

Epidemiology of Cancers in Adolescents and Young Adults in Nigeria

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Keywords

adolescents, cancer, epidemiology, Nigeria

Submission received: 2026-05-20 / Accepted: 2026-07-17 / Published: 2026-08-31

<https://doi.org/10.53876/001c.130057>

Abstract

Introduction

Adolescents and young adults (AYAs; ages 15-39 years) with cancers have peculiar psychosocial and economic concerns, cancer biology, risk factors, delayed diagnosis, less research focus and survivorship concerns. Even though this group of people constitute about 40% of Nigeria's estimated population, there are few studies about cancers in AYAs in Nigeria. This study aims to describe the epidemiological distribution of cancers in adolescents and young adults in Nigeria.

Methods

Data collated from 14 cancer registries in Nigeria between 2009 and 2016 were retrospectively reviewed and analysed. The data extracted was analysed using SPSS version 25. Frequencies, percentages, tables, and charts were used to represent and present the results. Association between categorical variables was tested using the Chi-squared test. Anonymised publicly available data were used for this study; hence, ethical approval and informed consent were not required.

Results

A total of 7,143 cancer cases seen within the study period occurred among AYAs, accounting for 24.2% (≈ 1 in 4) of cancer cases in Nigeria (28.7% and 22.2% in northern and southern Nigeria, respectively). Females

constituted 73.5% of AYAs with cancer, with M: F $\approx$ 1:3 (M: F $\approx$ 1:3 and $\approx$ 1:2 in Southern and Northern Nigeria, respectively). About two-thirds (65.7%) of cancers in AYAs occurred among those within the age group 30-39 years. The proportion of AYAs with cancers within the age groups 15-19 years and 20-29 years was higher in the North and among males compared to the South and female AYAs. Cancer cases incidence among AYAs increased rapidly from ages 20-25 years and peaked among those aged 35-39 years, especially among females. The most common cancers in AYAs in Nigeria were breast cancer (37.4%), bone and soft tissue cancer (7.2%) and cervical cancer (5.4%). While breast cancer (30.5%), bone and soft tissue cancer (6.8%) and non-melanoma skin cancer (NMSC) (6.5%) were the most common cancers in the north, breast cancer (41.4%), bone and soft tissue cancer (7.4%) and lymphomas (5.3%) were the most common in the south. Among female AYAs, Breast, cervical and ovarian cancers were the most common cancers nationwide (50.3%, 7.4% and 6.2%, respectively), while bone and soft tissue cancer (14.8%), liver cancer (11.0%), and colorectal cancer (9.2%) were the most common cancers among males.

Conclusion

AYAs accounted for 1 in 4 cancer cases in Nigeria, and about 75% occurred in females. Breast cancer was the most common cancer among female AYAs, while bone and soft tissue cancers were the most common among males.

Take Home Messages

1. AYA accounted for 1 in 4 of all cancer cases in Nigeria
2. AYAs' cancers in Nigeria were about six and five times more than AYA cancers in the USA and Europe
3. There is a need to improve AYAs' cancer awareness, screening and vaccination
4. Targeted policies and guidelines which would aid prompt diagnosis, treatment and survivorship should be encouraged

Introduction

In recent times, there has been an increasing need to prioritise cancers in adolescents and young adults, who are individuals aged 15-39 years at cancer diagnosis, due to their unique cancer biology, cancer predisposing factors and cancer epidemiology, peculiar economic, psychological and social needs, heterogeneity of the population, delayed and missed diagnosis, limited clinical trial participation and special survivorship issues.^{1-2,3,4} In addition, AYAs present with a distinct clinical need for fertility preservation and incorporating fertility-sparing options is critical to safeguarding reproductive functions.²

The incidence of cancers among adolescents and young adults (AYAs) has increased over the years, while the survival rates, on the other hand, though slightly improved, lag behind those achieved in paediatrics and older adults.^{1,3,5,6} Also, the spectrum of adolescent and young adult cancers differs from those in paediatric and older adults and varies with age, ethnicity and geographical locations.¹⁻⁶ Haematological malignancies, breast cancer, thyroid cancer, bone and soft tissue cancers, colorectal cancer, CNS tumours, germ cell tumours, cervical cancer and melanoma are common in adolescents and young adults.^{1,4,5,6}

In 2022, adolescents and young adults made up about 40% of Nigeria's population.⁷ Despite this, studies on adolescent and young adult oncology patients in Nigeria are scarce. This study aims to describe the epidemiological distribution of cancers in adolescents and young adults in Nigeria, which would guide targeted policies, guidelines, research and interventions specific to cancer control in this population.

Methods

Data on all adolescents and young adults were extracted from a publication by the Nigerian National System of Cancer Registries, Federal Ministry of Health of Nigeria, on Cancer in Nigeria.⁸ The publication contains data from 14 cancer registries (7 population-based [PB] and 7 hospital-based [HB]) out of 30 cancer registries (10 population-based and 20 hospital-based) in Nigeria, from 2009 to 2016. Five cancer registries were located in Northern Nigeria (Abuja Cancer Registry; PB, [2009-2016], Maiduguri Cancer Registry; PB, [2016], FMC Gombe Cancer Registry; HB, [2009-2016], FMC Keffi Cancer Registry; HB, [2009-2016], and Sokoto Cancer Registry; PB, [2014-2015]) while 9 were in Southern Nigeria (NAUTH Cancer Registry; HB, [2009-2016], FMC Yenagoa; HB, [2009-2016], Calabar Cancer Registry; PB, [2009-2016], Benin Cancer Registry; PB, [2014-2016], Ekiti Cancer Registry; PB, [2014-2016], Enugu Cancer Registry; PB, [2012-2016], LASUTH Cancer Registry; HB, [2009-2016], LUTH Cancer Registry; HB, [2009-2016] and UPTH Cancer Registry; HB, [2009-2016]). [Figure 1] Other details describing the registry coverage, case ascertainment/primary data sources are shown in Table 1.

The data extracted was analysed using SPSS version 25. Frequencies, percentages, tables, and charts were used to represent and present the results. The association between categorical variables (age group, sex, and region) was tested using the Chi-squared test, which met the required assumptions.

This study utilised secondary analysis of fully anonymised, de-identified and publicly available data derived from a publication by the Nigerian National System of Cancer Registries, Federal Ministry of Health of Nigeria, on Cancer in Nigeria (Available from: <https://www.ncbi.nlm.nih.gov/books/NBK581073/>).⁸ Individual patient confidentiality was preserved throughout the research as there were no direct or indirect personal identifiers in the dataset.

Table 1: Cancer registries in Nigeria used for this report.⁸

Registry	Location	Registry Type	Year(s)	Coverage	Catchment Population [^]	Basis for diagnosis
Abuja Cancer Registry	North	PB	2009-2016	Abuja Municipal Area, Kuje, Bwari, Abaji, Gwagwalada and Kwali LGAs.	1,406,000	Histology/cytology (94.9%), Clinically (2.1%), Radiology (1.1%), Laboratory (0.2%), Autopsy/Surgery (0.1%), Death certificate (0.2%), Unknown (1.2%)
Maiduguri Cancer Registry	North	PB	2016	Maiduguri and Jere LGAs	476,000	Histology/cytology (100.0%)
FMC Gombe Cancer Registry	North	HB	2009-2016			Histology/cytology (99.8%), Clinically (0.1%), Laboratory (0.1%)
FMC Keffi Cancer Registry	North	HB	2009-2016			Histology/cytology (100.0%)
Sokoto Cancer Registry	North	PB	2014-2015	Sokoto-North, Sokoto South, and Wamako	610,000	Histology/cytology (93.3%), Clinically (6.7%)
NAUTH Cancer Registry	South	HB	2009-2016			Histology/cytology (46.2%), Clinically (32.0%), Laboratory (18.9%), Autopsy/Surgery (1.8%), Death certificate (0.3%), Unknown (0.7%)
FMC Yenagoa Cancer Registry	South	HB	2009-2016			Histology/cytology (57.4%), Clinically (31.5%), Radiology (9.6%), Laboratory (0.9%), Unknown (0.6%)
Calabar Cancer Registry	South	PB	2009-2016	Calabar municipality, Calabar-south and Akpabio LGAs	647,000	Histology/cytology (76.0%), Clinically (16.0%), Radiology (1.9%), Laboratory (0.1%), Autopsy/Surgery (5.8%), Unknown (0.2%)
Benin Cancer Registry	South	PB	2014-2016	Benin City metropolitan area, Egor, Oredo and Ikpoba Okha LGAs	1,242,000	Histology/cytology (95.6%), Clinically (1.4%), Laboratory (2.8%), Autopsy/Surgery (0.1%), Death certificate (0.1%), Unknown (0.1%)

Ekiti Cancer Registry	South	PB	2014-2016	Ado, Ikere, Irepodun, Ifedolun, Ido/Osi, and Ekiti South-West LGAs	622,000	Histology/cytology (79.3%), Clinically (16.6%), Death certificate (4.1%)
Enugu Cancer Registry	South	PB	2012-2016	Enugu-South, Enugu-East, Enugu-North, Nkanu-East, Nkanu-West and Udi LGAs	1,103,000	Histology/cytology (93.9%), Clinically (4.9%), Autopsy/Surgery (1.2%)
LASUTH Cancer Registry	South	HB	2009-2016			Histology/cytology (91.0%), Clinically (0.2%), Laboratory (0.5%), Unknown (8.4%)
LUTH Cancer Registry	South	HB	2009-2016			Histology/cytology (99.2%), Clinically (0.4%), Autopsy/Surgery (0.3%), Unknown (0.1%)
UPTH Cancer Registry	South	HB	2009-2016			Histology/cytology (99.7%), Clinically (0.3%)

^ 2006 census. PB: Population-based. HB: Hospital-based. FMC: Federal Medical Centre. NAUTH: Nnamdi Azikiwe University Teaching Hospital. LASUTH: Lagos State University Teaching Hospital. LUTH: Lagos University Teaching Hospital. UPTH: University of Port-Harcourt Teaching Hospital.

Figure 1: Map of Nigeria showing the registry locations (adapted from Akintola et al., eds. Cancer in Nigeria: 2009 – 2016. Nigeria: Nigerian National System of Cancer Registries; 2021)

Results

A total of 7,143 cancer cases seen within the study period occurred among adolescents and young adults (AYAs), accounting for 24.2% (≈ 1 in 4) of cancer cases in Nigeria. In Northern and Southern Nigeria, cancer in AYAs accounted for 28.7% and 22.2% of cancer cases, respectively. Among female patients with cancers, AYAs accounted for 27.9% of cases (32.1% and 26.2% in the North and South, respectively), while among male cancer patients, AYAs accounted for 17.7% of cases (23.4% and 14.8% in Northern and Southern Nigeria, respectively) [Figure 2].

Females constituted 73.5% of AYAs with cancer, with a male-to-female ratio of $\approx 1:3$. The proportion of female AYAs with cancer was higher in the south compared to the north (76.7% and 67.9%, $X^2=66.241$, 95%CI=0.58-0.71, $p=0.000$), and the male-to-female ratio was $\approx 1:3$ and $\approx 1:2$ in Southern and Northern Nigeria, respectively [Table 2].

About two-thirds (65.7%) of cancers in AYAs occurred among those within the age group 30-39 years. The proportion of AYAs with cancers within age group 15-19 years and 20-29 years were higher in the north (6.4% and 29.9% respectively) compared to the south (5.1% and 28.1% respectively), while the proportion of AYAs within age group 30-39 years was higher in the south compared to the north (66.8% and 63.6% respectively, $X^2=9.653$, 95%CI=0.01-0.06, $p=0.008$) [Table 2]. Similarly, the proportion of AYAs with cancer within age group 15-19 years and 20-29 years was significantly higher among the males compared to the females, while the proportion of AYAs within age group 30-39 years was higher among the females both nationwide ($X^2=213.471$, 95%CI=0.15-0.20, $p=0.000$) and across the two geographic regions ($X^2=33.632$, 95%CI=0.08-0.15, $p=0.000$ and $X^2=204.478$, 95%CI=0.18-0.24, $p=0.000$, in the North and South respectively) [Table 3].

The number of cancer cases among AYAs increased rapidly from ages 20-25 years and peaked among those 35-39 years; however, this rapid increase was more among females compared to males [Figure 3A].

The most common cancers in AYAs in Nigeria were breast cancer (37.4%), bone and soft tissue cancer (7.2%), cervical cancer (5.4%), lymphomas (4.7%), ovarian cancer (4.5%) and colorectal cancer (4.5%) [Table 4]. While breast cancer (30.5%), bone and soft tissue cancer (6.8%), non-melanoma skin cancer (NMSC) (6.5%), liver cancer (6.4%), cervical cancer (6.0%) and colorectal cancer (5.1%) were the most common cancers in the north, breast cancer (41.4%), bone and soft tissue cancer (7.4%), lymphomas (5.3%), cervical cancer (5.1%), ovarian cancer (4.4%) and colorectal cancer (4.1%) were the most common in the south [Table 5].

Among female AYAs, Breast, cervical and ovarian cancers were the most common cancers nationwide (50.3%, 7.4% and 6.2%, respectively), as well as the most common cancers in northern Nigeria (44.2%, 8.8% and 7.1%, respectively) and southern Nigeria (53.4%, 6.7% and 5.7%, respectively). Among males, bone and soft tissue cancer (14.8%), liver cancer (11.0%) and colorectal cancer (9.2%) were the most common cancers in Nigeria. In northern Nigeria, liver cancer (14.2%), bone and soft tissue cancer (12.5%) and NMSC (10.7%) were the most common cancers among the male AYAs while bone and soft tissue cancer (16.7%), lymphomas (10.1%) and colorectal cancer (9.3%) were the most common among male AYAs in southern Nigeria [Table 6A-C, see supplementary data for Tables 6B and 6C].

Bone and soft tissue cancer, lymphomas and NMSC were the most common cancers among AYAs within the age group 15-19 years in Nigeria (22.4%, 13.3% and 8.3%, respectively), northern Nigeria (18.7%, 12.0% and 10.2%, respectively) and southern Nigeria (25.0%, 14.2% and 6.9%, respectively). Among AYAs within the age group 20-29 years, breast cancer (26.7%), bone and soft tissue cancer (10.5%) and lymphomas (6.5%) were the most common cancers in Nigeria. While breast cancer, bone and soft tissue cancer and NMSC were the most common cancers among AYAs aged 20-29 years in northern Nigeria (21.5%, 9.9% and 7.9% respectively), breast cancer (29.8%), bone and soft tissue cancer (10.8%) and lymphomas (8.1%) were the most common cancers among AYAs within the same age group in southern Nigeria. Breast cancer, cervical cancer and bone and soft tissue cancer were the most common malignancies among AYAs aged 30-39 years nationwide (45.1%, 6.9% and 4.5%

respectively) and in southern Nigeria (49.1%, 6.7% and 4.75 respectively), while breast cancer (37.7%), cervical cancer and liver cancer were the most common malignancies among AYAs between 30-39 years in the north [Table 7A-C, see supplementary data for Tables 7B and 7C].

There was an increase in the incidence of cases of the common cancers among AYAs with increasing age, except for bone and soft tissue cancer, which had a slight decline after age 25-29 years [Figure 4].

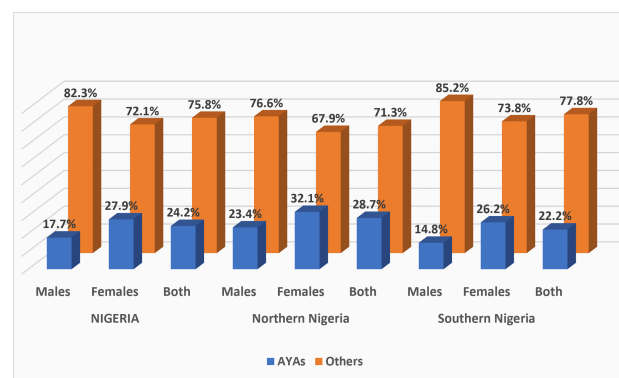


Figure 2. Shows the proportion of AYAs among patients with cancer, distributed by sex, in Nigeria, as well as the Northern and Southern parts of Nigeria.

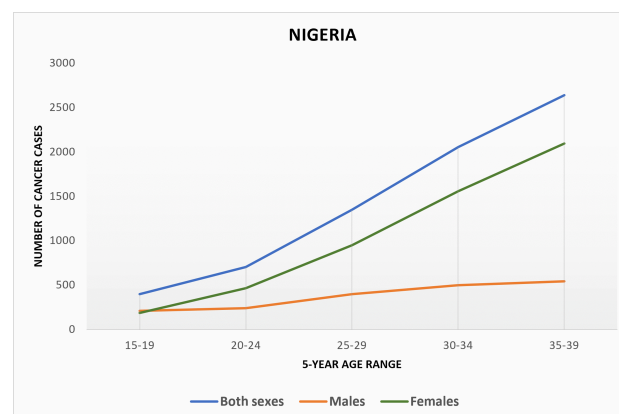


Figure 3A. Number of cancer cases in AYAs by Age range and sex in Nigeria.

See supplementary data for Figures 3B and 3C.

Table 2: Sex and age distribution of cancers among AYAs in Nigeria, Northern Nigeria and Southern Nigeria
Comparison of sex distribution between Northern and Southern Nigeria *Chi-square

Variables	Nigeria	Northern Nigeria	Southern Nigeria	P-Value*
Sex (N=7143)				
Male	1894(26.5%)	833(32.1%)	1061(23.3%)	0.000**
Female	5249(73.5%)	1758(67.9%)	3491(76.7%)	
Age Range (Years) (N=7143)				
15-19	398(5.6%)	166(6.4%)	232(5.1%)	0.008**
20-29	2054(28.8%)	776(29.9%)	1278(28.1%)	
30-39	4691(65.7%)	1649(63.6%)	3042(66.8%)	

Table 3: AYA Age distribution by sex.

**Chi-square

Location	Age Range (Years)	Sex		P-Value
		Males	Females	
Nigeria				
	15-19	212(11.2%)	186(3.5%)	0.000**
	20-29	640(33.8%)	1414(26.9%)	
	30-39	1042(55.0%)	3649(69.5%)	
Northern Nigeria				
	15-19	86(10.3%)	80(4.6%)	0.000**
	20-29	255(30.6%)	521(29.6%)	
	30-39	492(59.1%)	1157(65.8%)	
Southern Nigeria				
	15-19	126(11.9%)	106(3.0%)	0.000**
	20-29	385(36.3%)	893(25.6%)	
	30-39	550(51.8%)	2492(71.4%)	

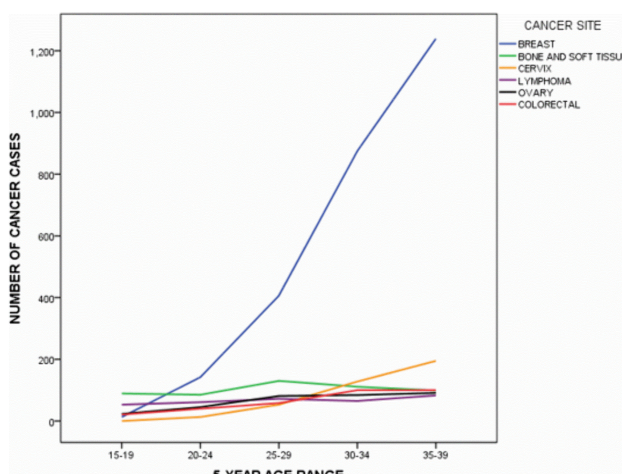


Figure 4: Cancer Cases in AYAs by site and age group

Discussion

This study set out to evaluate the national burden of cancers in AYAs in Nigeria, as well as describe the epidemiological distribution of cancers in AYAs in Nigeria by sex, age and geographical location.

AYA cancers accounted for about 1 in 4 (24.2%) of all cancer cases in Nigeria within the study period. This finding differed from those of studies conducted in the United States of America (USA) and Europe, which reported that cancers in AYAs accounted for 4.2% (≈ 1 in 24) and 5.0% (1 in 20) of all cancer cases, respectively.^{5, 9} The proportion of AYA cancers in Nigeria was about 6 and 5 times higher than the proportion of AYA cancers in the USA and Europe. This could be due to the high

Table 4: Cancer sites in AYAs in Nigeria

*Hodgkin and Non-Hodgkin Lymphoma +Corpus Uterus and Other Uterus ^ Myeloid and Lymphoid Leukaemia.
See the full table in the supplementary data.

S/N	Sites	ICD 10	N (%)
1	Breast	C50	2675(37.4%)
2	Bone And Soft Tissue	C40-41, C47, C49	514(7.2%)
3	Cervix	C53	389(5.4%)
4	Lymphoma*	C81-85, C96	334(4.7%)
5	Ovary	C56	324(4.5%)
6	Colorectal	C18-20	319(4.5%)
7	Non melanoma Skin Cancer	C44	316(4.4%)
8	Liver	C22	312(4.4%)
9	Uterine ⁺	C54, C55	180(2.5%)
10	Kaposi Sarcoma	C46	159(2.2%)
11	Others		1621(22.7%)
12	Total		7143(100.0%)

Table 5: Cancer sites in AYAs in Northern and Southern Nigeria

*Hodgkin and Non-Hodgkin Lymphoma +Corpus Uterus and Other Uterus ^ Myeloid and Lymphoid Leukaemia.

Northern Nigeria			Southern Nigeria		
	Sites	N (%)		Sites	N (%)
1	Breast	789(30.5%)	1	Breast	1886(41.4%)
2	Bone And Soft Tissue	176(6.8%)	2	Bone And Soft Tissue	338(7.4%)
3	Non melanoma skin cancer	169(6.5%)	3	Lymphoma*	240(5.3%)
4	Liver	167(6.4%)	4	Cervix	234(5.1%)
5	Cervix	155(6.0%)	5	Ovary	200(4.4%)
6	Colorectal	131(5.1%)	6	Colorectal	188(4.1%)
7	Ovary	124(4.8%)	7	Uterine ⁺	148(3.3%)
8	Kaposi Sarcoma	109(4.2%)	8	Non melanoma skin cancer	147(3.2%)
9	Lymphoma*	94(3.6%)	9	Liver	145(3.2%)
10	Leukaemia [^]	74(2.9%)	10	Nasopharynx	86(1.9%)
11	Others	603(23.3%)	11	Others	940(20.7%)
	Total	2591(100.0%)		Total	4552(100.0%)

proportion of AYAs in the Nigerian population⁷ as well as the early occurrence of some common malignancies at an earlier age in blacks.^{10,11} Our study revealed that the proportion of AYA cancers in Northern Nigeria was significantly higher than that

in Southern Nigeria (28.7% and 22.2%, respectively, $p < 0.001$). This could be due to underestimation as a result of fewer reported cases, as well as a lower number of registries in the North compared to the South.

Table 6A: Cancer sites in AYAs by sex in Nigeria

*Hodgkin and Non-Hodgkin Lymphoma +Corpus Uterus and Other Uterus ^ Myeloid and Lymphoid Leukaemia
See supplementary data for Table 6B and 6C.

Female		Male	
Breast	2640(50.3%)	Bone And Soft Tissue	281(14.8%)
Cervix	389(7.4%)	Liver	208(11.0%)
Ovary	324(6.2%)	Colorectal	174(9.2%)
Bone And Soft Tissue	233(4.4%)	Lymphoma*	169(8.9%)
Uterine ⁺	180(3.4%)	Non melanoma skin cancer	168(8.9%)
Lymphoma*	165(3.1%)	Leukaemia [^]	88(4.6%)
Non melanoma skin cancer	148(2.8%)	Nasopharynx	86(4.5%)
Colorectal	145(2.8%)	Kaposi Sarcoma	67(3.5%)
Liver	104(2.0%)	Sinonasal	49(2.6%)
Others	921(17.5%)	Others	604(31.9%)
Total	5249(100.0%)	Total	1894(100.0%)

Table 7A: Cancer sites in AYAs by Age group in Nigeria

*Hodgkin and Non-Hodgkin Lymphoma +Corpus Uterus and Other Uterus ^ Myeloid and Lymphoid Leukaemia. NMSC: Non melanoma skin cancer.
See Supplementary Data for Tables 7b And 7c.

15-19 years		20-29 years		30-39 years	
Bone And Soft Tissue	89(22.4%)	Breast	548(26.7%)	Breast	2114(45.1%)
Lymphoma*	53(13.3%)	Bone And Soft Tissue	215(10.5%)	Cervix	323(6.9%)
NMSC	33(8.3%)	Lymphoma*	133(6.5%)	Bone And Soft Tissue	210(4.5%)
Ovary	23(5.8%)	Ovary	126(6.1%)	Colorectal	200(4.3%)
Leukaemia [^]	22(5.5%)	NMSC	118(5.7%)	Liver	197(4.2%)
Nasopharynx	22(5.5%)	Liver	105(5.1%)	Ovary	175(3.7%)
Colorectal	21(5.3%)	Colorectal	98(4.8%)	NMSC	165(3.5%)
Breast	13(3.3%)	Cervix	66(3.2%)	Lymphoma*	148(3.2%)
Liver	10(2.5%)	Nasopharynx	53(2.6%)	Uterine ⁺	140(3.0%)
Others	112(28.1%)	Others	592(28.8%)	Others	1019(21.7%)
Total	398(100.0%)	Total	2054(100.0%)	Total	4691(100.0%)

Females accounted for about three-quarters of cancers in AYAs, with a male-to-female ratio of $\approx 1:3$. The sex distribution of breast cancer, the most common malignancy in Nigeria, could explain the skewed sex distribution of AYA cancers. Studies done by Li et al and Trama et al also demonstrated

similar findings of female preponderance of AYA cancers with a male-to-female ratio of 1:2.^{6, 9} Across Northern and Southern Nigeria, female AYAs with cancers were more than the male AYAs; however, the proportion of female AYAs with cancers was

significantly higher in the South than in the North (76.7% and 67.9%, respectively, $p=0.000$)

A higher proportion of AYAs with cancer (65.7%) occurred among those between 30 and 39 years. A similar age distribution was also noticed across Northern and Southern Nigeria (63.6% and 66.8%, respectively). These findings were in Tandem with those from previous studies, which reported that AYAs within the ages of 30 and 39 years accounted for about 65.7% - 68.3% of AYA cancers.¹²⁻¹⁴ This is not unexpected, as the incidence of cancers increases with increasing age. However, this increase was more rapid among the females compared to the males, and this further explains the reason for the female preponderance. The proportions of AYAs with cancers within the ages 15-19 years and 20-29 years were higher among the males as well as among the Northerners compared to the females and the Southerners. A similar age distribution among sexes was reported in the USA by Scot et al.¹³ Furthermore, the male-to-female ratio varied with increasing age, from $\approx 1:1$ among those 15-19 years, to $\approx 1:2$ among those 20-29 years, to $\approx 1:4$ among those 30-39 years. These findings suggest the earlier occurrence of AYA cancer among males compared to females, and buttress the heterogeneity of cancers in AYAs by age, sex and geographical location.

Breast cancer, bone and soft tissue cancers, cervical cancer and lymphomas were the most common cancers in AYAs in Nigeria. This finding differed slightly from that reported by Li et al, who revealed that breast cancer, thyroid cancer, cervical cancer and lymphomas were the most common malignancies in AYAs globally.⁶ Also, the National Cancer Institute (NCI) and Trama et al reported breast cancer, thyroid cancer, testicular cancer and melanoma as the most common cancers among AYAs in the USA and Europe.^{5,9} Within Nigeria, AYAs' malignancies varied based on geographical location. While breast cancer, bone and soft tissue cancers, non-melanoma skin cancer (NMSC) and liver cancer were the most common AYA cancers in the North, breast cancer, bone and soft tissue cancers, lymphomas and cervical cancers were the most common AYA cancers in the South. The difference could be due to variation of risk factors (genetic and environmental) based on geographical location.

In our study, breast cancer, cervical cancer and ovarian cancer were the most common malignancies among female AYAs, while bone and soft tissue cancers, liver cancer and colorectal cancer were the most common among male AYAs. This finding corroborates the variation of AYA cancers based on sex as reported by a global population-based study in AYA malignancies by Li et al.⁶ They demonstrated that breast cancer, thyroid cancer and cervical cancer were the most frequently diagnosed AYA cancers in females, while thyroid cancer, lymphomas and testicular cancer were the most frequently diagnosed in male AYAs.⁶ In the USA, AYAs' cancer also varied based on sex, as breast cancer, thyroid cancer and melanoma were the most common among female AYAs, while testicular cancer, lymphomas and colorectal cancer were the most common among male AYAs.⁵ Worth of note is that the high burden of thyroid cancer among AYAs in the USA and the global population, compared to the findings from our study. This could be due to differences in thyroid cancer risk factors (genetic and environmental), as well as differences in thyroid cancer diagnosis practices, which could lead to under-diagnosis and underestimation of thyroid cancer in our setting. Breast cancer was the most common cancer among female AYAs in both Northern and Southern Nigeria. However, among male AYAs, liver cancer was the most common in the North, while bone and soft tissue cancers were the most common in the South. This could be due to variation in risk factors of liver cancer across both regions. Musa et al demonstrated that the prevalence of hepatitis B virus infection was higher in Northern Nigeria compared to the South.¹⁵

Bone and soft tissue malignancies, lymphomas and NMSC were the most common cancers among AYAs aged 15-19 years. Breast cancer, bone and soft tissue cancers and lymphomas were the most common among AYAs aged 20-29 years, while breast cancer, cervical cancer and bone and soft tissue cancers were the most common among AYAs aged 30-39 years. These findings were in tandem with reports from other studies by Li et al and Miller et al, which also demonstrated age variation of AYA cancers.^{6,12} Li et al reported Leukaemia, thyroid cancer and breast cancer as the most common malignancies among AYAs aged 15-19 years, 20-29 years and 30-39 years respectively,⁶ while Miller et al reported lymphoma, thyroid cancer and

breast cancer as the most common malignancies among AYAs aged 15-19 years, 20-29 years and 30-39 years respectively.¹² The age variation of AYA cancers was fairly similar in both the Northern and Southern parts of Nigeria.

The most common cancer in AYAs in Nigeria was breast cancer, accounting for 37.4% of cancers in AYAs (30.5% in the North and 41.1% in the South). Breast cancer was also the most common among female AYAs as well as among AYAs between the ages of 20-29 years and 30-39 years in Nigeria. AYAs accounted for ≈ 1 in 4 (30.4%) of all breast cancer cases in Nigeria (≈ 1 in 3 in the North and ≈ 2 in 7 in the South). Most of the breast cancer cases in AYAs in Nigeria occurred among those between the ages of 30-39 years, and 1.3% occurred among males (1.5% in the North and 1.2% in the South).

The second most common cancers in AYAs in Nigeria were bone and soft tissue cancers, accounting for 7.2% of cancers in AYAs (6.8% in the North and 7.4% in the South). Bone and soft tissue sarcomas were also the most common cancers among male AYAs, as well as among AYAs between 15 to 19 years. AYAs accounted for ≈ 2 in 5 (42.5%) of all cases of bone and soft tissue cancers in Nigeria (≈ 2 in 5 in both Northern and Southern Nigeria, respectively). The male-to-female ratio was 1:0.8, indicating a slight male preponderance (1:0.7 in the North and 1:0.9 in the South). Most bone and soft tissue cancers occurred among AYAs aged 20-29 years (20-29 years in Northern Nigeria and 30-39 years in Southern Nigeria).

Cervical cancer was the third most common cancer in AYAs in Nigeria (fifth in the North and fourth in the South), accounting for 5.4% of AYA cancers (6.0% in the North and 5.1% in the South). It was the second most common malignancy among female AYAs. AYAs accounted for about 2 in 15 (13.4%) of all cases of cervical cancer in Nigeria (≈ 1 in 6 in the North and ≈ 2 in 17 in the South). Most of the AYA cervical cancer cases occurred among AYAs between the ages of 30-39 years, and the incidence of cases increased with increasing age.

Lymphomas (Hodgkin and non-Hodgkin lymphomas) were the fourth most common cancers in AYAs in Nigeria (ninth in the North and third in the South), accounting for 4.7% of AYA cancers (3.6% in the North and 5.3% in the South). Lymphomas ranked fourth and sixth in cancer

cases in male and female AYAs, respectively, with fairly equal sex distribution. About 1 in 3 of all lymphomas in Nigeria occurred among AYAs (1 in 3 in both Northern and Southern Nigeria). A higher proportion of AYAs with lymphoma occurred among those in the age group 30-39 years.

Ovarian cancer was the fifth most common cancer among AYAs in Nigeria (7th in the North and 5th in the South), accounting for 4.5% of AYA cancers (4.8% in the North and 4.4% in the South). It was the third most common cancer among female AYAs in Nigeria. About 1 in 3 of all ovarian cancer cases in Nigeria occurred among AYAs (≈ 2 in 5 in the North and ≈ 1 in 3 in the South). Over half of the cases of ovarian cancer in AYAs occurred among those between 30-39 years.

The 6th most common AYA cancer in Nigeria was colorectal cancer, accounting for 4.5% of AYA cancers (5.1% in the North and 4.1% in the South). About 1 in 5 cases of colorectal cancer in Nigeria occurred among AYAs (≈ 2 in 7 in the North and ≈ 2 in 11 in the South). There was a slight male preponderance of colorectal cancer in AYAs with a male-to-female ratio of 1:0.8 (1:0.7 in the North and 1:0.9 in the South).

Limitations of the Study

This study used data published from cancer registries in Nigeria; hence, the accuracy depends on the data reported by the cancer registries. Challenges documented from the publication about the data from the cancer registries were data availability, data inconsistency, data insufficiency and data quality concerns. Some reasons for these challenges include: industrial actions, lack of sufficient manpower, lack of funding, inefficiency of registry personnel and Boko Haram insurgency⁸ which could lead to underestimation of cancer burden and a distorted public health trend. In addition, information about the completeness/quality metrics and management of duplicate data was not available. Data from 7 seven hospital-based cancer registries were used, and may not be representative of true cancer distribution in the general population. Also, hospitals with specialised oncology centres will show artificially high numbers of cancers, especially rare cancers, due to selection bias. Furthermore, as patients move from cities/states to hospitals with specialised oncology centres, this skews the data,

making it difficult to ascertain the geographic origin of the cancer cases. It also leads to duplication of cancer registrations, as there is no unified cancer registry database in the Country as of the time of writing this article. While most of the cancer cases were diagnosed with histology/cytology, some of the diagnoses were based on clinical, radiological and laboratory diagnosis, which may affect the data quality, increase the risk of diagnostic inaccuracy and mask disparity across geographic regions. Furthermore, Procedures used for handling multiple primaries, validating age and sex or missing/unspecified values were not stated. In addition, the cancer registry data currently available for Nigeria were collected from 2009 to 2016, and this may not represent the current epidemiological status of AYA cancers in Nigeria. Also, the use of 2009-2016 data would fail to demonstrate demographic shifts, fail to reflect modern diagnostic advances and changes in tumour classification, and fail to reflect current changes in registry infrastructure. Furthermore, data on cancer survivorship were not available. Despite these limitations, this study presents a comprehensive epidemiological picture of cancers in AYAs in Nigeria using available registry data.

Conclusion

Cancers in AYAs accounted for about 1 in 4 (24.2%) of cancers in Nigeria, with a male-to-female ratio of about 1:3 and most cancers in AYAs occurred among those within the age group 30-39 breast cancer was the most common cancer among females, while bone and soft tissue cancers were the most common among male. The occurrence of AYA cancers in Nigeria varied based on sex, age group and geographical location.

Conflict(s) of Interest

The authors declare no conflicts of interest.

Funding Information

No specific funding was received for this work.

Ethical Statements

This study was a secondary analysis of aggregated, de-identified data obtained from the publicly available report Cancer in Nigeria: 2009–2016, published by the Nigerian National System of Cancer

Registries. The investigators had no access to individual-level records or direct or indirect patient identifiers. Because the study involved only analysis of publicly available, aggregated data and did not constitute human-participant research, institutional ethics committee approval was not required.

Informed Consent

Informed consent was not applicable because no participants were recruited or contacted, and the investigators analyzed only publicly available, aggregated data containing no identifiable patient information.

Data Availability Statement

Not applicable. No direct participant enrollment or prospective data collection occurred.

Authors Contribution

All authors contributed to the study conception and design. Data collection was done by Chiamaka G Ehiedu, Olabisi T Ojo, and Abel S Anegbe under the supervision of Ayorinde M Folasire, Adebayo A Oladeji, Ajibike A Orekoya and Atara I Ntekim. The draft preparation was made by Chiamaka G Ehiedu and Olabisi T Ojo, reviewed and edited by the supervisors. The final manuscript represents the aggregate of revisions and adjustments by all the authors. All authors agreed on the publication of the manuscript.

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Supplementary File

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