ORIGINAL ARTICLE

Cancer Patterns among Children and Adolescents Under 18 Years of Age across Different Ethnic Groups: A Retrospective Study at Shaukat Khanum Cancer Hospital, Pakistan

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ABSTRACT

Background: In Pakistan, an estimated 8,000 children are diagnosed with cancer annually. The incidence is unclear due to limited awareness and insufficient diagnostic facilities in the underdeveloped regions of KPK and Baluchistan. The lack of a dedicated cancer registry system underestimates the incidence of pediatric cancer in different ethnicities in Pakistan.

Objective: To evaluate the pattern of pediatric cancer in different ethnic groups presenting in Shaukat Khanum Cancer Hospital and Research Center, Peshawar, Lahore, and Karachi diagnostic centers.

Methods: This is a retrospective cross-sectional study conducted by the Pediatric Oncology Department. The study included pediatric patients newly diagnosed with cancer under 18 years who presented to the Walk-in Clinic at Shaukat Khanum Cancer Hospital & Research Center (SKMCH & RC) in Lahore, Peshawar, and Karachi Diagnostic Centers from January 1, 2024, to December 2024 through chart review in the computerized hospital information system in 2025. Data was analyzed using SPSS version 20.

Results: A total of 3306 cases were retrieved, of whom 2830 cases were included in the study, with 1756 (62%) male and 1074 (38%) female. The majority of patients were Punjabi (43.2%), followed by Pashtuns (33.2%) and Afghans (18.1%). The most common malignancies were ALL (28.7%), lymphoma (18.1%, both HL and NHL), and CNS tumors (10.6%).

Conclusion: There is a need for a dedicated provincial and national cancer registry system to ensure accurate data collection. Population-based studies are required to determine the exact incidence and prevalence of pediatric cancers across different ethnicities at the provincial level.

Keywords: *Age-wise distribution, Pediatric cancer, pediatric leukemia, cancer registry, retinoblastoma, leukemia, lymphoma.*

INTRODUCTION

According to 2023 estimates, approximately 377,000 new cases of childhood cancer are diagnosed worldwide each year [1]. In Pakistan, around 8,000 children are diagnosed with cancer annually [2]. The actual incidence might be higher than 8000. This underestimation may be due to inadequate public awareness, insufficient diagnostic facilities, and geographic limitations in access to dedicated cancer centers. This gap in healthcare facilities is particularly pronounced in regions such as the former tribal agencies of Khyber Pakhtunkhwa (KPK) and Baluchistan, Pakistan's largest province by land area.

Childhood cancer is a growing burden, as per the National Cancer Registry of Pakistan (2015-2019), childhood and adolescent cancer account for 6.4% of all registered malignancies, with almost 7000 to 7500 childhood cancer cases submitted annually [3]. The most common childhood cancers vary across registries: the Karachi Cancer Registry reports leukemia (31%) and lymphomas (20%) as the leading malignancies, whereas the Punjab Cancer Registry identifies lymphomas (31%) and leukemia (23%) as the most prevalent [4, 5]. Despite these regional data, information available through the Pakistan Health Research Council remains limited and does not adequately reflect the national burden of childhood cancer [6].

A major challenge in understanding pediatric cancer epidemiology in Pakistan is the absence of a unified national cancer registry. Existing data are fragmented across multiple institutions, limiting accurate estimates of disease burden and regional variation. Furthermore, little is known about the incidence and distribution of pediatric cancers among Pakistan's diverse ethnic groups. Strengthening cancer surveillance systems would facilitate accurate epidemiological assessments, support investigations into ethnic and genetic predispositions, and inform targeted cancer control strategies [7].

Access to cancer care is also unevenly distributed across the country, as depicted in Fig. (**1**) [8]. The Pakistan Atomic Energy Commission operates 19 cancer hospitals nationwide, including six in Punjab, five in Sindh, five in Khyber Pakhtunkhwa, one in Balochistan, one in Gilgit-Baltistan, and one in Islamabad. In Baluchistan, specialized cancer care is largely limited to CENAR in Quetta, highlighting geographic disparities in access [9].

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Email: ayesha.latif@skm.org.pk
Received: April 29, 2026; Revised: June 16, 2026; Accepted: June 25, 2026
DOI: https://doi.org/10.37184/lnjcc.2789-0112.7.24

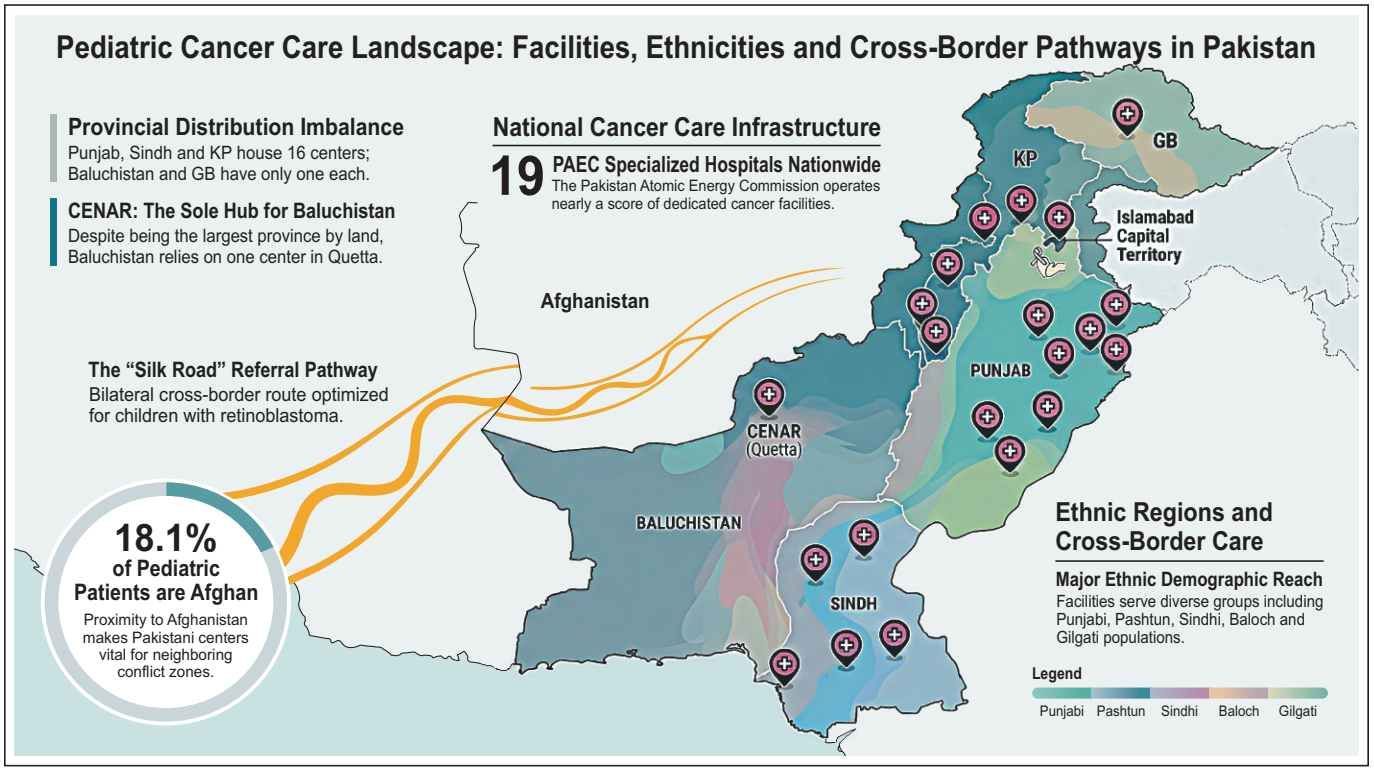

Fig. (1): Regional and ethnic distribution of cancer care centers in Pakistan.

Given the limited data on ethnic and regional patterns of childhood cancer in Pakistan, we conducted this study to examine the distribution of pediatric malignancies among different ethnic groups presenting to Shaukat Khanum Memorial Cancer Hospital and Research Centre. Understanding these patterns may contribute to improved cancer surveillance, equitable healthcare planning, and the development of targeted cancer control policies.

METHODOLOGY

This is a retrospective cross-sectional study conducted by the Pediatric Oncology Department at Shaukat Khanum Memorial Cancer Hospital and Research Hospital. Data of all new pediatric patients diagnosed with cancer on histopathology or radiology scans under 18 years of age presented to the Walk-in Clinic (WIC) at Shaukat Khanum Cancer Hospital & Research Center (SKMCH & RC), Lahore, Peshawar, and Karachi Diagnostic Centers (KDC) from January 1, 2024, till December 2024, were included in the study. The record was reviewed in 2025. As it is a retrospective study, a waiver of informed consent was granted by the Institutional Review Board *via* number EX-25-06-25-01.

Pediatric patients diagnosed with cancer in Shaukat Khanum diagnostic centers other than KDC were excluded from the study, as they would have insufficient records in HIS. Variables included in the study were basic demographics such as age, sex, place of residence, ethnicity, and type of tumor, obtained through chart review in the computerized hospital information system (HIS) without direct contact with the patient. HIS is an electronic health record system used by hospitals to collect these variables.

Statistical analysis was done through SPSS version 20. The distribution of malignancies across all age groups was checked using the Pearson Chi-square test. P-value of <0.05 was considered statistically significant.

RESULTS

A total of 3306 cases were retrieved, of whom 2830 were included in the study, with 1756 males (62.0%) and 1074 females (38.0%). 917/2830 (32.0%) patients fulfilling the guidelines of WIC acceptance criteria were treated at SKMCH & RC while 1913/2830 (68.0%) were unfortunately not accepted for further treatment because of the limited resources of the trust while Patients were divided into 3 age groups: 0-5 years, 996 (35.2%); 6-10 years, 679 (24.0%); and 11-18 years, 1155 (40.8%) (**Table 1**).

Table 1: Demographic characteristics of childhood cancer.

Characteristics	Frequency	Percentage
Gender		
Male	1756	62.0
Female	1074	38.0
Age Categories		
0-5 years	996	35.2
6-10 years	679	24.0
11-18 years	1155	40.8

The majority of patients were Punjabi, 1222 (43.2%); Pashtun, 939 (33.2%); Afghani, 512 (18.1%); Sindhi, 49 (1.7%); and Baloch, 25 (0.9%). The remaining patients belonged to other minor ethnic groups in Pakistan, as depicted in Table **2**.

Table 2: Frequencies of pediatric cancer in different ethnicities.

Ethnicities	Frequency	Percentage
Punjabi	1222	43.2
Sindhi	49	1.7
Pashtun	939	33.2
Baloch	25	0.9
Kashmiri	32	1.1
Gilgit	25	0.9
Afghan	512	18.1
Saraiki	8	0.3
Hindkowan	12	0.4
Miscellaneous	6	0.2

ALL was the most common cancer of 813 patients (28.7%), AML 199 patients (7.0%), lymphoma (both HL and NHL) 18.1%, and CNS tumors were the 3rd most common cancer, 301 (10.6%); the remaining distribution of cancer types is shown in Table **3**.

Table 3: Distribution of childhood cancer.

Type of cancer	Frequency (n)	Percentage (%)
ALL	813	28.7
AML	199	7.0
Bone tumors	264	9.3
CML	30	1.1
CNS tumors	301	10.6
GCT	106	3.7
Hepatoblastoma	37	1.3
HL	280	9.9
LCH	1	0.1
Neuroblastoma	61	2.2
NHL	232	8.2
Retinoblastoma	88	3.1
Rhabdomyosarcoma	74	2.6
Wilms tumor	78	2.8
Miscellaneous	266	9.4

ALL; acute lymphoblastic leukemia, AML; acute myeloblastic leukemia, CML; chronic myeloid leukemia, CNS; central nervous system, GCT; germ cell tumors, HL; Hodgkin's lymphoma, LCH; Langerhans cell histiocytosis, NHL; non-Hodgkin lymphoma.

The distribution of malignancies across the 3 age groups (0-5 years, 6-10 years, and 11-18 years) showed a highly significant correlation ($p < 0.001$). The most common diagnosis was acute lymphoblastic leukemia (n=813, 28.7%), with high frequency in the age group 0-5 years (n=351, 43.2%). Retinoblastoma is predominantly diagnosed in children under 5 years (95.5%), followed by Wilms tumor (83.3%) and neuroblastoma (72.1%) within the same age group. Bone tumors were commonly diagnosed among adolescents, with 67.4% of cases occurring within the 11-18-year age range. Hodgkin lymphoma showed a strikingly uniform distribution among all age groups, whereas chronic myeloid leukemia (CML) was predominantly diagnosed in adolescents (83.3%). Germ cell tumors showed a bimodal age distribution, with peaks in the 0-5 years and 11-18 years age groups, indicating the well-established distribution of the tumor type. In the oldest age group (71.8%), miscellaneous tumors (including GI tumors, breast malignancy, uterine tumors, and ovarian tumors) were most common, as summarized in Table **4**.

Table 4: Association of age groups with diseases.

Diagnosis	0-5 Years n (%)	6-10 Years n (%)	11-18 Years n (%)	p-value
ALL	351 (35.2)	198 (29.2)	264 (22.9)	*<0.001
AML	57 (5.7)	54 (8.0)	88 (7.6)	0.129
Bone Tumor	25 (2.5)	61 (9.0)	178 (15.4)	*<0.001
Brain Tumor	80 (8.0)	104 (15.3)	117(10.1)	*<0.001
CML	0 (0.0)	5 (0.7)	25 (2.2)	*<0.001
GCT	41 (4.1)	24 (3.5)	41 (3.5)	0.746
Hepatoblastoma	24 (2.4)	5 (0.7)	8 (0.7)	*<0.001
HL	92 (9.2)	97 (14.3)	91 (7.9)	*<0.001
Neuroblastoma	44 (4.4)	9 (1.3)	8 (0.7)	*<0.001
NHL	73 (7.3)	50 (7.4)	109 (9.4)	0.137
RB	84 (8.4)	3 (0.4)	1 (0.1)	*<0.001
RMS	30 (3.0)	15 (2.2)	29 (2.5)	0.576
Wilms Tumor	65 (6.5)	9 (1.3)	4 (0.3)	*<0.001
Miscellaneous	30 (3.0)	45 (6.6)	191 (16.5)	*<0.001

ALL; acute lymphoblastic leukemia, AML; acute myeloblastic leukemia, CML; chronic myeloid leukemia, CNS; central nervous system, GCT; germ cell tumors, HL; Hodgkin's lymphoma, LCH; Langerhans cell histiocytosis, NHL; non-Hodgkin lymphoma, *Significant at p<0.05

There was an association between ethnicity and the distribution of disease types. Most ethnicities had ALL as the most common cancer occurrence, specifically in terms of Saraiki ethnicity. Overall, 50% of Saraiki had ALL, and 41% of Hindko had ALL. Ethnicities also show similar proportions of NHL; however, Hindko (12.1%) appears to have a higher NHL proportion than other ethnic groups. The Afghan ethnicity has a high percentage of patients with retinoblastoma (4.9%), compared to other ethnicities. Other surprisingly large percentages of Hodgkin's lymphoma are also present among these ethnicities. Hodgkin lymphoma was more frequent among Baluch (20.0%) and Saraiki (25.0%) patients. Overall, the distribution of hematological and solid malignancies varied significantly across ethnicities (p<0.001) (**Table 5**).

Table 5: Association of disease types with different ethnicities.

Variables	Punjabi n(%)	Sindhi n(%)	Pakhtun n(%)	Baluch n(%)	Kashmiri n(%)	Gilgati n(%)	Afghan n(%)	Saraikii (n=8)	Hindko n(%)	Misc. n(%)	p-value
ALL	377 (30.9)	9 (18.4)	277 (29.5)	5 (20.0)	5 (15.6)	7 (28.0)	122 (23.8)	4 (50.0)	5 (41.7)	2 (33.3)	*<0.001
AML	70 (5.7)	11 (22.4)	76 (8.1)	3 (12.0)	6 (18.8)	2 (8.0)	29 (5.7)	1 (12.5)	0 (0.0)	1 (16.7)	*<0.001
Bone Tumor	145 (11.9)	1 (2.0)	56 (6.0)	2 (8.0)	4 (12.5)	2 (8.0)	51 (10.0)	0 (0.0)	2 (16.7)	0 (0.0)	*<0.001
Brain Tumor	129 (10.6)	2 (4.1)	88 (9.4)	0 (0.0)	6 (18.8)	4 (16.0)	71 (13.9)	0 (0.0)	1 (8.3)	0 (0.0)	*<0.001
CML	17 (1.4)	0 (0.0)	10 (1.1)	0 (0.0)	1 (3.1)	0 (0.0)	2 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
Germ Cell Tumor	53 (4.3)	1 (2.0)	33 (3.5)	1 (4.0)	0 (0.0)	0 (0.0)	18 (3.5)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
Hepatoblastoma	10 (0.8)	1 (2.0)	16 (1.7)	0 (0.0)	0 (0.0)	1 (4.0)	9 (1.8)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
Hodgkin Lymphoma	111 (9.1)	4 (8.2)	118 (12.6)	5 (20.0)	4 (12.5)	2 (8.0)	32 (6.2)	2 (25.0)	0 (0.0)	2 (33.3)	*<0.001
Neuroblastoma	24 (2.0)	1 (2.0)	25 (2.7)	0 (0.0)	1 (3.1)	1 (4.0)	9 (1.8)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
NHL	74 (6.1)	5 (10.2)	85 (9.1)	2 (8.0)	1 (3.1)	3 (12.0)	62 (12.1)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
Retinoblastoma	46 (3.8)	2 (4.1)	15 (1.6)	0 (0.0)	0 (0.0)	0 (0.0)	25 (4.9)	0 (0.0)	0 (0.0)	0 (0.0)	*<0.001
RMS	33 (2.7)	0 (0.0)	20 (2.1)	2 (8.0)	1 (3.1)	0 (0.0)	16 (3.1)	0 (0.0)	1 (8.3)	1 (16.7)	*<0.001
Wilms Tumor	27 (2.2)	1 (2.0)	26 (2.8)	1 (4.0)	1 (3.1)	2 (8.0)	18 (3.5)	1 (12.5)	1 (8.3)	0 (0.0)	*<0.001
Miscellaneous	104 (8.5)	11 (22.4)	94 (10.0)	4 (16.0)	2 (6.2)	1 (4.0)	48 (9.4)	0 (0.0)	2 (16.7)	0 (0.0)	*<0.001

ALL; acute lymphoblastic leukemia, AML; acute myeloblastic leukemia, CML; chronic myeloid leukemia, CNS; central nervous system, GCT; germ cell tumors, HL; Hodgkin's lymphoma, LCH; Langerhans cell histiocytosis, NHL; non-Hodgkin lymphoma, *Significant at p<0.05.

Note: Chi-square/Fisher-exact test was used for all comparisons of disease distribution across ethnic groups (p values reported per row). Overall p<0.001. Results should be interpreted with caution, as the geographic proximity of our center favors the representation of certain ethnic groups.

DISCUSSION

The annual rate of pediatric cancer in Pakistan is increasing steadily [2]. Unfortunately, there is a lack of dedicated cancer registry systems capable of capturing total cases across all provinces. According to 1 report, in Pakistan, an estimated 8,000 children are diagnosed with cancer annually [2]. Our study shows a total of 2830 annual cases presented in the year 2024 to WIC Shaukat Khanum Cancer Hospital & Research Center in Lahore, Peshawar, and Karachi, which is just the tip of the iceberg. The male-to-female ratio of 1.63:1 (62% male, 38% female) in the cohort is consistent with the well-established male predominance in childhood cancer [5, 10]. An institutional study from the Armed Forces Institute of Pathology (AFIP) similarly reported that 64% of their cohort were males [8]. The exact mechanism behind this gender disparity is unknown. Still, the role of differences in immune responses and higher incidence of congenital disabilities in males with childhood cancer is suggested as one of the predisposing factors [11].

The age distribution of malignancies was also consistent with previous reports. ALL was the most common diagnosis overall, with the highest rate in the 0-5-year age group. This is consistent with the Global Burden of Disease analysis, which confirmed that children under 5 years have the highest burden of ALL [12]. The Karachi cancer registry data also reported that ALL accounted for 31% of childhood cancers [13]. Embryonal tumors also exhibited the age-specific pattern observed in previous studies. The high percentage of retinoblastoma at 95% and neuroblastoma at 72% in under 5 years also aligns with global epidemiological data [14]. Bone tumors also demonstrated the adolescent preponderance at 67% in the 11-18-year age group, in agreement with previous literature [15]. This is well established and explained by the rapid bone turnover and remodeling, characteristic of the adolescent growth spurt. CML occurred almost exclusively in the 11-18-year age bracket, consistent with its known pattern and attributable to the acquired nature of the BCR-ABL translocation [16]. CNS tumors at 10% differ slightly from previous reports from the Karachi cancer registry, which reported 15%, likely reflecting differences in referral pathways and acceptance criteria at our institution [17]. This underrepresentation of CNS tumors in our study also correlates with other registry-based studies from LMICs and is mainly attributed to reduced neuroimaging facilities and neurosurgical expertise [18].

Our study shows high numbers of Afghans, 18% of whom were treated at SKMCH & RC. The high rate of Afghans being treated at our center was also discussed in detail by Yusaf *et al.* and Mahmood *et al.* [18, 19]. The Afghan population demonstrated a relatively higher proportion of of retinoblastoma and NHL relative to their total percentage of 18%. This higher percentage of retinoblastoma in Afghan children reinforces the existing, well-established crisis of the disease in the country, with no specialist center. A major diagnostic gap was

demonstrated in the recent study, where the annual projected rate of retinoblastoma in Afghanistan was 74 cases, but only 23 were reported [20]. Similarly, an abundance of NHL among Afghan children can also be attributed to the absence of oncology centers in the country, geographic proximity, and ease of access to care at our facility. In conflict zones with long-duration wars and limited health infrastructure, cancer care becomes one of the most underserved areas. To address this gap, healthcare programs advocate for bilateral and multilateral referral pathways across international borders, with support from humanitarian foundations. In line with this, a new Afghanistan-Pakistan silk referral pathway has also been initiated with SKMCH & RC, one of the primary referral centers, to optimize care for children with retinoblastoma [20]. This was also seen during the Syrian conflict when Lebanon and Jordan established cancer referral pathways for displaced Syrians [21]. In the context of existing cross-border escalations between Afghanistan and Pakistan, children with cancer become a particularly vulnerable population. Given existing visa issues, the role of telehealth becomes particularly important and warrants further exploration. This has precedent in the form of virtual tumor boards [22]. Another striking finding of this study was that only 32% of presenting patients met the hospital's treatment acceptance criteria, largely reflecting resource constraints within a charitable healthcare model. This underscores the urgent need for expanded infrastructure, sustainable funding, and greater governmental investment in pediatric oncology services, consistent with the World Health Organization's Global Initiative for Childhood Cancer [23]. However, the single-center nature of the study and institution-specific referral and acceptance practices may have introduced selection bias, resulting in a cohort that may not be fully representative of the broader pediatric cancer population in Pakistan. Therefore, the findings should be interpreted with caution, and their generalizability remains limited.

LIMITATIONS

The limitations of the present study should be acknowledged. As this is a hospital-based study, the findings may not accurately reflect the true population-level incidence of childhood cancers across different ethnic groups. According to the Pakistan Bureau of Statistics, Punjab has a population exceeding 120 million, whereas Khyber Pakhtunkhwa (KPK) has an estimated population of approximately 40 million [24]. Despite this demographic disparity, Pashtun children accounted for 33.2% of cases in our cohort, compared with 43.2% among Punjabis. This disproportionate representation may reflect referral patterns to our institution, variations in access to oncology services, or a potentially higher burden of childhood cancer within the Pashtun population.

Furthermore, the National Cancer Registry of Pakistan primarily compiles data from the Punjab Cancer Registry (PCR), the Karachi Cancer Registry (KCR), the Pakistan Atomic Energy Commission (PAEC) registries, the Armed Forces Institute of Pathology (AFIP), and other contributing centers. Consequently, national cancer surveillance remains more comprehensive for Punjab and Sindh, while systematic population-level data from KPK and Baluchistan are comparatively limited. These factors should be considered when interpreting the ethnic distribution observed in our study and when extrapolating the findings to the broader Pakistani population.

CONCLUSION

There is an urgent need for higher authorities and policymakers to establish dedicated provincial and national cancer registry systems to ensure accurate data collection. Large-scale, population-based studies are required to determine the exact incidence and prevalence of pediatric cancers at the provincial level, especially in KPK, where more new cases are being reported, and to explore the risk factors for pediatric cancer by ethnicity.

ETHICS APPROVAL

Ethical approval was obtained from the ethical review committee of Shaukat Khanum Memorial Cancer Hospital and Research Center, Peshawar, before data collection *under* EX-25-06-25-01. All procedures performed in studies involving human participants followed the ethical standards of the institutional and/or national research committee and the Declaration of Helsinki.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA

Data is available from the corresponding author upon reasonable request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

AUTHORS' CONTRIBUTION

SU: Conception, design, analysis, manuscript writing, final approval for publishing, and agreement to be accountable for all aspects of the work.

AL: Study design, data collection and analysis, manuscript writing, critical analysis, final approval for publishing, and agreement to be accountable for all aspects of work.

BJ: Study design, data collection and analysis, manuscript writing, critical analysis, final approval for publishing, and agreement to be accountable for all aspects of the work.

PR: Study design, data collection and analysis, manuscript writing, critical analysis, approval for publishing, and agreement to be accountable for all aspects of work.

GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

AI was used to generate the figure, as details on cancer centers in the country were not available in map form.

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