International Journal of Surgery Publish Ahead of Print
DOI: 10.1097/JS9.0000000000004417
OPEN

Global patterns and trends in brain and central nervous system tumors incidence by histological subtype in 185 countries in 2022: a population-based study

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Sources of Funding: This work was supported by Capital's Funds for Health Improvement and Research (CFH2024-2G-40214), the Chinese Academy of Medical Sciences Innovation Fund for Medical Sciences (2021-I2M-1-011), and the Clinical cultivation research program (LCYJ202404).

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Summary

Background. Brain and central nervous system (CNS) tumors pose a major global health challenge. However, the distribution of histological subtypes remains limited. To quantify the global, regional, and national incidence of brain and CNS tumors by histological subtype in 2022 and to analyze variations across age groups and human development (HDI) levels.

Methods. Data from *GLOBOCAN* and *Cancer Incidence in Five Continents* (CI5) Volume X-XII were extracted. Nine histological subtypes of brain and CNS tumors were identified. The number of incident cases and age-standardized incidence rates (ASIR) for each histological subtype, stratified by age group (0-19 years vs. ≥20 years) and HDI levels, and ASIR were calculated using the world standard population. Trends in brain and CNS tumors incidence by histological subtypes from 2003 to 2017 were assessed using Joinpoint regression.

Findings. In 2022, an estimated 321,370 new cases of brain and CNS tumors were diagnosed globally (ASIR: 34.6 per million population). Astrocytic tumors accounted for the largest proportion (173,763 cases; ASIR: 18.5), followed by meningeal tumors (43,796 cases; ASIR: 4.6), gliomas of uncertain origin (43,094 cases; ASIR: 4.7), and oligodendroglia/mixed gliomas (22,673 cases; ASIR: 2.4). Age-specific distributions revealed astrocytic tumors predominant in both children/adolescents (37.4%) and adults (55.9%), whereas medulloblastoma was the most common subtype in children/adolescents (17.4%) and meningeal tumors in adults (14.6%). Considerablevariations in subtype proportions and ASIR were observed across countries and in HDI levels. Temporal trends of brain and CNS tumors ASIR varied considerably among sex, regions and histology types

Interpretation. Astrocytic tumors were the most prevalent histological subtype of brain and CNS tumors in 2022. These findings enhance our understanding of the epidemiology of brain tumors and underscore the need for tailored prevention and resource allocation strategies at national levels.

Keywords: Brain and CNS tumors; Histological subtype; Incidence; Geographic disparities

Highlights

• This study comprehensively and systematically assessment on the global burden of brain and CNS tumors by histological subtype.

• The most common histological type of brain and CNS tumors was glioma, including glioblastoma, astrocytoma, oligodendroglioma, ependymoma, oligoastrocytoma.

• Considerable variations in subtype proportions and ASIR were observed across countries and HDI levels. The findings enhance our understanding of the epidemiology of brain tumors and underscore the need for tailored prevention and resource allocation strategies at national levels

Introduction

Brain and central nervous system (CNS) tumors, a diverse group of neoplasms originating from the brain or CNS tissues, represent one of the most formidable cancers worldwide[1]. Significant heterogeneity exists in the incidence and mortality rates, with higher rates observed in developed countries than in less developed countries, higher rates in men than in women, and notably in children and adolescent [1-3]. While most etiological factors of brain and CNS tumors remain unclear, the potential factors incorporating exposure to ionizing radiation (including atomic bomb radiation exposure and childhood nasopharyngeal radium exposure), cyclic aromatic hydrocarbons, infection and allergens, contaminated drinking water, pesticides, discrepancies in the different brain and CNS tumors subtypes and different age[4-7].

The most common histological type of brain and CNS tumors was glioma, a malignant tumor group originating from glial or precursor cells, including glioblastoma, astrocytoma, oligodendroglioma, ependymoma, and oligoastrocytoma (mixed glioma)[8]; other glial-origin tumors include ependymomas, schwannomas, medulloblastomas, and meningiomas[8]. Each subtype exhibits distinct clinical characteristics and prognosis, and varies across regions and different age groups[8-10]. In children and adolescents, predominant subtypes include astrocytoma, medulloblastoma, germ-cell tumors[9],while glioblastoma is the most common types among adults[11], with the 5-year survival rates ranging from 20% to 40% in adults and 20% to 80% in children[10]. Treatment strategies depend critically on the histological subtype, underscoring the importance of understanding the global subtype distribution to provide etiological clues and benefit policy makers developing a tailor-made strategy. However, previous studies on brain and CNS tumors subtypes have mainly focused on specific regions, with limited comprehensive global analyses[3,11-13].

The aim of this study was to estimate the global distribution of brain and CNS tumors incidence by histological subtypes, sex, and age across 185 countries, utilizing updated data from the GLOBOCAN 2022 and Cancer Incidence in Five Continents (CI5) databases, analysis the temporal trends in brain and CNS tumors incidence by subtype from 2003 to 2017 in 28 countries on the basis of high-quality, population-based cancer registries. These findings will inform targeted prevention strategies and advance comprehensive management approaches for brain and CNS tumors.

Methods

Brain and CNS tumors estimates by histological subtype in 2022

Brain and CNS tumors data were obtained from the Cancer Today and Cancer Incidence in Five Continents (CI5) database (https://ci5.iarc.fr/)[14]. The Cancer Today database provides the most updated assessment of cancer incidence, mortality and prevalence across 185 countries of the world. The CI5 database is a long-term series that provides high-quality, comparable cancer registry data and is published every five years by the International Association of Cancer Registries (IACR). In this study, we extracted cases of brain and CNS tumors by country, sex, age (0-4, 5-9, …, 70-84, 85+ years) in 2022 from the Cancer Today database. Primary histological data were obtained from the CI5 Volume X-XII for 428 cancer registries located in 64 countries for the period 2003-2007 to 2013-2017. Brain and CNS tumors were identified according to the 10th edition of the International Classification of Diseases (ICD-10), and ICD codes C70-72 were extracted from the entire cancer database. Nine histological subtypes were defined using the International Classification of Diseases for Oncology, third edition (ICD-O-3) and morphology code as follows: meningeal tumors, oligodendroglial tumors and mixed gliomas, medulloblastoma, ependymal tumors, astrocytic tumors, other embryonal tumors, gliomas of uncertain origin, other neuroepithelial tumors, and other brain and CNS tumors. Detailed morphological codes are provided in ***Supplementary TableS1.*** To enable comparisons across different age groups, we applied the ICD-10 classification for brain and CNS tumors to both children and adults, rather than using the ICCC-3 classification, which is specifically recommended for childhood cancers. The countries were classified into 14 regions based on the United Nations and four human development (HDI) levels. The HDI serves as a synthetic indicator that emphasizes the development status, including education, life expectancy, and gross national income[15].

Temporal trends by histological subtypes

We extracted incident cases and population-at-risk data from CI5 Volumes X–XII. Countries with continuous qualified data from 2003 to 2017 were included to analyze the temporal trends of brain and CNS tumors by histological subtype, sex and age in 28 countries were included in the trends analysis.

Statistical analysis

To estimate the country-specific proportions of different histological subtypes in 2022, we applied the histological subtype distributions from CI5 X-XII to national cases of brain and CNS tumors within the GLOBOCAN database. The allocation was done by country and sex for children and adolescents (0-19 years) and adults (≥20 years). The detailed reallocation was performed in the following steps: First, we estimated the proportions of cases of different brain and CNS tumors subtypes by country and sex based on the CI5 volume X-XII and reassigned the unspecified cases into nine specific subtypes. The proportions of the unspecified subtypes across regions are provided in the ***Supplementary Table S2.*** Countries included in the analysis had at least five cases of brain and CNS tumors, with at least one case of astrocytic tumors, medulloblastoma of different sexes in children and adolescents, and at least one case of astrocytic tumors, oligodendroglia tumors and mixed gliomas for each sex in adults. We used the proportion of countries with similar sub-regional and Human Development Index (HDI) levels as proxies. Second, for countries not represented in volumes X–XII, we use the proportions of countries with similar sub-regional and HDI levels as proxies. Data sources for reallocation are provided in ***Supplementary Table S3.*** Finally, we applied the country-specific subtype proportions to the country-specific total cases of brain and CNS tumors for each sex and every 5-year age group from the GLOBOCAN 2022 database to estimate the national-level cases for each subtype. The robustness of the reallocation procedure has been previously validated [16]. The analysis flowchart and framework are shown in **Fig.S1**.

Crude incidence rates per million people for different brain and CNS tumor subtypes were calculated across the HDI levels, regions and countries. Age-standardized incidence rates (ASIR) per million population were estimated using Segi's world standard population[17]. Temporal trends were analyzed using Joinpoint regression (version 4.9.1, NIH, Maryland, USA) and the average annual percent change (AAPC) was estimated. The Lorenz curve and Concentration Index (CCI) were used to evaluate the distribution of unspecified morphology of inequality between countries classified by Human Development Index (HDI) levels. The value of CCI is bounded between -1 and 1. A positive CCI value denotes that unspecified morphology is concentrated among countries ranked higher on the HDI, while a negative value signifies concentration among lower-ranked countries. CCI values approaching zero reflect a more balanced resource allocation. This work has been reported in line with the STROCSS 2025 criteria[18].

Results

Global perspective on the incidence of brain and CNS tumors

In 2022, there were estimated 321370 (34.69 per 1 000 000 population) newly diagnosed cases of brain and CNS tumors worldwide, of which astrocytic tumors contributed 173763 cases (ASIR 18.46 [95%CI: 18.37-18.55] per 1000 000 populations), meningeal tumors contributed 43796 cases (ASIR 4.56 [95%CI: 4.52-4.61]), gliomas of uncertain origin contributed 43094 cases (ASIR: 4.68 [95%CI: 4.64-4.73]), oligodendroglia tumors and mixed gliomas contributed 22673 cases (ASIR:2.41 [95%CI: 2.37-2.44]). While Ependymal, medulloblastoma, other embryonal tumors and other neuroepithelial tumors were relatively rare, accounting for less than 10% of all brain and CNS tumors cases, with an ASIR lower than 1.30 per 1 000 000 populations for each type (***Table S4-S5***).

Considerable variations in the incidence of brain and CNS tumors have been observed across regions. The ASIR increased with the HDI levels, ranging from 15.41 in low HDI levels to 48.45 per 1000 000 in very high HDI levels. The highest number of brain and CNS tumors cases were occurred in Eastern Asia (29.9%), South Central Asia (15.7%) and North America (8.8%). The ASIR ranged from the highest in Southern Europe (57.7) to the lowest in Eastern Africa (12.41) (***Table S4***). The age-specific rates of brain and CNS tumors showed a U-shape, with the incidence rates decreasing with age in children and adolescents (age 0-19 years) and increasing with age in adults (≥20 years) (***Fig 1A***). Although most of the cases of brain and CNS tumors occur in adults, the brain and CNS tumors account for 11.2% all cancer cases in children and adolescents and less than 1.5% of cancer cases in adults (Fig 1B). All age-specific incidence rates were higher in men than in women (***Fig 1B***), with the global ASIR being 38.74 per 1000 000 in men and 30.83 in women (M: F=1.2) (***Table S4***). The overall proportion of unspecified morphology was 11.6% for children and adolescents and 21.6% for adults, and varied across regions (***Table S2***, ***Fig S2***).

Histological subtype distribution of brain and CNS tumors in children and adolescents

In children and adolescents, an estimated 30729 newly diagnosed cases of brain and CNS tumors worldwide (17186 cases in boys, 13543 cases in girls). The most common types of brain and CNS tumors were astrocytic tumors (37.4%), medulloblastoma (17.4%), gliomas of uncertain origin (15.3%) and other embryonal tumors (8.3%), with the corresponding ASIR per million population being 4.46 (95%CI: 4.42-4.49), 2.08 (95%CI: 2.06-2.10), 1.82 (95%CI: 1.80-1.84), and 0.99(95%CI: 0.98-1.01), respectively (***Table S5***). Of the four most common subtypes, most cases were diagnosed in boys (6257 [54.6%] of 11455 astrocytic tumor cases, 3308 [61.9%] of 5344 medulloblastoma cases, 2435 [51.8%] of 4698 gliomas of uncertain origin cases, and 1459 [57.1%] of 2555 other embryonal tumors cases).

Astrocytic tumors are the most frequently diagnosed subtype of brain and CNS tumors in children and adolescents worldwide, except in Eastern Asia and Western Europe. Among boys, the proportion of astrocytic tumors ranged from 21.7% in Eastern Asia to 59.3% in Caribbean and Central America, and among girls, ranged from 21.8 % in Oceania to 60.4% in the Caribbean and Central America (***Table 1, Fig 2A-B, Fig 3, Fig S3A***). Considerable variations were observed among countries and HDI levels (***Fig S4-S9***). The highest proportion of astrocytic tumors was observed in the majority of countries except Argentina, Bahrain, Brazil, Chile, Costa Rica, France (metropolitan)[19], Ireland, Kenya, Malaysia, New Zealand, Philippines, Saudi, Arabia, Singapore, Spain and Türkiye for both sexes, with distinctions between boys and girls (***Fig S10-S12***). In boys, the ASIR of astrocytic tumors ranged from 1.41 (95%CI: 1.15-1.66） in Kenya (lowest) to 28.66 (95%CI: 17.23-40.09) in Cyprus (highest); in girls, it ranged from

0.60 (95%CI: 0.43‑0.77) in Kenya (lowest) to 29.18 (95%CI: 17.59‑40.76) in Estonia (highest) (***Supplementary Fig S13A-21A***).

Medulloblastoma was the second most frequently diagnosed brain and CNS tumor type in children and adolescents globally, with a proportion of 19.3% (ASIR: 2.50[95%CI: 2.46‑2.53] per 1 000 000) in boys and 15.1% (ASIR: 1.63 [95%CI: 1.61‑1.66] per 1 000 000) in girls. Regional variation was the highest proportions in Northern Africa for boys (31.4%) and Western European girls (21.1%), while the lowest proportions occurred in Sub-Saharan Africa (6.6% in boys and 9.0% in girls) (***Fig2A-B***). The ASIR ranged from 0.28(95%CI: 0.25‑0.30) in boys and 0.36 (95%CI: 0.33‑0.39) in girls in Sub-Saharan Africa to the highest of 6.30 (95%CI: 5.74‑6.87) in North Europe for boys and 3.63 (95%CI: 3.29‑3.97) in girls in Western Europe(***Fig3***). Significant geographic and HDI related disparities were observed in both proportions and ASIR (***Fig S4-S8, Fig S22***). The third most common brain and CNS tumors were gliomas of uncertain origin (15.3%, ASIR: 1.82 [95%CI: 1.80‑1.84]), followed by other embryonal tumors (8.3%, ASIR: 0.99 [95%CI: 0.98‑1.01]), ependymal tumors (7.6%, ASIR:0.91 [95%CI: 0.90‑0.93]), meningeal tumors (4.4%, ASIR: 0.53 [95%CI: 0.52‑0.54]), oligodendroglia tumors and mixed gliomas (3.8%, ASIR: 0.46 [95%CI: 0.45‑0.47]), and other neuroepithelial tumors (0.7%, ASIR: 0.09 [95%CI: 0.08‑0.09]) per 1,000,000 population globally. More detailed information about subtypes across regions and countries is provided in ***Supplementary Fig S13B-21B***.

Histological subtype distribution of brain and CNS tumors in adults

The distribution of brain and other CNS tumors in adults differs significantly from that observed in children and adolescents. An estimated 290 450 new cases of brain and CNS tumors have been reported worldwide in adults (156250 cases in men, 134200 cases in women). Similar to the pattern observed in children and adolescents, the most common type was astrocytic tumors, accounting for over a half (55.9%) of cases of all brain and CNS tumors globally, with an ASIR of 27.80 (95%CI: 27.72–27.88) per 1000 000 population. A higher proportion of astrocytic tumors was diagnosed in men (93143 cases [54.6%] of 162308) compared to women **(*Table S5*)**.

Astrocytic tumors were the most frequently diagnosed subtype of brain and CNS tumors among adults across all regions, except Eastern Asia **(*Table 1, Fig 2C-D, Fig 4, Fig S3B*)**. The proportions of astrocytic tumors ranged from 27.0% in Eastern Asia to 80.6% in Oceania for both sexes, and the ASIR per 1000 000 were ranged from 8.09 (95%CI: 7.91‑8.27) in Sub-Saharan Africa to 64.43 (95%CI: 63.71‑65.16) in Western Europe. The astrocytic tumors also varied across countries and HDI levels (***Fig S7-S8, Fig S22-S25***). The highest proportion of astrocytic tumors was observed in the majority of countries except China, Zimbabwe and Uganda. The ASIR of astrocytic tumors ranged from the lowest 4.40 (95%CI: 3.30–5.50) for men and 2.11 (95%CI: 1.42‑2.79) for women in Uganda to (140.95 [95%CI: 104.71‑177.20] for men and 118.29 [95%CI: 85.60‑150.99] for women in Iceland) (***Fig S13B-21B***).

Globally, meningeal tumors were the second most frequently diagnosed type of brain and CNS tumors in adults. The global proportion and ASIR of medulloblastoma were 9.8% and 5.46 (95%CI: 5.40‑5.51) in men and 20.2% and 8.94 (95%CI: 8.88‑9.01) in women, respectively. The highest proportion of meningeal tumors was observed in Sub-Saharan Africa for men (24.3%) and in Eastern Asia for women (42.3%), while the lowest proportion was observed in North America for both men (1.0%) and women (1.1%) (***FigS4-S6***). The ASIR of meningeal tumors ranged from 1.10 (95%CI: 0.80‑1.41) for men in Oceania and

1.50 (95%CI: 1.38‑1.61) for women in North America and Caribbean/Central America to the highest with 12.76 (95%CI: 12.61‑12.92) for men and 23.68 (95%CI: 23.46‑23.89) for women in Eastern Asia (***Table 1, Fig 2C-D, Fig 4, Fig S3B***). Both the proportion and ASIR varied across countries and HDI levels (***Fig S4-S8, Fig S22***). The third most common brain and CNS tumors in adults was gliomas of uncertain origin (13.2%), followed by oligodendroglia tumors and mixed gliomas (7.4%), Ependymal tumors (2.8%), medulloblastoma (1.3%), other embryonal tumors (1.1%) and other neuroepithelial tumors (0.3%), with the corresponding ASIR per 1000 000 population were 6.59 (95%CI: 6.55‑6.63), 3.70 (95%CI: 3.67–3.74), 1.41 (95%CI: 1.39–1.43), 0.65 (95%CI: 0.63–0.66), 0.56 (95%CI: 0.54‑0.57), and 0.14 (95%CI: 0.13–0.14) worldwide, respectively. More detailed information on brain and CNS tumors subtypes across regions and countries in adults was provided in the ***Supplementary Materials*** **(*Fig S23-S25*)**.

Temporal trends by histological subtypes, sex and age

Temporal trends of ASIR in brain and CNS tumors to sex and age during 2003–2017 varied considerably across 28 countries (***Fig 5***). In general, there were seven of the 28 countries showed significant increasing trends, with the largest increases in Argentina (AAPC 3.81%, 95%CI: 1.97%–5.68%) and Japan (AAPC 3.48%, 95%CI: 0.75%–6.29%), while five countries showed significant decreasing trends, with largest decreases in Croatia (AAPC –3.35%, 95%CI:–4.14% to –2.55%) and Israel (AAPC –1.02%, 95%CI: –1.94% to –0.09%) (***Fig 5A-5C***). For children and adolescents, there were no statistically significant trends of ASIR among most of the 28 countries except in Lithuania (AAPC 5.61%, 95%CI:3.13%–8.15%), Puerto Rico (AAPC 2.87%, 95%CI: 0.37%–5.44%), Colombia (AAPC 2.47%, 95%CI: 0.19%–4.80%), Australia (AAPC –3.35%, 95%CI:–4.14% to –2.55%) and Croatia (AAPC –4.13%, 95%CI: –6.45% to –1.75%). In adults, Japan, Argentina and Belarus showed upward trends, and the USA, China and Croatia showed downward trends in persons aged 20–49 years and≥50 years (***Fig 5D-5F***).

For astrocytic tumors, ten of 28 countries showed increasing trends, with the largest increases occurring in Belarus (AAPC 4.19%, 95%CI: 2.25%–6.17%), and France (AAPC 3.69%, 95%CI: 2.76%–4.64%), while ASIR showed decreasing trends in Israel (AAPC –1.21%, 95%CI: –2.05% to –0.37%) (***Fig 5G***). For meningeal tumors, the ASIR increased in five countries with the AAPC ranging from 3.27% (95%CI: 0.46%–6.15%) in Türkiye to 11.13% (95%CI: 2.99%–19.90%) in Argentina; the ASIR substantially decreased in seven countries with the AAPC ranging from –3.43% (95%CI: –5.57% to –1.24%) in the USA to –19.06% (95%CI: –27.75% to –9.32%) in Croatia (***Fig 5H***). For oligodendroglia tumors/mixed gliomas, Japan (AAPC 7.4%, 95%CI: 2.92%–12.08%), China (AAPC 5.14%, 95%CI: 2.39%–7.97%) and India (AAPC 4.56%, 95%CI: 0.04%–9.28%) had increased trends of ASIR, France, USA, Denmark, Netherlands, Israel, Australia, and Czech Republic had the decreases trends, with the AAPC ranging from –3.43% (95%CI: –5.04% to –1.60%) in Czech Republic to –11.16% (95%CI: –14.01% to –8.21%) in France (***Fig 5I***).

Discussion

We provide a comprehensive assessment of the incidence of brain and CNS tumors by histological subtype at the global, regional, and national levels in 2022 and analyze the temporal trends of brain and CNS tumors incidence by subtype from 2003 to 2017. In this study, the top four most common types of brain and CNS tumors were astrocytic tumors, meningeal tumors, gliomas of uncertain origin, oligodendroglia tumors and mixed gliomas, contributing to over 80% all brain and CNS tumors cases, and had significant distinction between children, adolescents, and adults. For children and adolescents, the most common type was astrocytic tumors, followed by medulloblastoma, representing 37.4% and 17.4% all brain and CNS tumors diagnoses for each type, while for adults, the most common type was astrocytic tumors, followed by meningeal tumors, accounting for 55.9% and 19.3% of all brain and CNS tumors diagnoses. Temporal trends of brain and CNS tumors ASIR by sex and age during 2003–2017 varied considerably across the 28 countries.

The majority of brain and CNS tumor cases occur in countries with very high and high HDI values, respectively, with ASIR varying significantly among histological subtypes across HDI categories. The HDI levels may reflecting factors like healthcare access, diagnostic capabilities, and resource allocation that may affect the diagnosis and incidence of different histological subtypes. The total incidence of brain and CNS tumors was higher in highly developed countries in Europe and North America than in less developed countries, such as Kenya, Zimbabwe, and Uganda, which was consistent with other efforts[20-23]. The trends of brain and CNS tumors incidence have been on the rise, such as in Lithuania, Japan, Argentina etc.; this perhaps reflects the improvements in case finding and reporting. In our study, we further analyzed the socioeconomic inequalities of brain and CNS tumors. The Lorenz curve of the proportion of unspecific morphology lay above the equality line, with a negative CCI of -0.22 (95% CI: -0.14 to -0.30, P < 0.0001), indicating that the unspecified morphology was more concentrated among countries that ranked high on HDI values **(*Fig S26*)**.

Brain and CNS tumors represent the different source of cancer-related morbidity in children and adolescents[1]. The histological types exhibit considerable heterogeneity between pediatric and adult populations[3,24,25]. The two most common types of brain and CNS tumors in children and adolescents are astrocytic tumors and medulloblastoma, with the ASIR being slightly higher in boys than in girls. Similar results have also been reported in other studies[24,26-28]. In the United States and Canada, the most common gliomas and neuronal in children are astrocytoma and embryonal[24,26]. In South Korea, the most common types in children are germ cell tumors and gliomas[13]. Geographic variations in ASIR according to the histological type have been observed, although the underlying reasons remain unclear. Potential contributing factors include genetic predisposition, environmental exposure (e.g., radiation and infections), diagnostic capabilities, and socioeconomic conditions[29-31]. Approximately 5-10% of brain and other CNS tumors cases in children and adolescents have a family history[29,30]. Single gene inherited disorders and genetic syndromes are well studied, and most of these inherited syndromes are characterized by loss-of-function mutations in tumor suppressor genes[29,30]. A genetic predisposition to longer telomere length is also a suspected risk factor contributing to the incidence of childhood neuroblastoma and ependymoma[32]. Exposure to ionizing radiation is the only established environmental risk factor for brain tumors[30,33,34]. Ionizing radiation has carcinogenic effects especially in children, owing to their longer life expectancy and their increased radiosensitivity[34]. A meta-analysis showed that even lower levels of ionizing radiation exposure (such as that from X-ray) may cause an excess risk for childhood brain and CNS tumors[35]. The accessibility of medical resources, such as CT and MRI enhance the diagnostic capabilities, which play an important role in the burden of brain and CNS tumors[36]. In addition to the aforementioned factors, demographic differences and number of cancer registries may be associated with these variations.

In contrast to children and adolescents, the predominant category of brain and CNS tumors in adults are gliomas, which include tumors composed of astrocytes, oligodendrocytes, and ependymal cells[8,12,13,37,38].

Our study indicated that astrocytic tumors were the most frequently diagnosed types of brain and CNS tumors in the majority of countries in the world, and it was more common in men than in women. A study conducted in the United States also showed that sex differences are greatest, especially in adults aged ≥45 years, with incidence rates had 30% lower in women than in men[37]. Exposure to endogenous hormones during one's lifetime between sexes has been proposed as a potential explanation for this differential risk[30]. Geographic disparities in the incidence of brain and CNS tumors have also been documented. In countries with relatively high socio-economic status, astrocytoma was the predominant subtype. In the United States, glioblastoma, diffuse and anaplastic astrocytoma, and unique astrocytoma variants accounted for nearly 70% of malignant brain and CNS tumors in adults[37]. Similarly, in South Korea, glioblastomas, unspecified malignant gliomas and diffuse and anaplastic astrocytoma were the top three categories of brain and CNS tumors[13]. In China, glioblastoma, the most malignant neuroepithelial tumor, constituted 30.5% of brain and CNS tumors cases, followed by diffuse and anaplastic astrocytoma, which accounted for 25.1% of cases[11]. However, in country level, the highest proportions of meningeal tumors were found in Uganda and China. These regional disparities may be driven by variations in diagnose and medical treatment levels, distribution of cancer registries, and demographic difference[30,31]. In Sub-Saharan Africa, limited health resources, including the diagnostic capabilities and access to medical care, have resulted in biased estimates of brain and CNS tumor incidence[39]. The limited number of cancer registries and poor diagnostic practices in these countries may have contributed to the observed differences. Similar to children and adolescents, exposure to ionizing radiation was the only established risk factor for brain and CNS tumors in adults[34]. In contrast, hereditary factors accounted for only a small proportion of the cases[40].

The strength of this study is that we provided a comprehensive assessment of brain and CNS tumors by histological subtypes, utilizing high-quality data from the updated CI5 database. To our knowledge, this is the first study to report the epidemiological patterns of histological subtypes of brain and CNS tumors on a global scale, which will provide valuable information for the prevention and control of brain and CNS tumors. However, this study had several limitations. First, we reallocated the unspecified cases of brain and CNS tumors into nine specific histological types. However, the proportion of unspecified cases among different world regions may lead to misclassification of the subtypes. Therefore, more precise morphological data is required. Second, the CI5 database used for calculated the histological proportion of brain and CNS tumors had a certain lag. However, this is the data that we could obtain high-quality cancer surveillance data with the histological subtypes up to now. Although the incidence of brain and CNS tumors by histological types had slightly change during 2003 to 2017, the proportion of histological types remains relative stable during the period. Third, although cancer registries have been widely established globally, many countries, still lack high-quality cancer registry data, especially in less developed regions. For countries without available data on the proportions of brain and CNS tumors histological subtypes, we estimated the burden of brain and CNS tumors by subtypes based on regional information, which may narrow the discrepancy across these countries. Third, we could not classify brain and CNS tumors into more detailed subtypes owing to the lack of individual morphological data. Distinct types, however, with varying clinical characteristics, treatments, and prognose, further effort are needed to report more systematic data on brain and CNS tumors. Fourth, due to the scarcity of continuous surveillance data, we only included 28 countries in trend analysis, and most of countries tend to be high-income countries. It indicated that the need for more accurate morphological data especially in low-and middle-income countries.

Conclusion

This study provides an in-depth understanding of the current patterns of brain and CNS subtypes in children and adults worldwide. Our research findings indicate that the four most common types of brain and CNS tumors are astrocytic tumors, meningeal tumors, gliomas of uncertain origin, oligodendroglia tumors and mixed gliomas. The ASIR varies significantly worldwide, with distinct regional patterns between children and adolescents. These variations may be attributed to factors such as genetic susceptibility, environmental exposures (such as radiation and infections), diagnostic capabilities, and socioeconomic conditions. Comparable statistics data on incidence rate of cancer are crucial to establish a comprehensive epidemiological profile. Expanding cancer surveillance to regions currently underrepresented is crucial for developing effective cancer control and prevention strategies.

DECLARATIONS

Acknowledgements

Not applicable.

Conflict of interest statement

All authors declare no competing interests.

Availability of data and materials

All the data used in this study were obtained from a public database. Cancer data are available online at https://gco.iarc.fr/today/. Another request for the full dataset is available from the corresponding author.

Competing interests

The authors declare that they have no conflict of interest.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Provenance and peer review

Not commissioned, externally peer-reviewed

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Figure legends

Fig. 1 Global patterns of brain and CNS tumors by age, sex, and subtype. (A) Age-specific incidence rate of brain and CNS tumors by sex in 2022; (B) Percentage brain and CNS tumors cases of total cancer cases in 2022 by sex and age group.

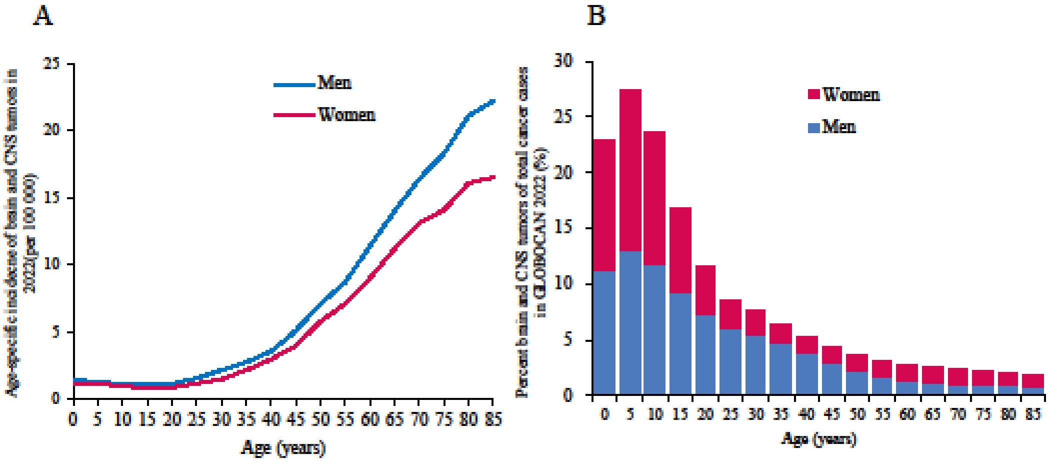

Fig. 2 Estimated distribution of incident cases of brain and CNS tumors subtypes in 14 world areas in 2022, by sex for adults and children. A, Children and adolescents in boys aged 0–19 years; B, Children and adolescents in girls aged 0–19 years; C, Adults in men aged 20 and above; D,

Adults in women aged 20 years and above.

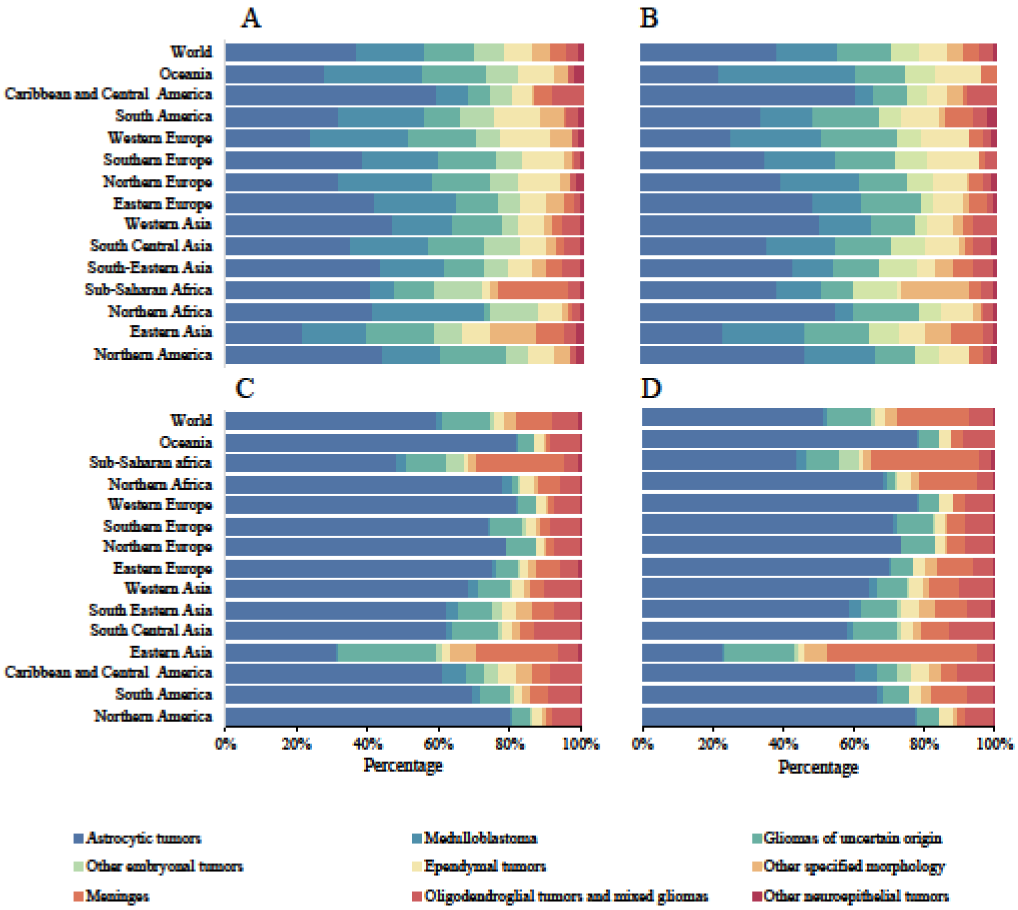

Fig. 3 Age-standardized incident of brain and CNS tumors by histological subtypes in 14 world areas in 2022, by sex for children and adolescents aged 0–19 years.

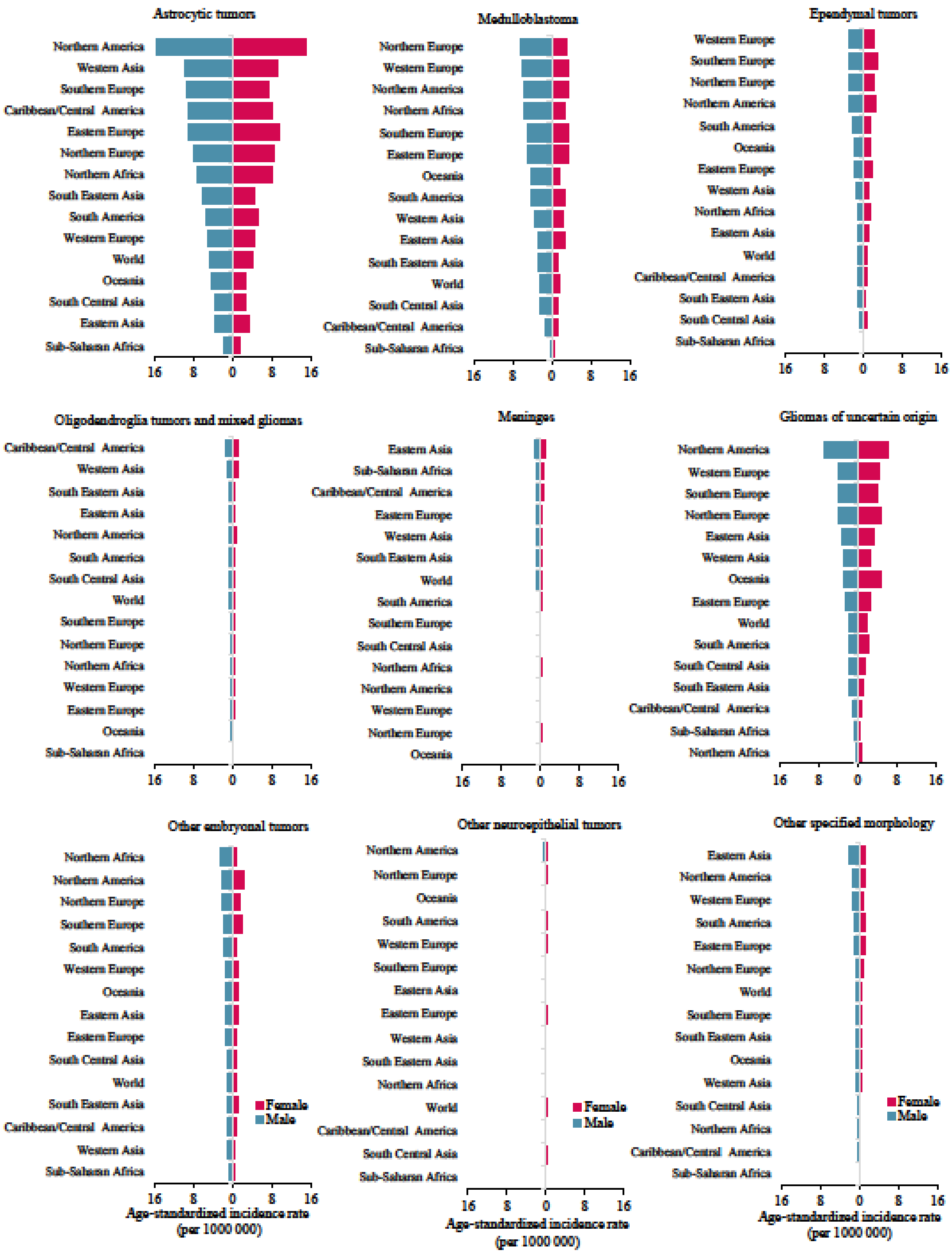

Fig. 4 Age-standardized incident of brain and CNS tumors by histological subtypes in 14 world areas in 2022, by sex for adults aged 20 years and above.

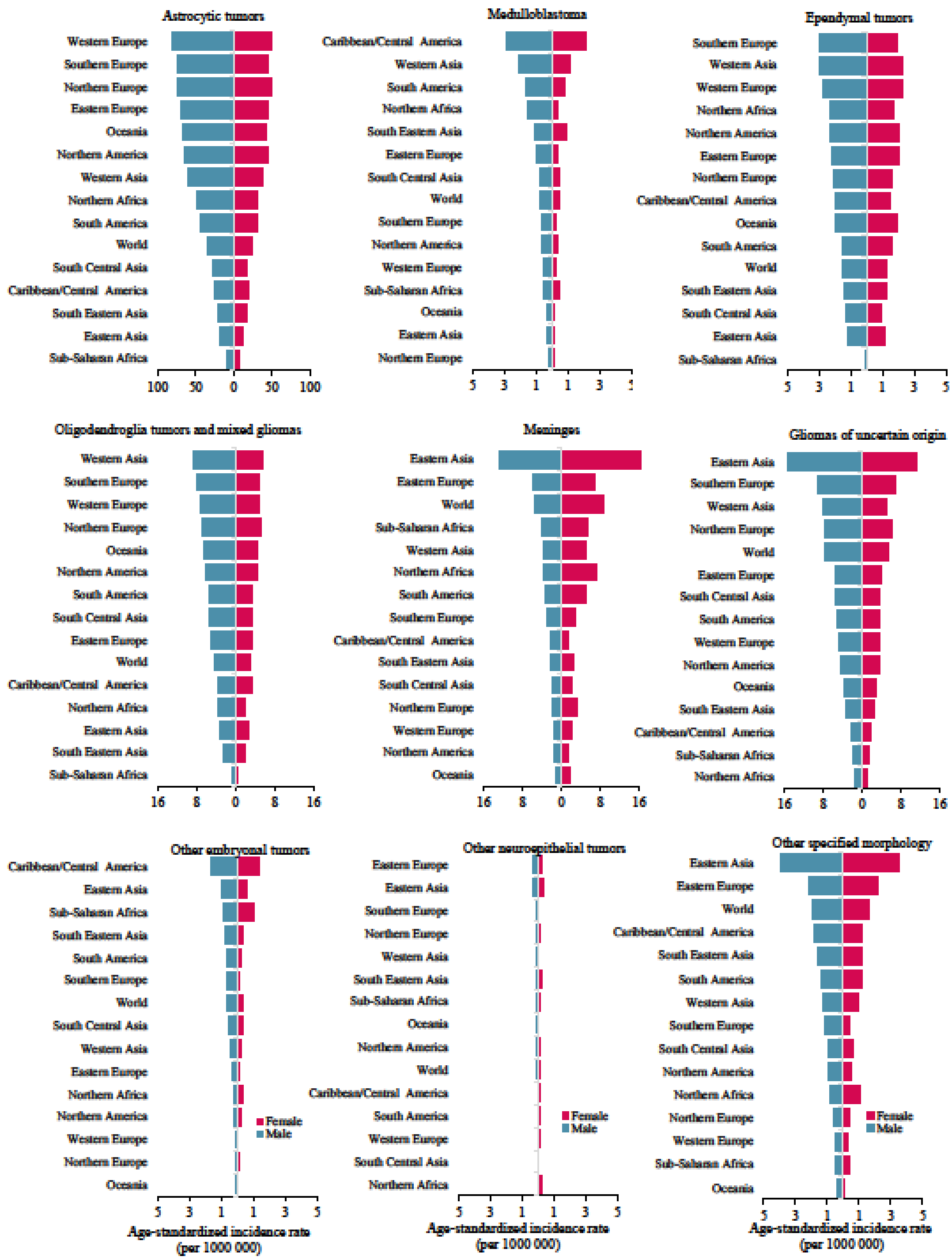

Fig. 5 The average annual percent change (AAPC) for age-standardized incident of brain and CNS tumors from 2003 to 2017 by country, both sexes. Notes: A. both sexes; B. male; C. female; D. age 0-19 years; E. age 20-49 year; F. age≥50 years; G. astrocytic tumors; H. meninges tumors; I. Oligodendroglia tumors/mixed gliomas. Red bars represent countries with a statistically

significant increasing trend (AAPC > 0, p < 0.05). Light red bars represent countries with an increasing trend that is not statistically significant (AAPC > 0, $P \geq 0.05$). Dark blue bars represent countries with a statistically significant decreasing trend (AAPC < 0, $P < 0.05$). Light blue bars represent the countries with a decreasing trend that is not statistically significant (AAPC < 0, $P \geq 0.05$). AAPC: average annual percent change (%).

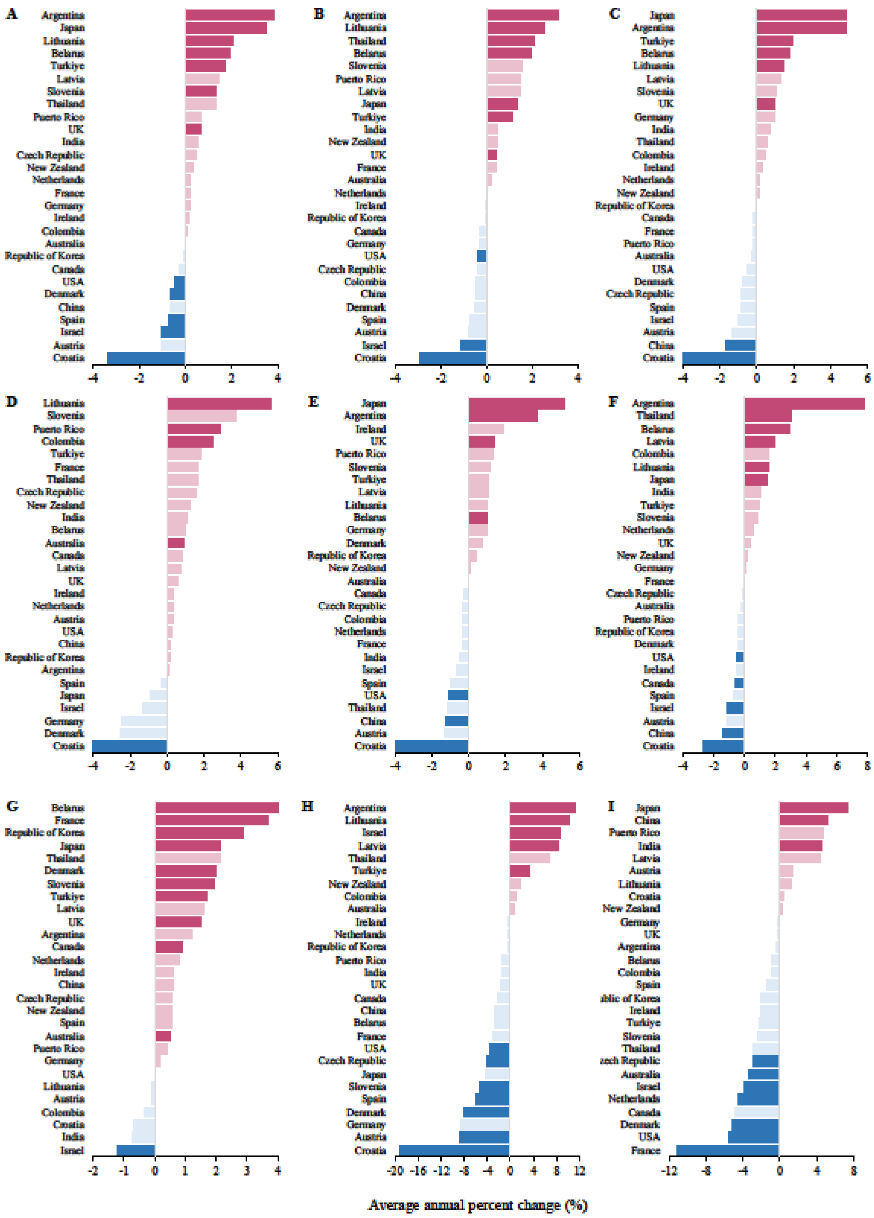

Table 1. Age-standardized incidence rates (per million) of brain and CNS tumors by subtypes, sex and region in 2022

	Meningeal tumors	Astrocytic tumors	oligodendroglia tumors/mixed gliomas	Ependymal tumors	Gliomas of uncertain origin	Medullo-blastoma	Other embryonal tumors	Other neuroepithelial tumors	Other specified morphology
Men									
World	3.50 (3.44–3.55)	21.87 (21.73–22.01)	2.83 (2.79–2.88)	1.29 (1.26–1.33)	5.38 (5.31–5.45)	1.47 (1.43–1.51)	0.85 (0.82–0.88)	0.12 (0.11–0.13)	1.39 (1.36–1.43)
Very high	1.73 (1.66–1.81)	38.63 (38.25–39.01)	3.86 (3.74–3.98)	2.23 (2.12–2.34)	4.98 (4.83–5.14)	2.50 (2.36–2.63)	0.83 (0.75–0.91)	0.16 (0.13–0.19)	1.19 (1.11–1.27)
High	6.26 (6.14–6.38)	17.86 (17.65–18.07)	2.46 (2.38–2.54)	1.39 (1.33–1.46)	7.75 (7.62–7.89)	1.81 (1.72–1.89)	1.17 (1.11–1.23)	0.19 (0.17–0.21)	2.48 (2.40–2.56)
Medium	1.21 (1.15–1.28)	15.56 (15.33–15.80)	2.84 (2.74–2.94)	0.91 (0.85–0.97)	3.76 (3.64–3.88)	1.33 (1.26–1.40)	0.74 (0.69–0.79)	0.04 (0.03–0.05)	0.55 (0.51–0.60)
Low	2.38 (2.22–2.54)	8.91 (8.61–9.22)	1.36 (1.24–1.47)	0.45 (0.38–0.51)	2.10 (1.95–2.25)	0.77 (0.68–0.86)	0.74 (0.65–0.83)	0.04 (0.02–0.06)	0.38 (0.32–0.44)
Children (0–19 years)	0.56 (0.54–0.57)	4.72 (4.67–4.77)	0.48 (0.47–0.50)	0.97 (0.95–0.99)	1.83 (1.80–1.86)	2.50 (2.46–2.53)	1.10 (1.08–1.13)	0.10 (0.09–0.10)	0.67 (0.65–0.68)
Adults (≥20 years)	5.46 (5.40–5.51)	33.30 (33.17–33.43)	4.40 (4.35–4.45)	1.51 (1.48–1.53)	7.75 (7.69–7.82)	0.78 (0.76–0.80)	0.68 (0.66–0.70)	0.14 (0.13–0.14)	1.88 (1.85–1.91)
South Central Asia	1.15 (1.08–1.21)	17.27 (17.01–17.52)	3.42 (3.30–3.53)	1.06 (0.99–1.12)	3.90 (3.78–4.02)	1.39 (1.31–1.46)	0.74 (0.69–0.80)	0.04 (0.03–0.05)	0.66 (0.61–0.71)
South-Eastern Asia	1.49 (1.36–1.62)	15.22 (14.81–15.64)	1.71 (1.57–1.84)	1.21 (1.10–1.33)	2.64 (2.46–2.81)	1.68 (1.53–1.82)	0.89 (0.79–0.99)	0.07 (0.04–0.09)	1.19 (1.07–1.31)
Eastern Asia	8.18	11.77	2.14	1.20	10.47	1.30	1.08	0.27	3.19

	(8.01–8.35)	(11.56–11.99)	(2.05–2.23)	(1.11–1.28)	(10.27–10.67)	(1.20–1.40)	(1.00–1.16)	(0.24–0.31)	(3.07–3.32)
Western Asia	2.42	39.57	5.57	2.33	5.98	2.69	0.61	0.11	0.98
	(2.16–2.69)	(38.50–40.65)	(5.17–5.98)	(2.07–2.59)	(5.56–6.40)	(2.41–2.97)	(0.47–0.74)	(0.05–0.17)	(0.81–1.15)
Southern Europe	1.74	48.56	4.95	2.86	7.10	2.42	1.12	0.14	0.91
	(1.49–1.99)	(47.17–49.95)	(4.53–5.37)	(2.43–3.29)	(6.50–7.71)	(1.92–2.91)	(0.81–1.42)	(0.04–0.24)	(0.69–1.12)
Western Europe	0.96	50.25	4.52	2.79	4.41	2.64	0.61	0.09	0.88
	(0.80–1.12)	(49.04–51.47)	(4.16–4.88)	(2.43–3.15)	(3.97–4.85)	(2.21–3.07)	(0.40–0.82)	(0.01–0.16)	(0.66–1.11)
Eastern Europe	3.81	44.62	3.05	1.94	4.37	2.56	0.67	0.21	1.77
	(3.52–4.09)	(43.62–45.62)	(2.80–3.30)	(1.70–2.18)	(4.04–4.71)	(2.24–2.89)	(0.51–0.84)	(0.14–0.28)	(1.55–1.99)
Northern Europe	1.04	47.58	4.35	2.40	6.28	2.64	0.86	0.18	0.63
	(0.81–1.27)	(45.94–49.22)	(3.86–4.83)	(1.94–2.85)	(5.61–6.94)	(2.07–3.21)	(0.54–1.19)	(0.04–0.31)	(0.40–0.87)
Caribbean and Central	1.55	18.74	2.64	1.55	1.69	2.29	1.34		1.15
America	(1.32–1.79)	(17.93–19.54)	(2.34–2.95)	(1.32–1.78)	(1.45–1.93)	(2.01–2.57)	(1.12–1.56)	–	(0.95–1.35)
Northern America	0.89	45.02	3.95	2.47	5.26	2.66	0.95	0.25	1.15
	(0.77–1.01)	(44.12–45.91)	(3.70–4.20)	(2.23–2.71)	(4.90–5.62)	(2.37–2.95)	(0.78–1.13)	(0.16–0.33)	(0.98–1.32)
South America	1.99	28.15	3.45	1.77	3.83	2.62	1.08	0.09	1.28
	(1.82–2.17)	(27.48–28.81)	(3.22–3.69)	(1.58–1.95)	(3.57–4.08)	(2.38–2.85)	(0.93–1.23)	(0.04–0.13)	(1.13–1.43)
Northern Africa	2.23	31.49	2.25	1.86	0.91	3.14	1.10	0.06	0.58
	(1.95–2.51)	(30.46–32.53)	(1.98–2.53)	(1.62–2.11)	(0.73–1.08)	(2.83–3.45)	(0.92–1.28)	(0.01–0.10)	(0.44–0.72)
Sub-Saharan Africa	2.86	5.85	0.51	0.11	1.38	0.41	0.76	0.04	0.31
	(2.67–3.06)	(5.57–6.13)	(0.43–0.59)	(0.08–0.14)	(1.25–1.51)	(0.35–0.48)	(0.66–0.85)	(0.02–0.06)	(0.25–0.37)
Oceania	0.66	41.60	4.08	1.86	3.35	1.92	0.60	0.19	0.45
	(0.36–0.96)	(39.15–44.05)	(3.31–4.84)	(1.29–2.43)	(2.59–4.11)	(1.27–2.58)	(0.24–0.97)	(0.00–0.38)	(0.16–0.73)
Women									
World	5.56	15.26	2.00	1.13	4.02	0.96	0.61	0.11	1.13
	(5.50–5.63)	(15.15–15.38)	(1.96–2.04)	(1.09–1.16)	(3.96–4.08)	(0.93–1.00)	(0.59–0.64)	(0.10–0.12)	(1.10–1.16)

Very high	2.29 (2.20–2.38)	26.62 (26.29–26.94)	2.73 (2.63–2.83)	1.98 (1.87–2.08)	4.25 (4.10–4.40)	1.55 (1.44–1.66)	0.72 (0.64–0.79)	0.12 (0.10–0.15)	0.98 (0.91–1.06)
High	10.83 (10.68–10.98)	13.52 (13.34–13.70)	1.84 (1.78–1.91)	1.27 (1.21–1.33)	5.76 (5.64–5.88)	1.32 (1.24–1.39)	0.79 (0.73–0.84)	0.18 (0.16–0.21)	2.03 (1.96–2.10)
Medium	1.60 (1.53–1.68)	9.78 (9.60–9.97)	1.88 (1.80–1.96)	0.75 (0.69–0.80)	2.62 (2.53–2.72)	0.82 (0.76–0.87)	0.55 (0.50–0.59)	0.05 (0.04–0.07)	0.41 (0.37–0.45)
Low	2.33 (2.18–2.48)	6.85 (6.59–7.10)	0.94 (0.84–1.03)	0.32 (0.26–0.37)	1.57 (1.45–1.69)	0.57 (0.49–0.64)	0.68 (0.60–0.76)	0.02 (0.01–0.04)	0.30 (0.25–0.36)
Children (0–19 years)	0.50 (0.48–0.51)	4.17 (4.13–4.22)	0.43 (0.41–0.44)	0.85 (0.83–0.87)	1.81 (1.78–1.84)	1.63 (1.61–1.66)	0.88 (0.86–0.90)	0.07 (0.07–0.08)	0.48 (0.47–0.50)
Adults (≥20 years)	8.94 (8.88–9.01)	22.66 (22.55–22.76)	3.05 (3.01–3.09)	1.31 (1.29–1.34)	5.50 (5.44–5.55)	0.52 (0.50–0.53)	0.44 (0.42–0.45)	0.14 (0.13–0.15)	1.56 (1.53–1.59)
South Central Asia	1.38 (1.31–1.46)	10.62 (10.42–10.82)	2.23 (2.14–2.32)	0.83 (0.77–0.89)	2.68 (2.58–2.79)	0.80 (0.74–0.86)	0.49 (0.44–0.53)	0.05 (0.04–0.07)	0.41 (0.37–0.45)
South-Eastern Asia	1.68 (1.54–1.81)	11.27 (10.92–11.61)	1.37 (1.25–1.49)	1.01 (0.91–1.12)	2.09 (1.94–2.24)	1.12 (1.00–1.23)	0.67 (0.58–0.77)	0.11 (0.08–0.14)	0.95 (0.85–1.05)
Eastern Asia	14.64 (14.42–14.87)	8.94 (8.75–9.14)	1.65 (1.57–1.73)	1.15 (1.07–1.23)	7.98 (7.80–8.17)	1.20 (1.10–1.31)	0.87 (0.79–0.95)	0.17 (0.15–0.20)	2.62 (2.51–2.73)
Western Asia	3.21 (2.91–3.52)	25.57 (24.71–26.42)	3.73 (3.40–4.05)	1.90 (1.66–2.13)	4.02 (3.68–4.36)	1.64 (1.42–1.86)	0.37 (0.26–0.48)	0.02 (0.00–0.05)	0.81 (0.66–0.97)
Southern Europe	1.78 (1.55–2.02)	29.83 (28.73–30.93)	3.17 (2.82–3.51)	2.35 (1.91–2.78)	5.72 (5.14–6.30)	1.60 (1.17–2.02)	0.84 (0.53–1.15)	0.02 (0.00–0.05)	0.35 (0.21–0.49)
Western Europe	1.29	31.27	3.06	2.29	3.88	1.60	0.49	0.13	0.43

	(1.11–1.48)	(30.30–32.23)	(2.76–3.36)	(1.96–2.62)	(3.44–4.32)	(1.26–1.95)	(0.29–0.68)	(0.05–0.22)	(0.27–0.59)
Eastern Europe	4.19	31.25	2.19	1.88	3.42	1.57	0.34	0.15	1.74
	(3.92–4.47)	(30.43–32.07)	(1.98–2.39)	(1.65–2.12)	(3.11–3.73)	(1.30–1.83)	(0.21–0.46)	(0.09–0.22)	(1.53–1.95)
Northern Europe	2.10	32.47	3.28	1.80	5.67	1.27	0.71	0.11	0.59
	(1.77–2.44)	(31.07–33.86)	(2.85–3.70)	(1.40–2.19)	(5.01–6.34)	(0.87–1.67)	(0.41–1.01)	(0.00–0.22)	(0.35–0.82)
Caribbean and Central America	1.15	15.00	2.36	1.22	1.41	1.80	1.10	0.06	0.76
	(0.95–1.34)	(14.31–15.70)	(2.08–2.63)	(1.02–1.42)	(1.20–1.62)	(1.56–2.05)	(0.91–1.29)	(0.02–0.10)	(0.60–0.91)
Northern America	0.95	32.32	2.94	2.31	4.77	1.66	1.05	0.18	0.82
	(0.82–1.07)	(31.54–33.10)	(2.72–3.17)	(2.07–2.55)	(4.41–5.12)	(1.42–1.89)	(0.86–1.23)	(0.10–0.26)	(0.67–0.97)
South America	3.17	20.93	2.25	1.59	3.00	1.61	0.47	0.21	1.16
	(2.96–3.38)	(20.38–21.49)	(2.07–2.43)	(1.42–1.77)	(2.77–3.23)	(1.42–1.80)	(0.37–0.58)	(0.14–0.28)	(1.02–1.31)
Northern Africa	4.59	21.56	1.28	1.55	0.93	1.38	0.54	0.11	0.71
	(4.21–4.98)	(20.74–22.39)	(1.08–1.48)	(1.33–1.77)	(0.76–1.10)	(1.18–1.59)	(0.41–0.67)	(0.05–0.17)	(0.56–0.86)
Sub-Saharan Africa	3.54	5.20	0.42	0.09	1.16	0.46	0.79	0.08	0.31
	(3.34–3.74)	(4.96–5.44)	(0.35–0.48)	(0.06–0.12)	(1.05–1.27)	(0.39–0.52)	(0.70–0.87)	(0.05–0.11)	(0.25–0.36)
Oceania	1.08	26.14	2.75	1.77	3.68	0.82	0.45		0.24
	(0.69–1.46)	(24.21–28.07)	(2.13–3.36)	(1.21–2.33)	(2.84–4.52)	(0.38–1.25)	(0.12–0.79)	−	(0.00–0.48)

ASIR, Age-standardized incidence rate was calculated by world Segi's world standard population;
−data was less than 0.01 per 1000 000 population

Supplementary Material: http://links.lww.com/JS9/G367

Highlights

• This study comprehensively and systematically assessment on the global burden of brain and CNS tumors by histological subtype.

• The most common histological type of brain and CNS tumors was glioma, including glioblastoma, astrocytoma, oligodendroglioma, ependymoma, oligoastrocytoma.

• Considerable variations in subtype proportions and ASIR were observed across countries and HDI levels. The findings enhance our understanding of the epidemiology of brain tumors and underscore the need for tailored prevention and resource allocation strategies at national levels.