 14.32</b>	<b>22.79</b>	<b>22.15, 23.45</b>



**Table 4** Five-year total cases and incidence rates for brain and other CNS tumors by histology group and age at diagnosis in children and adolescents (aged 0–19 years), 2009–2013, per 100 000 per year, adjusted for the 2011 Canadian census age distribution

Histology	0–4 Years			5–9 Years			10–14 Years			15–19 Years		
	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI	5-Year Total	Rate	95% CI
<b>Tumors of neuroepithelial tissue</b>	<b>315</b>	<b>3.91</b>	<b>3.49, 4.36</b>	<b>270</b>	<b>3.44</b>	<b>3.04, 3.87</b>	<b>190</b>	<b>2.28</b>	<b>1.96, 2.62</b>	<b>190</b>	<b>2.02</b>	<b>1.74, 2.33</b>
Pilocytic astrocytoma	65	0.81	0.62, 1.03	80	1.02	0.81, 1.27	60	0.72	0.55, 0.93	45	0.48	0.35, 0.64
Diffuse astrocytoma	20	0.25	0.15, 0.38	20	0.25	0.16, 0.39	15	0.18	0.10, 0.30	15	0.16	0.09, 0.26
Glioblastoma	10	0.12	0.06, 0.23	15	0.19	0.11, 0.32	10	0.12	0.06, 0.22	20	0.21	0.13, 0.33
Ependymal tumors	50	0.62	0.46, 0.82	15	0.19	0.11, 0.32	15	0.18	0.10, 0.30	20	0.21	0.13, 0.33
Glioma malignant, NOS	55	0.68	0.51, 0.89	50	0.64	0.47, 0.84	35	0.42	0.29, 0.58	30	0.32	0.22, 0.46
Embryonal tumors	100	1.24	1.01, 1.51	65	0.83	0.64, 1.06	35	0.42	0.29, 0.58	20	0.21	0.13, 0.33
<i>Medulloblastoma</i>	45	0.56	0.41, 0.75	55	0.70	0.53, 0.91	25	0.30	0.19, 0.44	15	0.16	0.09, 0.26
Other neuroepithelial tumors	15	0.19	0.10, 0.31	25	0.32	0.21, 0.47	20	0.24	0.15, 0.37	40	0.42	0.30, 0.58
<b>Tumors of meninges</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.15</b>	<b>10</b>	<b>0.13</b>	<b>0.06, 0.23</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.14</b>	<b>5</b>	<b>0.05</b>	<b>0.02, 0.12</b>
<b>Unclassified tumors</b>	<b>15</b>	<b>0.19</b>	<b>0.10, 0.31</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.15</b>	<b>10</b>	<b>0.12</b>	<b>0.06, 0.22</b>	<b>15</b>	<b>0.16</b>	<b>0.09, 0.26</b>
<b>All others</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.15</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.14</b>	<b>5</b>	<b>0.06</b>	<b>0.02, 0.14</b>	<b>0</b>	<b>-</b>	<b>-</b>
<b>Total</b>	<b>350</b>	<b>4.34</b>	<b>3.90, 4.82</b>	<b>300</b>	<b>3.82</b>	<b>3.40, 4.28</b>	<b>240</b>	<b>2.88</b>	<b>2.52, 3.26</b>	<b>240</b>	<b>2.55</b>	<b>2.24, 2.89</b>

among those aged 0–4 and declines sharply with increasing age (Table 4).

Using the ICC classification, the most common diagnosis was III(b)-astrocytoma (36.2% [95% CI: 33.5%, 39.2%] of pediatric tumor diagnoses) (Supplementary Table 2). There was no clear relationship between age category and incidence of III(b) astrocytoma diagnoses, with incremental IRRs for this grouping of: 5–9 versus 0–4 years, 1.30 (95% CI: 0.98, 1.72); 10–14 versus 5–9 years, 0.74 (95% CI: 0.56, 0.98); and 15–19 versus 10–14 years, 0.93 (95% CI: 0.70, 1.25).

## Geographic Distribution

The distribution of malignant brain and other CNS tumor diagnoses across provinces, adjusted to the 2011 Canadian population, is shown in Fig. 1. The age-adjusted incidence rates were higher among residents of central and Atlantic provinces relative to western provinces and territories, with the highest age-adjusted rates estimated among residents of Quebec (IR: 9.07 per 100 000 py) and Ontario (IR: 9.06 per 100 000 py). However, this estimate reflects only 2 years of data from Quebec. It was not possible to assess the extent to which these 2 years reflect the IR of malignant primary brain tumors for the full 5-year period included for other provinces and territories. The IR of malignant brain and other CNS tumor diagnoses appears lowest among the residents of the territories; however, it should be noted that case numbers were insufficient for adequate adjustment for the age distribution in these populations. Excluding the territories, the age-adjusted IRs for all provinces ranged 7.8–9.07 diagnoses per 100 000 py. The geographic distribution of cases further stratified by pediatric and adult populations is shown in Fig. 1. Data from the territories and Prince Edward Island were excluded from pediatric estimates due to insufficient case numbers for accurate adjustment for age.

## Comparison between the United States and Canada

The distribution of malignant brain and other CNS tumor diagnoses across provinces and states, adjusted to the 2000 US population, is shown in Fig. 2. The frequency of brain tumor diagnoses across Canadian provinces and US states was similar.<sup>4</sup> When adjusted to the 2000 US population, the IR of brain tumor diagnoses between 2009 and 2013 ranged 4.9–8.19 diagnoses per 100 000 py across Canadian provinces and territories. Excluding the territories, the IR ranged 7.1–8.2 diagnoses per 100 000 py across Canadian provinces. Similarly, the IR of all brain tumor diagnoses among the US population for the same period ranged 4.86–8.55 diagnoses per 100 000.<sup>4</sup> When restricted to the pediatric population, the incidence of brain tumor diagnoses ranged 1.78–3.90 diagnoses per 100 000 py across Canadian provinces and 2.27–4.81 diagnoses per 100 000 across the United States.<sup>4</sup>

## Discussion

### Summary of Main Results

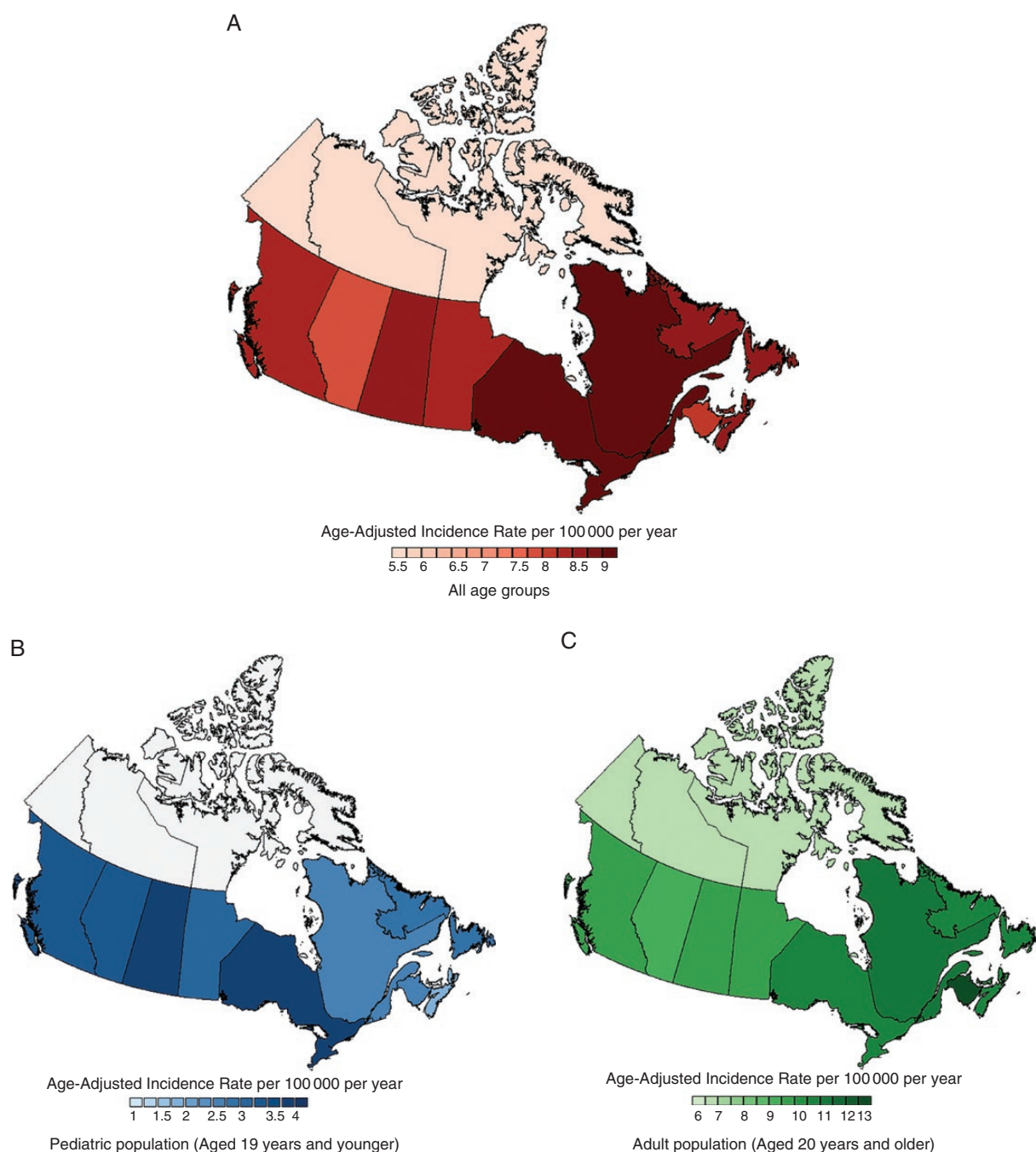
These data reflect IR estimates not previously reported for malignant brain tumor subtypes among the entire Canadian population and stratified by demographic characteristics. The 5 years reported (2009–2013) were the most recent years available from the CCR through the Research Data Centre network and reflect population rates after the introduction of Bill M235 in 2007 and changes in histological classifications in the same year.<sup>2,6</sup> Malignant tumors originating in the neuroepithelial tissue were most commonly diagnosed between 2009 and 2013. Of these, glioblastoma was the most commonly diagnosed histological subtype. The rate of diagnoses was higher among males relative to females. The relationship between age category and IR of diagnosis varied by histological subtype. There was no clear relationship between geographic location and IR of diagnosis within Canada.

### Comparison of Findings with the Literature

For most tumor categories, particularly the neuroepithelial tumors, the patterns by sex and age reflect those in the literature.<sup>4,7</sup> As expected, neuroepithelial tumors are the largest category of malignant tumors.<sup>4,7</sup> Patterns for cranial and spinal tumors and tumors of the meninges reflect the restriction to malignant tumors; these rates will change as data on all primary brain tumors become available in the future. Within this report, Canadian age-adjusted estimates are based on the same standard distribution, allowing comparison of rates within and across tables. The reader should be cautious about comparing rates reported here with data from other countries as the standards used for adjustment tend to be based on the population of interest. The overall IRs in these Canadian data are generally slightly higher than those reported in the US, as these estimates are standardized to their respective national populations.<sup>4</sup> These systematic differences are likely to reflect the older age distribution of the Canadian population. However, when Canadian rates are adjusted to the 2000 US age distribution or are stratified by age, the rates reported here and by CBTRUS are comparable.<sup>4</sup> Additionally, it should be noted that due to the population size of Canada and reporting guidelines developed by Statistics Canada, several smaller tumor categories were combined into an “other” category. Given variation across countries in reporting requirements and case numbers, the “other” categories presented in this report are not likely to be comparable to those in reports summarizing data from other countries.

### Limitations

The CCR is a well-established cancer registry system, and ascertainment of malignant brain tumor cases is considered high quality.<sup>3</sup> However, the potential for misclassification of identified cases by site and histology exists because

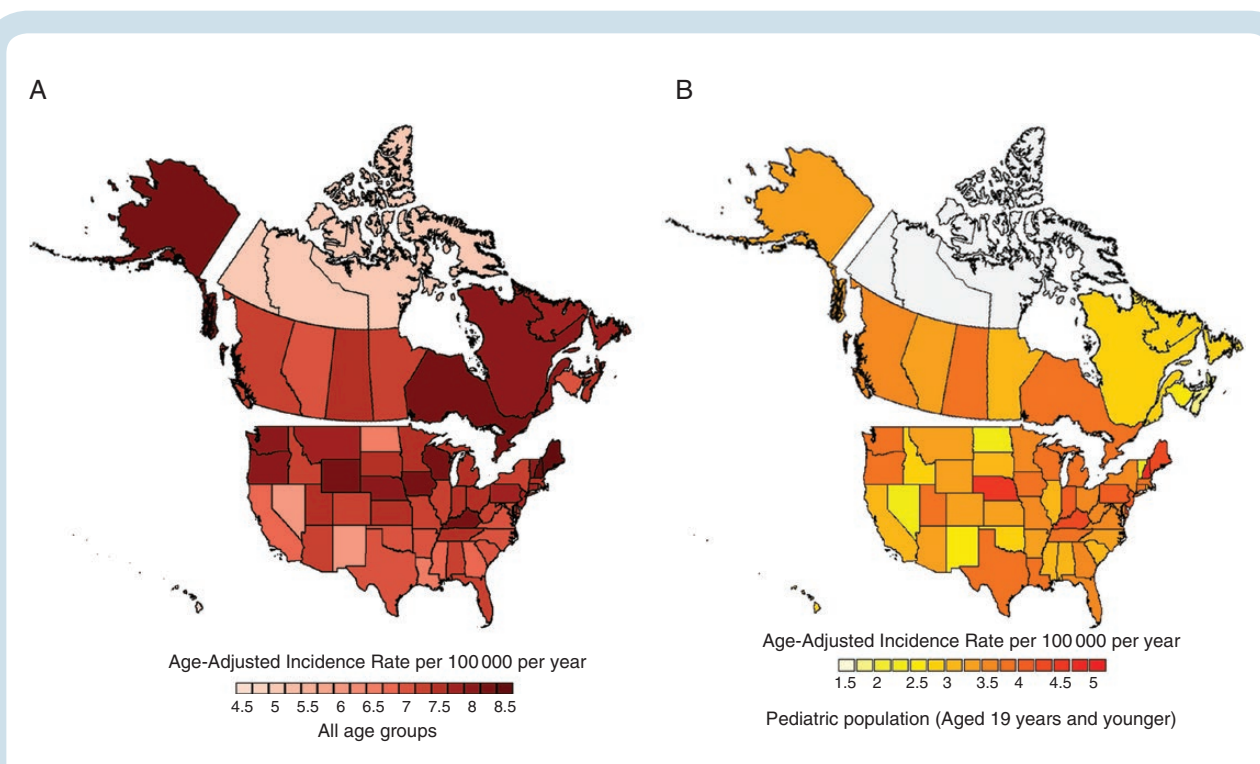


**Fig. 1** Incidence rates for brain and other CNS tumors by province/territory and age group, 2009–2013, adjusted for the 2011 Canadian census age distribution.

specific coding guidelines for brain tumors from each reporting province or territory are not available. Given that malignant brain tumors can be classified as rare cancers, they account for only a small proportion of a tumor registry workload, which may influence the accuracy of coding within a complex individual record. Uncertainty in classification is evident in the fact that the second most common tumor diagnosis during this period was malignant

glioma NOS, which represents a large range of potential diagnoses. Additionally, the classification of brain tumors has changed over time, with recent changes based on an increasing recognition of distinct molecular characteristics within histological subtypes.<sup>6</sup> This classification approach was introduced about 2007 in Canada, and emerging information on diagnostic markers continues to impact diagnostic decisions.<sup>6,8</sup> Local approaches to incorporating new





**Fig. 2** Incidence rates for brain and other CNS tumors by Canadian province/territory, US states, and age group, 2009–2013, adjusted for the 2000 US age distribution.

classifications and diagnostic biomarkers may be implemented differently by administrative regions and/or clinical centers, which would be reflected as varying degrees of misclassification across regions during this time period.

## Conclusions and Future Directions

These data represent an initial detailed report on the frequency and distribution of primary malignant brain and other CNS tumors diagnosed in the Canadian population between 2009 and 2013. The reported distributions of tumor diagnoses by sex and age reflected expected patterns based on the literature from similar populations. Data are restricted to malignant tumors given that the incorporation of data on nonmalignant tumors is currently ongoing and the territory-specific information is limited by the small numbers within these regional populations. A subsequent report incorporating data on all primary brain tumors is forthcoming. Additionally, we are working with provincial cancer registries to implement consistent incorporation of data on diagnostic biomarkers across regions, which will allow more accurate diagnostic categorizations in the future.

## Supplementary Material

Supplementary data are available at *Neuro-Oncology* online.

## Keywords

malignant brain neoplasms | malignant central nervous system neoplasms | neuro-oncology | Canadian surveillance report | epidemiology

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