

# Epidemiologic profile of pediatric brain tumors in Morocco

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## Abstract

**Introduction** Brain tumors are the most common solid tumors diagnosed among children below 15 years worldwide. However, little is known about the profile of pediatric brain tumors in Africa. The purpose of this study was to

further elaborate the epidemiological profile of pediatric brain tumors in Africa, specifically Morocco.

**Methods** A retrospective review was conducted of all patients with primary brain tumors in the age group 0–19 years, from 2003 to 2007, from multiple centers in two cities of Rabat and Casablanca, Morocco. Only patients with histopathological confirmation were included ( $n=542$ ). Descriptive epidemiologic profiles were created for the patients by age, sex, and histological subtypes of brain tumors.

**Results** Overall medulloblastoma was the most common brain tumor (34.5%), followed by pilocytic astrocytoma (17.3%) and diffuse astrocytoma grade 2 (12.5%). Brain tumors occurred most commonly in 5–9-year age group followed by 10–14-year age group with the former being more common among males and the latter being more common among females. We also found medulloblastoma to be the most common brain tumor in the 0–14-year-olds. **Conclusions** In this rare study focused on pediatric brain tumors in Morocco, most of the findings were consistent with past studies from other parts of the world. However, we found medulloblastoma to be the most common pediatric brain tumor followed by astrocytoma.

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## Introduction

Each year, 30,000–40,000 children worldwide are diagnosed with brain tumors, the most common solid tumors diagnosed in children under the age of 15 years both in developed and developing countries [1, 3–6, 12]. Malignant brain tumors cause most deaths among children and are the

second most common pediatric cancers after leukemia [2, 10]. In Africa, including Morocco, there is a paucity of descriptive cancer data especially on pediatric brain tumors. The International Agency for Research on Cancer (IARC) has been the main source of the limited brain tumor data from Africa. However, data reported by IARC is classified under the general category of “CNS and miscellaneous intracranial and intraspinal neoplasms,” without differentiation by histopathological types [16]. It is hypothesized that in Africa, as in developed countries, the most common pediatric brain tumors are astrocytomas and medulloblastomas [2, 11, 13]. However, data on demographic and histopathological distribution of pediatric brain tumors is lacking.

Therefore, we conducted this study to characterize the demographic and histopathological types of brain cancers among Moroccan children. The study included a thorough review of all pediatric brain tumors at nine major hospitals and clinics in Morocco.

## Methods

We reviewed the charts of all patients aged 0–19 years who had been diagnosed with primary brain tumors in Casablanca and Rabat, Morocco between January 2003 and December 2007. We identified cases from the nine major primary and secondary treatment facilities in the public and private sectors. We included public pediatric oncology, neuropathology, and radiotherapy departments, as well as private neurosurgery, radiotherapy, and pediatric oncology practices, located in Casablanca and Rabat, the two largest cities of Morocco. These centers represented the primary and most of the secondary treatment centers within Casablanca and Rabat. In Casablanca, cases were obtained from the Department of Pathology of the Centre Hospitalier Universitaire Ibn Rochd, the city’s only public hospital with a neurosurgery department; from the Department of Pediatric Hematology/Oncology at Hôpital du 20 Août 1953; and from a private pediatric hematology/oncology office. In Rabat, cases were obtained from the Department of Pathology of the Hôpital des Spécialités, which includes the city’s primary public neurosurgery department; the Department of Pediatric Hematology and Oncology of Rabat Children’s Hospital; the National Institute of Oncology; private neurosurgeons; a private radiation oncology center; and the primary private neuropathologist specializing in neuropathology.

Cases were cross-referenced to ensure that patients treated at more than one medical facility were included only once in our study. For each case, we obtained the following data from the institutional databases: age at diagnosis, sex, and tumor classification. Secondary tumors,

metastases, cysts, and vascular malformations were excluded. In addition, we excluded cases that lacked histopathological confirmation of the diagnosis. All histopathological diagnoses had been made according to the 2007 World Health Organization (WHO) classification system [17]. This study was reviewed and approved by the University of Michigan Institutional Review Board and did not require approval by the Institutional Review Boards in Morocco because of its retrospective record review design.

## Results

We reviewed a total of 647 charts and identified 542 patients who were eligible for our study. Of these, 281 (51.8%) were males, and 261 (48.2%) were females. Patient age ranged from 0 to 19 years, with a mean age of 9.3 years. Three hundred fifty-four patients (65.3%) had been diagnosed in Rabat and 188 (34.7%) in Casablanca. The sources of patients’ records were as follows: pathologists, 306 patients (56.5%); other sources, 236 patients (43.5%) with the majority (441 patients, 81.4%) being obtained from public institutions while the rest (101 patients, 18.6%) being obtained from private institutions.

Table 1 presents the clinical and demographic characteristics of the 542 patients included in our study. Medulloblastoma was the most common brain tumor in patients included in the study (34.5%), followed by pilocytic astrocytoma (17.3%), diffuse astrocytoma grade 2 (12.5%), ependymoma grade 2 (7.9%), and craniopharyngioma (6.6%). We also found that medulloblastoma, glioblastoma, anaplastic astrocytoma grade 3, oligodendroglioma, and ganglioma were more common among males than females.

The histological tumor types were grouped according to the WHO standard age-at-diagnosis groups (1–4, 5–9, 10–14, and 15–19 years), with one exception of dividing the 0–4 age group into 2 groups (0–2 and 3–4 years). We evaluated cases by sex and age and found that overall, brain tumors were most common in patients aged 5–9 (30.4%) and 10–14 years (25.3%; Table 2). We then evaluated males and females separately and found that, in males, brain tumors were most common in patients aged 10–14 years (30.2%), whereas in females, they were most common in patients aged 5–9 years (36.8%). Tumors in the age group of 0–2 represented 9.4% of tumors while the tumors of the age group 3–4 years constituted 14.4% of tumors (Table 2).

Table 3 shows histological tumor types classified by age groups. As shown, medulloblastoma was the most common histological type in patients aged 0–2, 3–4, 5–9, and 10–14 years. Pilocytic astrocytoma (grade 1) was the most common histological type in patients aged 15–19 and the second most common tumor type in patients aged 0–2 and 5–9 years. The second most common histological

**Table 1** Number of patients, mean age, and sex ratio for each histological pediatric brain tumor type, Morocco, Africa

Histopathological diagnosis	No. of patients (%)	Mean age (years)	Sex ratio (M:F)
Medulloblastoma	157 (28.9)	8	1.2
Pilocytic astrocytoma (I)	94 (17.3)	10	1
Low grade astrocytoma (II)	68 (12.5)	10.4	0.9
Ependymoma (II)	41 (7.6)	8.3	0.8
Craniopharyngioma	36 (6.6)	11	0.9
Glioblastoma	30 (5.5)	9.9	1.5
Anaplastic ependymoma (III)	20 (3.7)	9.3	0.9
Meningioma (I)	12 (2.2)	13.2	0.7
Anaplastic astrocytoma (III)	10 (1.8)	11.6	2.3
Oligodendroglioma	9 (1.7)	9.6	3.5
Ganglioglioma	7(1.3)	11.8	4
Germinoma	5 (0.9)	12.6	0.25
Neuroblastoma	5 (0.9)	8.4	0.25
Ependymblastoma	4 (0.7)	10	3
Pineoblastoma	4 (0.7)	9	3
Other	40(7.4)	–	–
Total	542 (100)	10.1	1.4

type in patients aged 3–4 was ependymoma, while in the age group of 10–14, it was diffuse astrocytoma (grade 2). Medulloblastoma was the second most common type in patients 15–19 years old. Ependymoma was the third most common tumor type in patients aged 0–2 years, while diffuse astrocytomas was the third most common tumor type in patients 5–9 and 15–19 years old. The third most common histological type in patients in the age group of 10–14 years was pilocytic astrocytoma (grade 1). The largest variation in histopathological tumor types was seen in patients aged 10–14 years, and the smallest variation was seen in patients aged 0–4 years.

## Discussion

In this study, we examined the histopathological and demographic data of 542 pediatric patients with brain tumors treated at nine treatment facilities located in Casablanca and Rabat, Morocco, over a 5-year period. Several other groups previously examined the epidemiologic profile of brain tumors among children living in

different geographic regions—in Korea (Cho et al.), Iran (Mehrazin and Yavari), Brazil (Rosemberg and Fujiwara), and worldwide (Stiller and Nectoux). However, according to our knowledge, our study is one of the first studies to examine the epidemiologic profile of brain tumors specifically among children in Africa. Consistent with findings of other published studies on pediatric brain tumors [4, 7, 14, 15, 18, 22], we found that medulloblastoma was the most common type of pediatric brain tumor in Morocco, followed by pilocytic astrocytomas (grade 1) and diffuse astrocytomas (grade 2). We also found that ependymoma was the fourth most common histological tumor type in all age groups and that craniopharyngeal tumors were the fifth most common tumor type in all age groups. Many studies, including a meta-analysis of 16 studies from around the world, performed by Rickert and Paulus [22], found that astrocytoma followed by medulloblastoma, ependymoma, and craniopharyngioma in descending order of incidence were the most common types of brain tumors during childhood and adolescence [7, 18, 21]. Rickert and Paulus [22] also reported a fifth common tumor type, germ cell tumors, which was not as common in our study.

**Table 2** Age and gender distribution of pediatric brain tumors, Morocco, Africa

Age group (years)	n (%)		
	Male (n=272)	Female (n=270)	Total (n=542)
0–2	25 (9.2)	26 (9.6)	51 (9.4)
3–4	42 (15.4)	36 (13.3)	78 (14.4)
5–9	69 (25.4)	96 (35.6)	165 (30.4)
10–14	85 (31.3)	52 (19.3)	137 (25.3)
15–19	51 (18.8)	60 (22.2)	111 (20.5)

**Table 3** Histopathological classification of pediatric brain tumors by age group, Morocco, Africa

Histological types by age group, <i>n</i> (%)	0–2years		3–4years		5–9years		10–14years		15–19years	
	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)	<i>n</i>	(%)
Medulloblastoma	14	(27.4)	24	(30.8)	66	(40.0)	39	(28.5)	28	(25.2)
Pilocytic astrocytoma	10	(19.6)	9	(11.5)	29	(17.6)	22	(16.1)	14	(12.6)
Ependymoma grade 2	7	(13.7)	8	(10.3)	24	(14.5)	19	(13.9)	14	(12.6)
Craniopharyngioma	3	(5.9)	7	(8.9)	9	(6.1)	12	(8.8)	10	(9.0)
Low grade astrocytoma	3	(5.9)	5	(6.4)	9	(5.5)	9	(6.6)	10	(9.0)
Glioblastoma	2	(3.9)	3	(3.8)	7	(4.2)	7	(5.1)	9	(8.1)
Anaplastic ependymoma	1	(1.9)	3	(3.8)	5	(3)	4	(2.9)	6	(5.4)
Anaplastic astrocytoma	1	(1.9)	2	(2.6)	2	(1.2)	3	(2.2)	4	(3.6)
Meningioma	1	(1.9)	2	(2.6)	2	(1.2)	3	(2.2)	2	(1.8)
Oligodendroglioma	1	(1.9)	1	(1.3)	1	(0.6)	3	(2.2)	2	(1.8)
Neuroblastoma	1	(1.9)	1	(1.3)	1	(0.6)	2	(1.5)	2	(1.8)
Other	7	(13.7)	11	(14.1)	9	(6.1)	2	(1.5)	8	(7.2)

Consistent with the findings of other international pediatric brain tumor studies [8, 9, 15, 18, 21, 22, 23, 24], we found a slightly higher proportion of brain tumors in male than in female patients. In our study, we found that the mean age at diagnosis was 9.3 years, which was similar to the mean age at diagnosis reported in Korea [7] and Iran [18] (7.8 and 8.8 years, for the two countries, respectively). However, we cannot directly compare our findings to the findings of these two studies because we used different age groups. The studies from Korea and Iran included patients whose age was 15 years old and younger, while our study included patients who were 19 years old and younger at diagnosis. We also found differences in peak tumor occurrence for age groups between this study and previously published studies from other countries. We have summarized these findings in Table 4. These differences are possibly more influenced by differences in health organization in the different countries rather than the characteristics of the tumors.

The overall male-to-female ratio in our study was 1.3, indicating that pediatric brain tumors were more common in males than in females, which is consistent with the literature [7, 9, 18, 22, 24]. However, several tumor types were more common in females than in males (sex ratio was <1) including diffuse astrocytomas (grade 2), ependymomas (grade 2), craniopharyngiomas, anaplastic ependymomas (grade 3), meningiomas (grade 1), germinomas, and choroid plexus tumors. Cho et al. [7] reported a male-to-female ratio <1 in oligodendroglial tumors and pituitary adenomas.

In a pediatric cancer frequency study conducted by IARC at Rabat Children’s Hospital, one of the sites included in our analysis, 15 cases of brain and spinal neoplasms were found among 444 (3.4%) pediatric cancer cases from 1983 to 1985 [20]. While this earlier study provided initial insight into pediatric brain tumors in Morocco, the small sample size and lack of histopathological diagnosis from a single institution limited the usefulness of this information to truly understand the pediatric tumor burden in Morocco. Additionally, Amarti et al. [1] conducted a single-institution retrospective analysis of

2,374 cases of brain tumors at Hôpital des Spécialités, another site included in our analysis, from 1988 and 1997. Amarti et al. examined brain tumors in both adult and pediatric patients and as such added further insight regarding pediatric brain tumor profiles. For instance, for pediatric patients, defined in both studies as those aged 0–19 years, we found a similar rate of astrocytomas as they did (29.1% vs 25.3%, respectively), but we found a much higher rate of medulloblastomas (28.3% vs 17.3%, respectively) [3]. The studies by IARC and Amarti et al. had formed the knowledge base of the incidence and characteristics of pediatric brain tumors in Morocco. Our study creates a more comprehensive picture of pediatric brain tumors in Morocco because it is a multi-institutional analysis and includes histopathological analysis, allowing it to provide more information about these childhood cancers than previous studies.

To date, most international pediatric brain tumor studies have been conducted at single institutions [7, 15, 18, 22, 23, 24]. The few multi-institutional pediatric brain tumor studies that have been conducted have all been conducted in developed nations [9, 14, 19]. Therefore, our study is unique in that it is a multi-institutional study conducted in a developing country. Too often institutions, both in developed as well as developing countries, do not communicate with each other about the burden of disease that they encounter. Our study facilitated the collaboration between public and private institutions located in the two largest cities of Morocco. To obtain the most representative findings, we obtained cases from pathology departments (56.5%) and pediatric hematology/oncology and radiation oncology departments (43.5%). Most cases (81.4%) were from public institutions, but some (18.6%) were from private institutions. The ability to examine brain tumors in such a wide variety of settings (i.e., private and public institutions) allowed a more accurate portrayal of the burden of pediatric brain tumors in Morocco and the distribution of care that is received.

Understanding Morocco’s treatment referral pattern is imperative to understanding the burden of pediatric brain tumors and the resources available to manage them.

**Table 4** Comparison of age peaks among pediatric brain tumors in Morocco (this study) and previously published studies from other countries

Age peaks	Sex	Age categories (in years)			
		This study	Cho et al. [7]	Farinotti et al. [9]	Rickert et al. [22]
First peak	Overall	5–9	6–10	5–9	12–14
	Male	10–14	6–10	5–9	3–5
	Female	5–9	6–10	5–9	9–11
Second peak	Overall	10–14	11–15	1–4	3–5
	Male	5–9	0–5	1–4	0–2
	Female	15–19	11–15	10–14	12–14

Casablanca and Rabat both lie in the northern part of the nation and are home to roughly 15% of its total population. Many physicians in Morocco believe that the northern and southern regions are divided in terms of patient referral and places of seeking medical care. Casablanca is referral site for patients in the southern part of the Morocco, while patients who live north of Casablanca are referred to Rabat.

Pediatric brain tumors are primarily treated by neurosurgeons. For many years, Rabat was the only city in the country that offered neurosurgery services. Now, neurosurgeons are found throughout the country, with many of them located in Casablanca, but Rabat still has a strong reputation as the premier/primary center for the treatment of pediatric brain tumors. We think this explains why we were able to obtain more cases from Rabat (354 cases; 65.3%) than from Casablanca (188 cases; 34.7%). Rabat is also home to the National Institute of Oncology, a dedicated governmental treatment facility for cancer located in the nation's capital.

Our study also draws attention to the fact that a working cancer registry is needed to fully understand the epidemiologic distribution of pediatric brain tumors and other cancers. The establishment of such a registry in Morocco would allow for better understanding of the pediatric tumor burden which could also allow for standard diagnostic and treatment protocols to be developed for these cases. A population-based cancer registry was established in Casablanca in 2004, but it is in its early stages of development. In this study, we found a significant number of children and adolescents with pediatric brain tumors who had been treated over a 5-year period. By compiling these data, we will enable public health officials to examine cases from multiple institutions and provide insight into the burden of pediatric brain tumors faced by children in Morocco.

Our study had a few limitations. One limitation was the inability to differentiate tumors by location of patient residence which limited our ability to calculate the incidence rate. The pathologic information was inconsistent across all of the sources, and some data were unobtainable leading to exclusion of some cases that fit our age criteria. Another limitation of this study was the underestimation of cases. Data were collected at all primary and most secondary treatment centers within Casablanca and Rabat. Some cases were treated by private neurosurgeons that we were unable to contact, within Casablanca and Rabat, in addition to those treated by neurosurgeons in other cities around the nation.

Despite these limitations, this study is quite significant as an initial attempt to estimate the burden of pediatric brain tumors treated in the urban areas of Morocco. Very little information exists about the frequency of pediatric brain tumors for the rest of the nation's population mostly because they have limited healthcare access. In summary, our findings support the widely held belief that pediatric

brain tumors have similar histopathological characteristics worldwide with astrocytomas and medulloblastomas being the two most frequently occurring pediatric brain tumors. However, contrary to the literature, we found medulloblastomas to be more common than either pilocytic (grade 1) or diffuse (grade 2) astrocytomas. We believe our results provide more comprehensive preliminary frequency data of pediatric brain tumors in Morocco than what previously existed, allowing for the development of clinical measures to address brain tumors among Moroccan children. Our study also has the potential to trigger further research into the area of pediatric brain tumors in Morocco and other developing countries in Africa and the world.

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**Conflict of interest** The authors declare that they have no commercial or other associations that might pose a conflict of interest in connection with this article.

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