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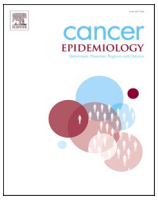

Incidence patterns of childhood cancer in two tertiary hospitals in Ghana from 2015 to 2019: A retrospective observational study

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ABSTRACT

Background: Accurate epidemiological data are vital in estimating the burden of disease in a country. Little is known about the incidence of childhood cancer in Ghana. This study describes the incidence patterns of cancer in children below 14 years and 11 months from 2015 to 2019 at the only two main pediatric cancer referral centers in Ghana: Korle Bu Teaching Hospital (KBTH) and Komfo Anokye Teaching Hospital (KATH).
Method: Data on the incidence of cancer in children below 14 years and 11 months were collected retrospectively between 1st January 2015 and 31st December 2019 from patients' medical folders at KBTH and the cancer registry at the pediatric units of KATH. Descriptive statistics were used to describe the data. Incident rates expressed as age-specific rates (ASRs) per 100,000 person-years using population estimates for age groups and sex in each year, were determined by age groups (0–4, 5–9, 10–14 years and 11 months), sex, region of residence and cancer types based on the International Childhood Cancer Classification, third edition.
Results: The total ASR per 100,000 person-years from 2015 to 2019 was 9.36 based on 1073 cases observed. The ASR increased from 1.6 per 100,000 person-years in 2015–2.41 in 2017, thereafter decreasing to 1.45 in 2019. The ASR was higher in male children (2.10 per 100,000 person-years), children between 0 and 4 years (0.27 per 100,000 person-years), and children living in the Greater Accra region (4.17 per 100,000 person-years). The most prevalent cancers were lymphomas (2.17 per 100,000 person-years) and leukemia (1.88 per 100,000 person-years).
Conclusion: The study provides baseline information on the incidence patterns of childhood cancer from 2015 to 2019, addressing a critical gap in childhood cancer epidemiology in Ghana.

1. Introduction

It is estimated that 80% of childhood cancer cases are found in low- and middle-income countries (LMICs) [1,2]. Despite LMICs being plagued by infectious diseases such as malaria, diarrhea and respiratory tract infections, more deaths result from cancer (approximately 80%) than in developed countries [3]. Ghana, a LMIC, is not an exception. Earlier studies conducted at only two major pediatric oncology units in Ghana that provide complete cancer treatment and care for children below 15 years [4,5], namely Korle Bu (KBTH) and Komfo Anokye (KATH) Teaching Hospitals, have shown an increasing trend in the incidence of childhood cancer Ghana [6–8]. For example, Segbefia and

Abbreviations: ALL, Acute lymphoblastic leukemia; AML, Acute myeloid leukemia; ASR, age-specific rate; CNS, central nervous system; ICCC, International Classification of Childhood Cancer; KATH, Komfo Anokye Teaching Hospital; KBTH, Korle Bu Teaching Hospital; LMICs, low- and middle-income countries; TTH, Tamale Teaching Hospital; USA, United States of America.

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Table 1
Study variables adapted from CanReg5.

	Variables in CanReg5	Variables in data collection tool for the study
Patient details	Name of patient.	Not applicable
	Patient medical ID (identification).	Patients' medical records were numbered consecutively, starting from 1. These numbers did not resemble the unique patient ID on the medical folder.
	Sex.	The sex of the patient was recorded as either male or female. The "Not Available" (NA) was selected when the patient's sex was unavailable in the medical file.
	Date of birth.	The patient's date of birth was recorded in the patient's medical folder. Where the date of birth was absent, "Not available" was selected. The date of birth was used to calculate the patient's age on the date of confirmed diagnosis (incident date). The patients' ages were grouped as follows 0–4 years, 5–9 years and 10–14 years 11 months.
	Address of patient.	A pre-validated drop-down list of the sixteen administrative regions of Ghana, namely Ahafo, Ashanti, Bono East, Brong Ahafo, Central, Eastern, Greater Accra, Northern, North-East, Oti, Savannah, Western, Western North, Volta, Upper East, Upper West and unknown were used. Only the region where the patient resides was recorded during the data collection process.
	Ethnic group.	Not applicable
	Religion.	Not applicable
	Race.	Not applicable
	Occupation.	Not applicable
Tumour details	Diagnosis.	A pre-validated drop-down list of the twelve (12) main diagnostic groups was used to describe the type of tumour diagnosed by the physician in the patient's medical folder.
	Date for a confirmed diagnosis	A pop-up calendar was utilised in selecting the incident date. Rules for documentation of cancer incident dates recommended by the European Network of Cancer Registries [20] were followed
	Most valid basis for diagnosis	The precise type of diagnostic test that the physician used to confirm cancer diagnoses was documented. A pre-validated drop-down list was used. A single or combination of options could be selected. The pre-validated set of answers was as follows: Non-Microscopic: ● Clinical investigation — all diagnostic techniques including x-rays, endoscopy, imaging, exploratory surgery and endoscopy ● Specific tumour markers ● Cytology Microscopic: ● Histology of metastasis ● Histology of primary tumour
	Topography/ Morphology	The data field had a detailed list of morphological and topographical codes to be selected from
	Behaviour	A pre-validated drop-down list was used to select options, namely "Malignant". "Benign", "*In situ*" or "Uncertain".
	Multiple primaries.	Where the patient developed more than one cancer during the study period (multiple primaries), rules developed by the International Agency on Cancer Research on reporting multiple primaries were followed [21].
Treatment outcome	Date of mortality.	The number of children who died from cancer among the entire population was calculated by finding the sum of individual patients who died from the disease in a calendar year.
	Relapse date	A pop-up calendar was utilised in selecting the relapse date (if applicable).
Comorbidities present	Diagnosis other than cancer	The blank data field was utilised to record comorbidities present.

colleagues [6] reported a total of 495 cases at the KBTH from 2008 to 2011 compared to 254 cases reported by Welbeck and Hesse [7] from 1992 to 1995 in the same institution. Paintsil and colleagues [8] also reported an increase in the incidence of childhood cancers from 83 to 113 cases at the KATH from 2012 to 2015. Although childhood cancers constitute less than 5% of all cancers reported at health facilities in Ghana [9], in 2016, cancer was ranked the fourth cause of mortality in children at the KBTH [10]. Childhood cancers have, therefore, become a public concern in Ghana [10].

Accurate epidemiological estimates are necessary for determining the disease burden, prioritizing healthcare, effectively allocating healthcare services, and developing policies and guidelines to control the disease [11]. It is estimated that approximately 60% of countries do not have quality data on the incidence of childhood cancers [12], and many LMICs do not have cancer registries, especially in countries with relatively low survival rates [13]. In LMICs where cancer registries exist, they are plagued with relatively weak health systems (difficulty in accessing healthcare and misdiagnoses), which tend to underestimate the incidence of childhood cancer in the country [14,15].

There are few recently published studies on the incidence patterns of childhood cancer in Ghana [6–8]. The study aimed to describe the incidence patterns of cancer in children from birth to 14 years in Ghana. This study addressed the gap in childhood cancer epidemiology categorized according to the International Childhood Cancer Classification, third edition [16]. Inferences from this study's results can be vital in the development of policies to reduce the childhood cancer burden in the country.

2. Materials and method

2.1. Study design

We conducted a retrospective, observational, cross-sectional study. Data on the incidence of childhood cancer from 1 January 2015–31 December 2019 were obtained from patients' medical folders at the pediatric unit of KBTH and the cancer registry at the pediatric unit of KATH to determine the incidence patterns of childhood cancer within the period.

2.2. Study setting

KBTH is situated in Accra, the capital of Ghana, in the southern part of the country. The hospital has a 2,000-bed facility with three centers of excellence, well-equipped diagnostic facilities and over 4000 medical and paramedical personnel [17]. The KATH referral center is located in the country's middle belt in Kumasi, the regional capital of the Ashanti region. It is a 1,200-bed facility providing healthcare services to patients from the three northern sectors, Brong Ahafo, Western, Central, Eastern and Volta regions [17].

2.3. Data source

The study involved collecting demographic and clinical data from patient's medical records to determine the epidemiology of children newly diagnosed with cancer during the study period. Data at KATH were obtained from the cancer registry, whereas data at KBTH were

obtained from specialized books for documenting patient medical records. The medical records and cancer registry contained the patient's name, demographic details, emergency contact, medical history, medical diagnoses, treatment plan, treatment chart and medications prescribed.

2.4. Study population

We adopted the definition of childhood cancer by Ward et al. [18] as cancers occurring in children from birth to 14 years and 11 months. Therefore, the target population of this study included all patients between birth and 14 years and 11 months diagnosed with at least one form of cancer according to the International Classification of Childhood Cancer (ICCC) from 1 January 2015–31 December 2019 in Ghana each year.

The following exclusion criteria were applied:

- Patients whose medical folders showed no or inconclusive diagnoses at the time of diagnosis.
- Patients who were above 14 years and 11 months at the time of diagnosis.
- Patients diagnosed with cancer before 1 January 2015.

2.5. Data collection

A data collection tool was developed in Microsoft Excel® (Microsoft Office Professional Plus 2013) based on an existing population-based cancer registry known as CanReg5 (version 5.00.43 released in November 2018) [19]. CanReg5 is an open-source data collection tool that records, stores, audits and analyses data in a cancer registry. The variables found in the CanReg5 were adapted for the study provided in Table 1.

Children were identified with unique codes to ensure patient confidentiality. Data on the date of birth, age, sex (male/female), region of residence, date of a confirmed diagnosis, the type of cancer diagnosed, diagnostic test utilized to confirm the diagnosis, description of cancer (topography, morphology and behavior) and multiple primaries diagnosed were obtained from the patient's medical folder and cancer registry.

Measures were employed to control data inconsistencies using a guide for the collection of data from patient medical records by Jansen et al. [22]. Incomplete data fields, unknown clinical outcomes and illegible physician handwriting were marked as unknown. Data were furthermore analyzed to check for outliers.

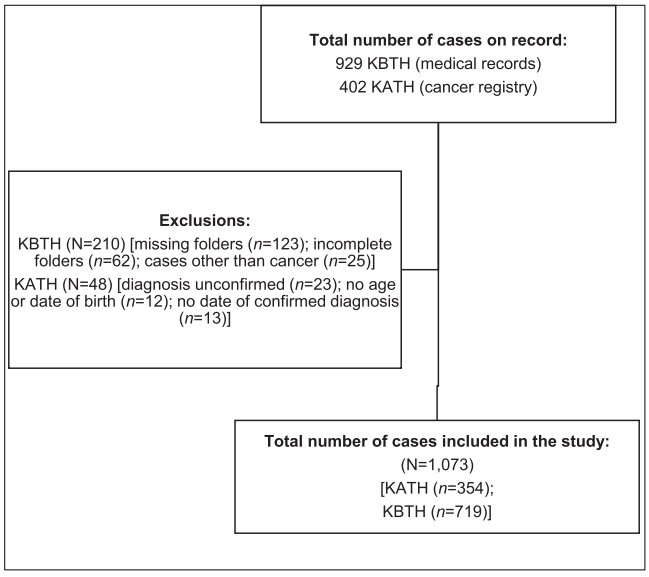

Fig. 1. Selection process of childhood cancer cases from 2015 to 2019 at Korle Bu Teaching Hospital (KBTH) and Komfo Anokye Teaching Hospital (KATH). The diagram illustrates the selection process for determining the study population for the study.

2.6. Measurements

Childhood cancer incidence was defined as the number of newly diagnosed cases divided by the number of children at risk for childhood cancer during the given period. The incidence rate was reported as an age-specific rate in a given year (ASRs per 100,000 person-years) using projected population estimates by the United States Census Bureau for Ghana by age groups and sex each year [23] as the denominator. Data were assessed by age categories (0–4, 5–9, 10–14 years and 11 months) to compare the results with studies conducted in other geographical locations, sex (male/female) and the regions in Ghana. The incidence rates and ASRs were estimated as the weighted average of 0–4, 5–9 and 10–14 years and 11 months, using the corresponding weights of the Segi 1960 World Standard Population [24]. The sixteen administrative regions of Ghana (Table 2) were used to indicate where the child resided. Regions not indicated in the folders were identified as unspecified.

The formula for calculating the ASR using population estimates from the United States Census Bureau for Ghana by age groups and sex each year [23]:

Table 2
Number of cases and age-specific incidence rate (ASR per 100,000 person-years) of childhood cancer incidence stratified by diagnostic group (2015–2019).

	2015		2016		2017		2018		2019		Total	
Cancer group	n	ASR$^{\beta}$	n	ASR$^{\alpha}$	N	ASR$^{\mu}$	n	ASR$^{\infty}$	N	ASR†	N	ASR
Leukemia myeloproliferative diseases and myelodysplastic diseases	38	0.35	31	0.28	61	0.53	47	0.40	39	0.33	216	1.88
Lymphomas and reticuloendothelial neoplasms	58	0.53	48	0.43	62	0.54	39	0.33	41	0.34	248	2.17
CNS and miscellaneous intracranial and intraspinal neoplasm	0	0.00	8	0.07	14	0.12	7	0.06	4	0.03	33	0.29
Neuroblastoma and other peripheral nervous cell tumors	5	0.05	12	0.11	11	0.10	11	0.09	6	0.05	45	0.39
Renal tumors	25	0.23	35	0.31	35	0.31	39	0.33	22	0.18	156	1.36
Retinoblastoma	19	0.17	24	0.21	50	0.44	39	0.33	25	0.21	157	1.36
Hepatic tumors	3	0.03	9	0.08	6	0.05	3	0.03	4	0.03	25	0.22
Malignant bone tumor	4	0.04	6	0.05	9	0.08	14	0.12	5	0.04	38	0.33
Soft tissue and other extra-osseous sarcomas	16	0.15	22	0.20	18	0.16	19	0.16	13	0.11	88	0.77
Germ cell tumors, trophoblastic tumor and neoplasm of the gonads	4	0.04	14	0.12	8	0.07	4	0.03	8	0.07	38	0.33
Other malignant epithelial neoplasms and malignant melanomas	3	0.03	10	0.09	1	0.01	5	0.04	5	0.04	24	0.21
Other and unspecified malignant neoplasm	0	0.00	1	0.01	2	0.02	1	0.01	1	0.01	5	0.04
TOTAL	**175**	**1.60**	**220**	**1.96**	**277**	**2.41**	**228**	**1.94**	**173**	**1.45**	**1073**	**9.36**

ASR – age-specific rate, n – number of patients in each year, N – total number of patients from 2015 to 2019
Population estimates for 0–14 years 11 months; The denominators for determining ASR per 100,000 person-years for each year were as follows: $^{\beta}$2015 (n = 10,953,985); $^{\alpha}$2016 (n = 11,218,805); $^{\mu}$2017 (n = 11,473,383); $^{\infty}$2018 (n = 11,723,813); †2019 (n = 11,962,905) and total (N = 57,332,891) [23]

$$ASR = \frac{Number\ of\ new\ cases\ in\ the\ age\ group\ in\ each\ year}{Population\ estimate\ in\ the\ specific\ age\ group\ in\ the\ year}\ x\ Segi\ World\ Population\ per\ 100,000\ person\ years$$

A total of 929 medical folders were on record at KBTH. Of these, 123 medical folders were not found; 62 medical folders had missing data fields such as the age at diagnosis or the date of a confirmed diagnosis, and 25 cases were not confirmed. Therefore, 210 medical folders at KBTH were excluded from the study (Fig. 1). The number of cases retrieved from the cancer registry at KATH was 402. A total of 48 cases were excluded due to missing data fields (Fig. 1).

2.7. Statistical analysis

The study population was an all-inclusive sample; hence, no power calculation was performed. Data were analyzed using Statistical Package for Social Sciences (SPSS®) [25]. Frequencies, percentages, mean, standard deviation, sex ratio and incidence rate were used to describe the study population within the given period. Age-specific rates were expressed in 100,000 person-years. Statistical significance was set at $p < 0.005$.

3. Results

A total of 1073 childhood cancer cases were identified in the two study sites from 2015 to 2019. Most cases were recorded at the KBTH ($n = 719$). Fig. 2 describes the study population. The mean (SD) age of the children during the study was 5.85 (3.87) [95% CI: 5.62, 6.08] years. There were more cases reported in male than in female patients. The incidence sex ratio (male-to-female) was 1.30:1. The highest number of cases of childhood cancer incidence was observed in children from 0 to 4 years (43.6%, $n = 482$), followed by children from 5 to 9 years (32.0%, $n = 353$). The highest number of cases of childhood cancer was observed in the Greater Accra region (29.7%, $n = 342$), followed by the Ashanti region (18.9%, $n = 209$). Only one case was observed in the North-East region.

The overall ASR from 2015 to 2019 was 9.36 per 100,000 person-years based on 1073 childhood cancer cases. The ASR of childhood cancer increased from 1.60 per 100,000 person-years in 2015–2.41 per 100,000 person-years in 2017, thereafter decreasing to 1.94 per 100,000 person-years in 2018 and 1.45 per 100,000 person-years in 2019 (Table 2). The most prevalent cancers were lymphomas (2.17 per 100,000 person-years), leukemias (1.88 per 100,000 person-years), retinoblastoma and renal tumors (1.36 per 100,000 person-years respectively).

Sex-specific incidence varied across the diagnostic groups (Table 3). The ASR in males (2.10 per 100,000 person-years) were higher compared to females (1.64 per 100,000 person-years) ($p < 0.0002$, Cramér's $V = 0.18$), with lymphomas more common in male (0.53 per 100,000 person-years) than in female patients (0.34 per 100,000 person-years). Germ cell tumors were more common in female patients (0.1 per 100,000 person-years) than in males (0.03 per 100,000 person-years).

The incidence of childhood cancer varied across the age groups ($p < 0.0001$, Cramér's $V = 0.39$). The highest ASR was observed in children from 0 to 4 years (0.27 per 100,000 person-years), followed by children between 5 and 9 years (0.18 per 100,000 person-years) (Table 4). The ASR of retinoblastoma and renal tumors was high in children aged 0–4 years (0.07 per 100,000 person-years). The highest ASR regarding the incidence of lymphomas (0.06 per 100,000 person-years) and leukemia (0.05 per 100,000 person-years) was observed in children from 5 to 9 years.

The incidence of childhood cancer varied by administrative region of Ghana (Table 5). The highest incidence of childhood cancer was observed in children living in the Greater Accra region (ASR 4.17 per 100,000 person-years), followed by the Central region (2.19 per 100,000 person-years) and the Ashanti region (2.08 per 100,000 person-years). The ASR of leukemia was highest in the Greater Accra region (1.04 per 100,000 person-years), followed by the Ashanti region (0.45 per 100,000 person-years). Lymphomas were commonly diagnosed in children living in the Greater Accra and Ashanti regions at ASRs of 0.67 and 0.65 per 100,000 person-years, respectively. In the Central region, the ASR of leukemia and renal tumors were relatively high among the cancer groups. Lymphomas (ASR 0.41 per 100,000 person-years) and retinoblastoma (0.38 per 100,000 person-years) were the most frequently diagnosed childhood cancers in the Volta region.

Table 6 provides the subtype of childhood cancer cases observed during the study period. Acute lymphoblastic leukemia (ALL) and acute

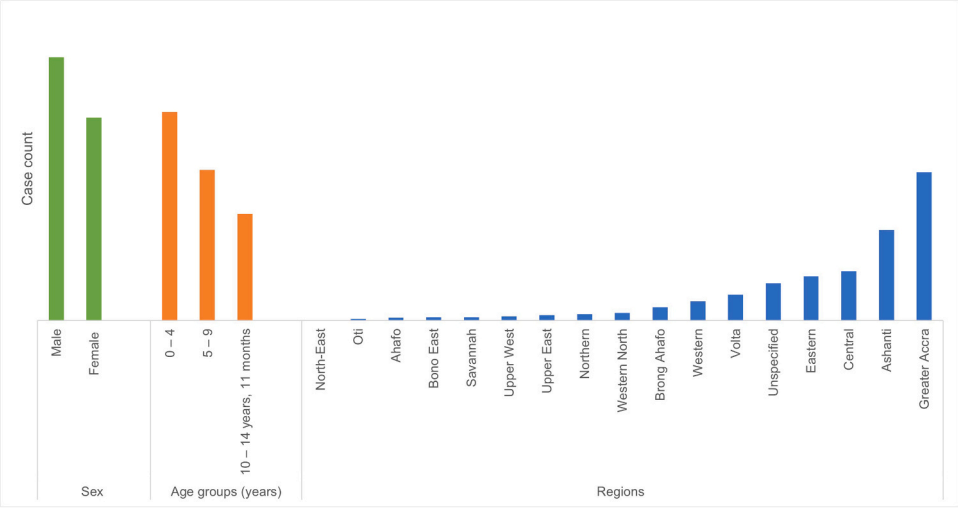

Fig. 2. Distribution of childhood cancer cases by sex (male/female), age groups and region of residence. The graph illustrates the cases of childhood cancer recorded at Komfo Anokye and Korle Bu Teaching Hospitals from 2015 to 2019 by sex (male/female), age group and region of residence.

Table 3
Age-specific incidence rate of childhood cancer, stratified by cancer type and sex (2015–2019).

Type of cancer	Males		Female	
	n	ASR/100,000 per person-years	n	ASR/100,000 per person-years
Leukemia myeloproliferative diseases and myelodysplastic diseases	126	0.44	90	0.32
Lymphomas and reticuloendothelial neoplasms	152	0.53	96	0.34
CNS and miscellaneous intracranial and intraspinal neoplasm	16	0.06	17	0.06
Neuroblastoma and other peripheral nervous cell tumors	24	0.08	21	0.07
Renal tumors	81	0.28	75	0.26
Retinoblastoma	82	0.28	75	0.26
Hepatic tumors	18	0.06	7	0.02
Malignant bone tumor	19	0.07	19	0.07
Soft tissue and other extra-osseous sarcomas	53	0.18	34	0.12
Germ cell tumors, trophoblastic tumors and neoplasm of the gonads	10	0.03	29	0.10
Other malignant epithelial neoplasms and malignant melanomas	21	0.07	3	0.01
Other and unspecified malignant neoplasm	4	0.01	1	0.00
TOTAL	**606**	**2.10**	**467**	**1.64**

ASR – age-specific rate, n – number of patients in each year. Population estimates for each year, 0 – 14 years 11 months; denominators for determining ASR; Males (n = 28,909,590); Females (n = 28,423,301) [23]

myeloid leukemia (AML) comprised 61.0% ($n = 133$) and 27.5% ($n = 60$) of all leukemia, myeloproliferative and myelodysplastic diseases, respectively. Burkitt lymphoma (BL) was the most frequently diagnosed, comprising 64.5% ($n = 165$) of cases observed within the study population. Wilms' tumor was observed to have the highest case count within the renal tumor group (95.7%, $n = 157$).

4. Discussion

This study reports the incidence of childhood cancer by sex, age and region of residence in Ghana from 1073 cases from 2015 to 2019 at KATH and KBTH. The incidence of childhood cancer was 9.36 per 100,000 person-years. We report an increase in the incidence of childhood cancer from 2015 to 2017 and a decline from 2018 to 2019. Earlier studies evaluating incidence patterns of childhood cancer in Ghana have also reported an increasing trend [11–13]. Paintsil et al. [13] reported an increase in childhood cancer incidence from 84 cases in 2012–133 cases in 2014 at the KATH.

The results of the study showed male dominance during the study period. This finding is similar to earlier studies at KBTH and KATH [11–13]. For example, in the study by Segbefia et al. [11] study, more males (56.6%) than females (43.4%) were diagnosed with childhood cancers within the study period, with a male-to-female ratio of 1.3:1. Sex disparities in cancer have been linked to the economic development of a country [26]. The genetic or biological constitution of males suggests that they are less likely to die during the early stages of the disease than females, although this effect has been proven to be insignificant [26]. Males are more resilient during the early stages of cancer and are more likely to visit the tertiary hospital for treatment, where cases are likely to be recorded. According to Pearce and Parker [27], in countries with a decreasing gross domestic product (GDP), a male child is more likely to be sent to a specialist center to receive medical care than a female, as culture favors males [27].

Age is an important demographic factor that influences the development of specific disease conditions [28]. The incidence of childhood cancer was highest in children aged from birth to four years, with the highest number of cases of retinoblastoma, renal tumors (predominately Wilms' tumor) (Table 6), CNS tumors, neuroblastoma, hepatic tumor, soft tissue sarcomas and germ cell tumors. This observation confirms an earlier study conducted in Ghana by Paintsil et al. [13].

Lymphomas were the most diagnosed childhood cancer in this study during the period under review. The results of the study by Sebgefia et al. [11] also showed that lymphomas were the most frequently diagnosed childhood cancer at the KBTH, accounting for 30.7% of the 495 cases of childhood cancers between 2008 and 2011. Lymphomas have been observed to be common in West Asia and Southern Europe [3] and sub-Saharan Africa, where human-immunodeficiency virus infections and malaria are endemic [11–13,29]. Leukemia has been

Table 4
Number of cases and age-specific incidence rate from 2015 to 2019 stratified by age group.

Cancer type	Age (years)					
	0–4		5–9		10–14	
	n	**ASR/100,000 per person-years**	**n**	**ASR/100,000 per person-years**	**n**	**ASR/100,000 per person-years**
Leukemias myeloproliferative diseases and myelodysplastic diseases	72	0.04	92	0.05	52	0.03
Lymphomas and reticuloendothelial neoplasms	39	0.02	111	0.06	98	0.05
CNS and miscellaneous intracranial and intraspinal neoplasm	17	0.01	13	0.01	3	0.00
Neuroblastoma and other peripheral nervous cell tumors	30	0.02	10	0.01	5	0.00
Renal tumors	102	0.06	46	0.02	8	0.00
Retinoblastoma	134	0.07	20	0.01	3	0.00
Hepatic tumors	16	0.01	3	0.00	6	0.00
Malignant bone tumor	4	0.00	12	0.01	22	0.01
Soft tissue and other extra-osseous sarcomas	40	0.02	24	0.01	23	0.01
Germ cell tumors, trophoblastic tumors and neoplasms of the gonads	21	0.01	10	0.01	9	0.00
Other malignant epithelial neoplasms and malignant melanomas	3	0.00	5	0.00	16	0.01
Other and unspecified malignant neoplasms	1	0.00	1	0.00	1	0.00
TOTAL	**480**	**2.22**	**347**	**1.80**	**246**	**1.49**

ASR – age-specific rate, n – number of patients in each year; Segi World Population Standard; 0 – 4 years (n = 12,000); 5 – 9 years (n = 10,000); 10 – 14 years 11 months (n = 9000) [24]. Population estimates for 0 – 14 years 11 months; denominators for determining ASR for each year per age category, 0 – 4 years (n = 21,596,240), 5 – 9 years(n = 19,236,591); 10 – 14 years 11 months (n = 16,500,060) [23].

Table 5
Age-specific incidence rate per 100,000 person-years from 2015 to 2019 stratified by administrative regions of Ghana.

Region	Leukemia	Lymphoma	CNS neoplasm	Neuroblastoma	Renal tumor	Retinoblastoma	Hepatic tumor	Malignant bone tumor	Soft tissue sarcoma	Germ cell tumors	Other malignant epithelial neoplasm	Other and unspecified malignant neoplasm
Ahafo	0.27	0.18	0.00	0.00	0.09	0.00	0.00	0.00	0.09	0.00	0.00	0.00
Ashanti	0.45	0.65	0.07	0.10	0.21	0.27	0.03	0.06	0.17	0.04	0.03	0.00
Bono	0.23	0.37	0.09	0.00	0.23	0.18	0.00	0.14	0.14	0.05	0.00	0.00
Bono East	0.17	0.12	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
Central	0.42	0.38	0.04	0.06	0.42	0.36	0.02	0.10	0.27	0.06	0.04	0.02
Eastern	0.34	0.49	0.02	0.07	0.29	0.24	0.02	0.05	0.11	0.15	0.07	0.00
Greater Accra	1.04	0.67	0.16	0.21	0.68	0.51	0.21	0.16	0.23	0.17	0.11	0.02
Northern	0.10	0.10	0.00	0.00	0.04	0.04	0.00	0.00	0.02	0.00	0.00	0.00
North-East	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00
Oti	0.00	0.18	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00
Savannah	0.07	0.14	0.00	0.07	0.14	0.07	0.00	0.00	0.07	0.00	0.00	0.00
Upper East	0.04	0.08	0.04	0.00	0.04	0.15	0.00	0.00	0.15	0.00	0.00	0.00
Upper West	0.06	0.11	0.00	0.06	0.06	0.06	0.00	0.06	0.11	0.06	0.00	0.00
Volta	0.22	0.41	0.06	0.03	0.32	0.38	0.00	0.06	0.19	0.06	0.13	0.03
Western	0.16	0.40	0.00	0.08	0.11	0.19	0.03	0.05	0.11	0.03	0.03	0.03
Western North	0.18	0.35	0.00	0.12	0.12	0.12	0.00	0.00	0.12	0.06	0.00	0.00
Total	**3.73**	**4.64**	**0.48**	**0.79**	**2.74**	**2.67**	**0.30**	**0.68**	**1.77**	**0.73**	**0.40**	**0.10**

Population estimates for 0 – 14 years 11 months; the denominators for determining ASR per 100,000 person-years for each year; 2015 (n = 10,953,985); 2016 (n = 11,218,805); 2017 (n = 11,473,383); 2018 (n = 11,723,813); 2019 (n = 11,962,905) [23]

Table 6
Case count of childhood cancer by subgroups from 2015 to 2019.

Cancer subtypes	Case count (*n*)
Leukemia, myeloproliferative diseases and myelodysplastic diseases	
Acute promyelocytic anemia	2
Acute Lymphoblastic Leukemia	131
Acute Myeloid Leukemia	60
Burkitt leukemia	5
Chronic Lymphocytic Leukemia	2
Chronic Myeloid Leukemia	11
Erythroleukemia	1
Infantile leukemia	1
Juvenile myelomonocytic leukemia	1
Leukemia Disorder	1
Myelodysplasia	1
Lymphomas and reticuloendothelial neoplasms	
Anaplastic large cell lymphoma	1
B-cell lymphoma	3
Burkitt lymphoma	157
Colonic MALT lymphoma	1
Diffuse large cell lymphoma	3
Hodgkin's lymphoma	20
Langerhans cell histiocytosis	1
Lymphoblastic lymphoma	1
Lymphoma	11
Non-Hodgkin's lymphoma	37
Retroperitoneal tumor	1
Small bowel lymphoma	1
T-cell lymphoma	11
CNS and miscellaneous intracranial and intraspinal neoplasm	
Brain tumor	7
Brainstem glioma	3
Craniopharyngioma	2
Ganglioneuroma	4
Diffuse pontine glioma	1
Glioma	2
Medulloblastoma	2
Meningioma	1
Oligodendroglioma	2
Pilocytic astrocytoma	4
Pineal gland tumor	2
Posterior fossa tumor	2
Residual astrocytoma	1
Neuroblastoma and other peripheral nervous cell tumours	
Neuroblastoma	43
Small round cell tumor	2
Renal tumours	
Chromophobe renal cell carcinoma	1
Mesoblastic nephroma	1
Nephrotic nephritic syndrome	1
Non-Wilms' Renal Cancer	1
Renal cell carcinoma	2
Renal tumors	1
Wilms' tumor	149
Retinoblastoma	
Retinoblastoma	157
Hepatic tumours	
Hepatoblastoma	18
Hepatocellular carcinoma	7
Malignant bone tumour	
Chondrosarcoma	3
Chronic osteomyelitis	2
Ewing sarcoma	1
Occipital bone osteomyelitis	1
Osteoclastoma	1
Osteomyelitis	1
Osteosarcoma	29

(*continued on next page*)

Table 6 (*continued*)

Cancer subtypes	Case count (*n*)
Soft tissue and other extra-osseous sarcomas	
Abdominal mesenchymoma	1
Alveolar rhabdomyosarcoma	1
Biphasic synovial sarcoma	1
Embryonal rhabdomyosarcoma	1
Infantile fibrosarcoma	1
Kaposi sarcoma	7
Malignant spindle cell carcinoma	1
Rhabdoid tumor	1
Rhabdomyosarcoma	56
Spindle cell sarcoma	12
Squamous cell carcinoma	3
Synovial sarcoma	2
Germ cell tumours, trophoblastic tumours and neoplasms of the gonads	
Choriocarcinoma	1
Dysgerminoma	4
Embryonal carcinoma	1
Germ cell tumor	9
Mesenchymal embryonal tumor	1
Retroperitoneal tumor	1
Teratoma	14
Yolk sac tumor	7
Complex ovarian tumor	1
Other malignant epithelial neoplasms and malignant melanomas	
Adenocarcinoma	5
Nasopharyngeal carcinoma	18
Adrenocortical tumor	1
Other and unspecified malignant neoplasm	
Adrenal tumor	1
Poorly differentiated carcinoma of the eye	1
Peri-pancreatic tumor benign	1
Poorly undifferentiated neoplasm	1
Unclassified malignant tumor	1
TOTAL	**1073**

reported to be the most frequently diagnosed cancer in children from birth to 14 years in other parts of the world; however, Steliarova et al. [3] reported a striking low incidence of leukemia in Africa. The authors ascribed the low incidence in Africa to under-diagnosis due to reduced access to healthcare [3].

BL accounted for the majority of the total number of cases of lymphoma reported during the study period. This observation confirms the study results by Segbefia et al. [11], Paintsil et al. [13], and Stefan et al. [30], which showed BL as the most frequently diagnosed childhood cancer between 1990 and 1999 in the Ghanaian registry. Ghana is located in West Africa, where malaria is endemic. BL has been linked to regions endemic to malaria and Epstein-Barr virus [29–31]. In a region where malaria is endemic, the incidence of BL is likely to be high, as observed in this study.

Regional variations of ASRs were observed during the study period. From the results of the study, the highest incidence of childhood cancer was observed in the Greater Accra region, followed by the Ashanti region. This observation could be attributed to the availability of pediatric oncology units in both regions. The relative ease of access to care may encourage parents and caregivers to visit the hospital compared to residents who do not live in the two regions. The variation in the type of childhood cancer predominant in these regions is worth noting. Leukemia was predominant in the Greater Accra, while lymphomas were mostly diagnosed in the Ashanti region. In the Central regions, renal tumors and leukemia were the most commonly diagnosed in children.

Our study provided a childhood cancer incidence estimate involving two main pediatric cancer referral units in the country. Previous studies conducted were at a single site, and results were not reported using the ICCC system of classification [6–8]. Despite these strengths, the data collection process was challenged, with 253 cases being excluded due to missing or incomplete folders and missing data fields in the cancer registry, limiting the reporting of actual incidence. These challenges, therefore, underestimate the incidence of childhood cancer during the study period. With the strengthening of the national cancer registry in tertiary hospitals, we believe accurate reporting of new cases will be encouraged to achieve accurate estimates of childhood cancer cases in the country.

5. Conclusion

The results from this study provide insight into the incidence of childhood cancer over a five-year period from 2015 to 2019 in two major tertiary hospitals in the country. The incidence of childhood cancer decreased over the study period from 1.60 to 1.45 per 100,000 person-years. Lymphomas, leukemias, renal tumors and retinoblastoma were the four most commonly diagnosed cancers observed during the study. BL was the most commonly diagnosed type of lymphoma during the period and with malaria still endemic in the country; tightening malaria controls can positively impact its reduction in the country. Childhood cancer cases were the highest in children in the 0–4 years category, with renal tumor and retinoblastoma dominant in this age category. Screening for cancer during and after pregnancy can help in the early identification and treatment of cancers commonly diagnosed in this age group. Childhood cancer cases were relatively high in male patients except for germ cell tumors. The Greater Accra region recorded the most cases of childhood cancer, with leukemia being the most frequently reported malignancy. We recommend further studies be conducted to provide further explanation for the results observed in this current study focusing on the Ghanaian socio-economic setting coupled with health-seeking behavior using this study as the benchmark. Further epidemiological studies are recommended to explore the association between the incidence of BL and endemic malaria areas in Ghana.

Ethical approval

Permission to conduct the study was obtained from the North-West University Health Research Ethics Committee (NWU-HREC) (NWU-0045–19-S1), the Korle Bu Teaching Hospital-Scientific and Technical Committee and Institutional Review Board (KBTH-STC/IRB/000130/2019), the Komfo Anokye Teaching Hospital Institutional Review Board (KATH-IRB/AP/028/20) and the Chief Director for the Ministry of Health of the Republic of Ghana (MH/DP/042/20).

Consent for publication

Not applicable. Data were collected retrospectively from patients' medical records; hence, there was no contact with the patients. The researcher obtained permission from the Health Research Ethics Committee of the North-West University (HREC) (NWU-0045–19-S1) and the Ethics Boards of Korle Bu Teaching Hospital (KBTH-STC/IRB/000130/2019) and Komfo Anokye Teaching Hospital (KATH-IRB/AP/028/20) to waive obtaining informed consent from the patients before commencing the study.

Authorship contribution statement

WEO, JRB, MSL and RJ designed the study. WEO collected the data. WEO, JRB and MC performed the data analysis and interpretation. WEO wrote the first draft of the paper. JRB, MSL, RJ and MC reviewed the paper. All authors approved the submitted version of the article.

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Declaration of Competing Interest

The authors have no competing interest to declare.

Data Availability

Data collection forms, data extracted from medical folders and cancer registry, data used for all analyses and analytic code can be obtained by contacting the corresponding author.

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References

[1] C. Rodriguez-Galindo, P. Friedrich, P. Alcasabas, F. Antillon, S. Banavali, L. Castillo, T. Israels, S. Jeha, M. Harif, M.J. Sullivan, T.C. Quah, C. Patte, C.H. Pui, R. Barr, T. Gross, Toward the cure of all children with cancer through collaborative efforts: pediatric oncology as a global challenge, J. Clin. Oncol. 33 (2016) 3065–3073, https://doi.org/10.1200/JCO.2014.60.6376.

[2] I. Magrath, E. Steliarova-Foucher, S. Epelman, R.C. Ribeiro, M. Harif, C.K. Li, R. Kebudi, S.D. Macfarlane, S.C. Howard, Paediatric cancer in low-income and middle-income countries, Lancet Oncol. 14 (2013) e104–e116, https://doi.org/10.1016/S1470-2045(13)70008-1.

[3] E. Steliarova-Foucher, C. Stiller, P. Kaatsch, F. Berrino, J.W. Coebergh, B. Lacour, M. Parkin, Geographical patterns and time trends of cancer incidence and survival among children and adolescents in Europe since the 1970s (the ACCIS project): an epidemiological study, Lancet 364 (2004) 2097–2105.

[4] City cancer challenge, The pediatric oncology networking project, ⟨https://citycancerchallenge.org/the-paediatric-oncology-networking-project/⟩, (Accessed 31 July 2023).

[5] World Child Cancer, Background, ⟨https://worldchildcancer.org/ghana/⟩ (Accessed 14 November 2022).

[6] C.I. Segbefia, L.A. Renner, Y. Dei-Adomako, J. Welbeck, Changing patterns of childhood cancers at Korle Bu Teaching Hospital, Accra, Ghana. Postgrad. Med J. Ghana. 3 (2013) 65–67.

[7] J.E. Welbeck, A.A. Hesse, Pattern of childhood malignancy in Korle Bu Teaching Hospital, Ghana, West Afr. J. Med 17 (1998) 81–84.

[8] V. Paintsil, H. David, J. Kambugu, L. Renner, F. Kouya, T. Eden, P. Hesseling, E. Molyneux, T. Israels, The Collaborative Wilms Tumor Africa Project; baseline evaluation of Wilms tumor treatment and outcome in eight institutes in sub-Saharan Africa, Eur. J. Cancer 51 (2015) 84–91, https://doi.org/10.1016/j.ejca.2014.10.030.

[9] National strategy for cancer control in Ghana, chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.iccp-portal.org/system/files/plans/Cancer%20Plan%20Ghana%20Ministry%20of%20Health.pdf (Accessed 25 November 2022).

[10] Korle Bu Teaching Hospital, 2016 Annual report. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://kbth.gov.gh/assets/downloads/pdf/2016_Annual_Report.pdf (Accessed 15 November 2022).

[11] R. Atun, N. Bhakta, A. Denburg, A.L. Frazier, P. Friedrich, S. Gupta, C.G. Lam, Z. J. Ward, J.M. Yeh, C. Allemani, M.P. Coleman, V. Di Carlo, E. Loucaides, E. Fitchett, F. Girardi, S.E. Horton, F. Bray, E. Steliarova-Foucher, R. Sullivan, F. Aitken, C. Rodriguez-Galindo, Sustainable care for children with cancer: a lancet oncology commission, Lancet Oncol. 21 (2020) e185–e224, https://doi.org/10.1016/S1470-2045(20)30022-X.

[12] Global Burden of Disease Cancer Collaboration, C. Fitzmaurice, C. Allen, R. M. Barber, L. Barregard, Z.A. Bhutta, H. Brenner, D.J. Dicker, O. Chimed-Orchir, R. Dandona, L., T. Fleming, M.H. Forouzanfar, J. Hancock, R.J. Hay, R. Hunter-Merrill, C. Huynh, H.D. Hosgood, C.O. Johnson, J.B. Jonas, M. Naghavi, Global, regional, and national cancer incidence, mortality, years of life lost, years lived with disability, and disability-adjusted life-years for 32 cancer groups, 1990 to 2015: a systematic analysis for the global burden of disease study, JAMA Oncol. 3 (2017) 524–548, https://doi.org/10.1001/jamaoncol.2016.5688.

[13] J. Ferlay, I. Soerjomataram, R. Dikshit, S. Eser, C. Mathers, M. Rebelo, D.M. Parkin, D. Forman, F. Bray, Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012, Int J. Cancer 36 (2015) E359–E386, https://doi.org/10.1002/ijc.29210.

[14] J. Hopkins, E. Burns, T. Eden, International twinning partnerships: An effective method of improving diagnosis, treatment and care for children with cancer in low-middle income countries, J. Can. Pol. 1 (2013) e8–e19.

[15] Z.J. Ward, J.M. Yeh, N. Bhakta, A.L. Frazier, R. Atun, Estimating the total incidence of global childhood cancer: a simulation-based analysis, Lancet Oncol. 20 (2019) 483–493, https://doi.org/10.1016/S1470-2045(18)30909-4.

[16] E. Steliarova-Foucher, C. Stiller, B. Lacour, P. Kaatsch, International Classification of Childhood Cancer, third edition, Cancer 103 (2005) 1457–1467, https://doi.org/10.1002/cncr.20910.

[17] Komfo Anokye Teaching Hospital, ⟨https://kath.gov.gh/our-history/⟩ (Accessed 28 November 2022).

[18] Z.J. Ward, J.M. Yeh, N. Bhakta, A.L. Frazier, R. Atun, Estimating the total incidence of global childhood cancer: a simulation-based analysis, Lancet Oncol. 20 (2019) 483–493, https://doi.org/10.1016/S1470-2045(18)30909-4.

[19] M.J. Ervik, Canreg5. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://www.iacr.com.fr/CanReg5/CanReg5-Instructions.pdf. (Accessed 3 August 2020).

[20] European Network of Cancer Registries, Coding incident dates. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://encr.eu/sites/default/files/Recommendations/ENCR%20Recommendation%20DOI_Mar2022_0.pdf, (Accessed 12 May 2022).

[21] International Agency for Research on Cancer, ⟨https://gco.iarc.fr/today/online-analysis-table?v=2020&mode=cancer&mode_population=continents&population=900&populations=900&key=asr&sex=0&cancer=39&type=0&statistic=5&prevalence=0&population_group=0&ages_group%5B%5D=0&ages_group%5B%5D=17&group_cancer=1&include_nmsc=0&include_nmsc_other=1⟩, (Accessed 14 April 2022).

[22] A.C. Jansen, E.S. van Aalst-Cohen, B.A. Hutten, H.R. Buller, J.J. Kastelein, M. H. Prins, Guidelines were developed for data collection from medical records for use in retrospective analyses, J. Clin. Epid. 58 (2005) 269–274.

[23] Ghana population estimates and projections, ⟨https://www2.census.gov/programs-surveys/international-programs/tables/time-series/pepfar/ghana.xlsx⟩ (Accessed 10 December 2022).

[24] M. Segi, Cancer mortality for selected sites in 24 countries (1950-1957), Department of Public Health, Tohoku Univ. Sch. Med. (1960).

[25] Statistical Package for the Social Sciences (SPSS), IBM Corp, IBM SPSS Statistics for Windows, Armonk, Version 28.0, NY: IBM Corp, 2023.

[26] M.T. Dorak, E. Karpuzoglu, Gender differences in cancer susceptibility: an inadequately addressed issue, Front Genet 3 (2012) 1–11, https://doi.org/10.3389/fgene.2012.00268.

[27] M.S. Pearce, L. Parker, Childhood cancer registrations in the developing world: still more males than females, Int J. Cancer 91 (2001) 402–406, https://doi.org/10.1002/1097-0215(200002).

[28] A. Beltrami, A. Hilliard, A.L. Green, Demographic and socioeconomic disparities in pediatric cancer in the United States: Current knowledge, deepening understanding, and expanding intervention, Cancer Epidemiol. 76 (2022), 102082, https://doi.org/10.1016/j.canep.2021.102082.

[29] C. Torgbor, P. Awuah, K. Deitsch, P. Kalantari, K.A. Duca, D.A. Thorley-Lawson, A multifactorial role for *P. falciparum* malaria in endemic Burkitt's lymphoma pathogenesis, PLoS Pathog. 10 (2014), e1004170.

[30] C. Stefan, F. Bray, J. Ferlay, B. Liu, D. Maxwell Parkin, Cancer of childhood in sub-Saharan Africa, E-Cancer 11 (2017) 1–5, https://doi.org/10.3332/ecancer.2017.755.

[31] N. Mutalima, E. Molyneux, H. Jaffe, S. Kamiza, E. Borgstein, N. Mkandawire, G. Liomba, M. Batumba, D. Lagos, F. Gratrix, C. Boshoff, D. Casabonne, L. M. Carpenter, R. Newton, Associations between Burkitt lymphoma among children in Malawi and infection with HIV, EBV and malaria: results from a case-control study, PLoS One 3 (2008), e2505, https://doi.org/10.1371/journal.pone.0002505.