

ORIGINAL RESEARCH



Epidemiology of Cancers in Zambia: A significant variation in Cancer incidence and prevalence across the nation

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Abstract

Background

Cancer is one of the leading causes of death worldwide. More than two-thirds of deaths due to cancers occur in low- and middle-income countries where Zambia belongs. This study, therefore, sought to assess the epidemiology of various types of cancers in Zambia.

Methods

We conducted a retrospective observational study using the Zambia National Cancer Registry (ZNCR) population based data from 2007 to 2014. Zambia Central Statistics Office (CSO) demographic data were used to determine catchment area denominator used to calculate prevalence and incidence rates of cancers. Age-adjusted rates and case fatality rates were estimated using standard methods. We used a Poisson Approximation for calculating 95% confidence intervals (CI).

Results

The seven most cancer prevalent districts in Zambia were Luangwa, Kabwe, Lusaka, Monze, Mongu, Katete and Chipata. Cervical cancer, prostate cancer, breast cancer and Kaposi's sarcoma were the four most prevalent cancers as well as major causes of cancer related deaths in Zambia. Age adjusted rates and 95% CI for these cancers were: cervix uteri (186.3; CI = 181.77 – 190.83), prostate (60.03; CI = 57.03 – 63.03), breast (38.08; CI = 36.0 – 40.16) and Kaposi's sarcoma (26.18; CI = 25.14 – 27.22). CFR were: Leukaemia (38.1%); pancreatic cancer (36.3%); lung cancer (33.3%); and brain, nervous system (30.2%). The cancer population was associated with HIV with p-value of 0.000 and a Pearson correlation coefficient of 0.818.

Conclusions

The widespread distribution of cancers with high prevalence observed in the southern zone may have been perpetrated by lifestyle and sexual culture (traditional male circumcision known to prevent STIs is practiced in the northern belt) as well as geography. Intensifying cancer screening and early detection countrywide as well as changing the lifestyle and sexual culture would greatly help in the reduction of cancer cases in Zambia.

Keywords: Cancer epidemiology; Cervical cancer; Prostate cancer; Breast cancer, Kaposi's sarcoma; Cancers in Zambia;

Introduction

The global burden of cancer has been on the increase over the past few decades despite some remarkable advances in treatment and prevention¹. Cancer continues to be one of the leading causes of death worldwide. This has driven scientists to make advancements in conventional medicine as well as anticancer nanomedicine and nanotechnology to broaden the spectrum of combating the scourge²⁻⁴. In the year 2017, cancers caused over 9.6 million deaths worldwide and moved from the third leading cause of death in 1990 to the second leading cause behind cardiovascular diseases⁵⁻⁷. More than two-thirds of deaths due to cancers occur in low- and middle-income countries⁸. Low-income countries reported approximately 51% of all cancers globally in the year 1975 but this proportion steadily increased to 55% in 2007. It is estimated that by 2050, low-income countries will account for 61% of all cancers globally⁹⁻¹¹.

The global increase in the number of cancer cases is due to multiple factors, which include: lifestyle factors (smoking, alcohol, lack of physical exercise, poor/unhealthy

diet, environmental factors (exposure to carcinogens), socioeconomic status and infectious agents¹²⁻¹⁵. Developing countries have 26% cancers attributable to infection while developed countries have 8% which is a third of those in developing countries¹⁶. The oncogenic infections that have been linked to these cancers are Human Papilloma Virus (HPV)¹⁷, Hepatitis B Virus (HBV)¹⁸, *Helicobacter pylori* (*H. pylori*)¹⁹, Human Herpes Virus (HHV8)²⁰, and Epstein Barr Virus (EBV)²¹.

Although cancer incidence has been increasing in every part of the world, there are huge inequalities between developed and developing countries. Age adjusted incidence rates remain highest in developed countries and mortality is relatively much higher in developing countries due to lack of early detection and access to treatment facilities⁸. Infections due to human papillomavirus and hepatitis B and C viruses significantly contribute to the burden of cervical and liver cancers respectively on the African Continent⁸. The most common cancers in the African region are cervical, breast, liver and prostate as well as Kaposi's sarcoma and non-

Hodgkin's lymphoma⁸.

Zambia is one of the sub-Saharan African countries that has not been spared by the increasing burden of cancers. Many lives can be saved if appropriate investment is made in raising public awareness on the early signs and symptoms of common cancers as well as implementation of early detection strategies⁸. This study therefore sought to assess the epidemiology of cancers in Zambia.

Materials and Methods

Study site

Zambia is located in the southern zone of the African continent and lies between latitudes 8° and 18° south, and longitudes 22° and 34° east. The country has a total geographical area of 753,612km^{2,22}.

Study design

We conducted a retrospective observational study using the Zambia National Cancer Registry (ZNCR) population based data from 2007 to 2014. ZNCR collects and keeps population based cancer data in Zambia. Sources of data include Health Management Information System (HMIS), Government and private Hospital Registries, which are also linked from grass root level by health centres to ensure that all suspected cancer cases are referred to the hospitals. Other sources include death records, Community Health Workers (CHW) and Churches Health Organisation (CHAZ). The collected information include patient's personal details (names, age, sex, date of birth and residential address at diagnosis). Hospital details (hospital, consultant patient unit number), diagnostics, tumour and treatment details (site of primary, morphology, laterality, stage, grade of tumour, basis of diagnosis, date of diagnosis, treatment indicators) as well as death details (alive or dead, date of death, cause(s) and place of death).

ZNCR ensures that cancer registration data is stored securely, backed up and only accessible to authorised cancer registry staff and researchers. All cancer notification forms or books are filed and locked in a secure place. Information request for data on cancers are made in writing to the Registrar and the Permanent Secretary at the Ministry of Health for approval. This study got formal administrative approval from the Cancer registry for data access, approved by both the University of Zambia Biomedical Research Ethics Committee (UNZABREC) and the National Health Research Authority of Zambia with reference number 003-08-17.

Zambia Central Statistics Office (CSO) provided us with shapes files for provinces and districts as well as demographic data, which we used to determine prevalence and Age-specific rates while World Standard Population²³ was used to determine Standardised Incidence Rates (SIR). Case fatality rate (CFR) was calculated as: . We used a Poisson Approximation for calculating 95% confidence intervals. The 95% confidence interval for the age-standardised rate was calculated as:

$$RATE \pm 1.96 * \sqrt{var}$$

Where the variance for the age-standardised rate was given

$$\sum \left(\frac{p_i}{\sum p_i} \right)^2 * \frac{r_i^2}{d_i}$$

d_i is the number of events in age group i in the study population

r_i is the incidence rate in the study population for the persons in age group i

P_i is the number of persons in age group i in the standard population.

Mapping of the distribution of cancers at district and provincial levels were done using Geographical Information System (ArcGIS) version 10.3.1, Redlands, CA. Some big districts in Zambia were split to form new districts for effective administrative purposes. New population figures for new districts were not available hence population figures for original districts were considered. For instance, districts such as Ikelenge, Zimba and Mafinga were still part of the original districts namely, Mwinilunga, Kalomo and Isoka respectively during the study period hence; we considered cancer rates of original districts in these new districts.

Sampling

Since our study was registry based, we considered all cancer cases in the Zambia National Cancer Registry database from 2007 to 2014. We ,however, excluded cancer cases not belonging to any of the ten provinces in Zambia (i.e. not coded cases from any region in Zambia) for the purpose of GIS mapping which required that cancer cases be linked to districts and provinces of origin. In addition, we sampled and surveyed ten districts across Zambia to assess the incidence and prevalence of cancer and determine risk factors contributing to escalating cancer cases.

Statistical Analyses

We used SPSS version 21 in our data analyses. Logistic regression model was used to determine the association between cancer and HIV while Pearson Correlation was used to determine the correlation coefficient. We used a Poisson Approximation for calculating 95% confidence intervals.

Results

Distribution of cancers by region and province

During our study period from 2007 to 2014, a total of 21,512 cancer cases were notified to ZNCR of which 7,560 (35.14%) were males and 13,952 (64.86%) were females. The four most prevalent types of cancers were cervical (97.1/10000), prostate (22.1/100,000), breast (19.3/100,000) and Kaposi sarcoma (19.2/100,000). Cancers were widely distributed in Zambia with high prevalence (105-281/100,000) concentrated in the southern zone comprising Eastern, Central, Lusaka, Western and Southern Provinces. The southern zone was divided into high prevalence and medium prevalence regions. Eastern and Lusaka Provinces formed the high prevalence region (126-281/100,000) while Central, Southern and Western Provinces formed the medium prevalence region (105-125/100,000). The northern zone comprising North Western, Copperbelt, Luapula, Northern and Muchinga Provinces had relatively low cancer prevalence of 78-104/100,000 population.

By gender, cancers were more prevalent in females than in males in all the ten provinces with mean sex ratio F/M = 1.85. Table 1 shows the prevalence of cancers by province and sex. The prevalence of cancer in both males and females were more in Lusaka, Eastern and Central Provinces. However,

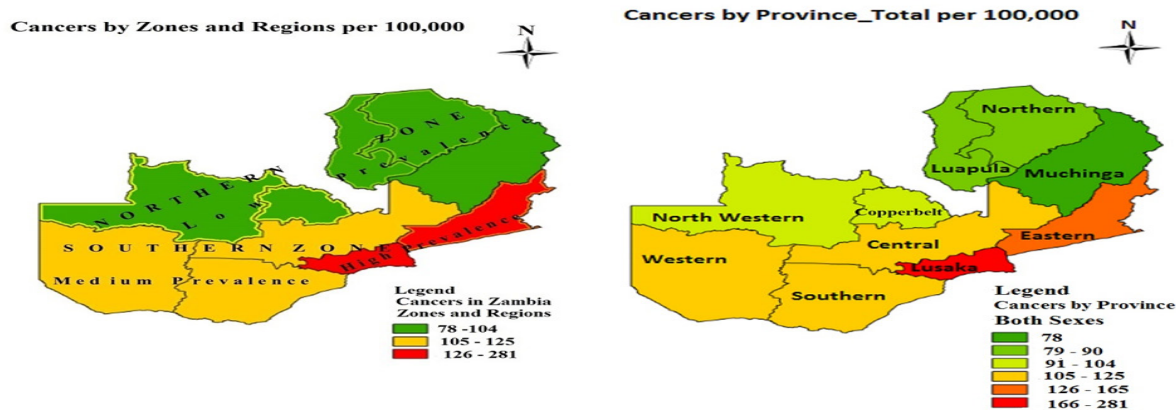


Figure 1: Regional and provincial distribution of cancers in Zambia

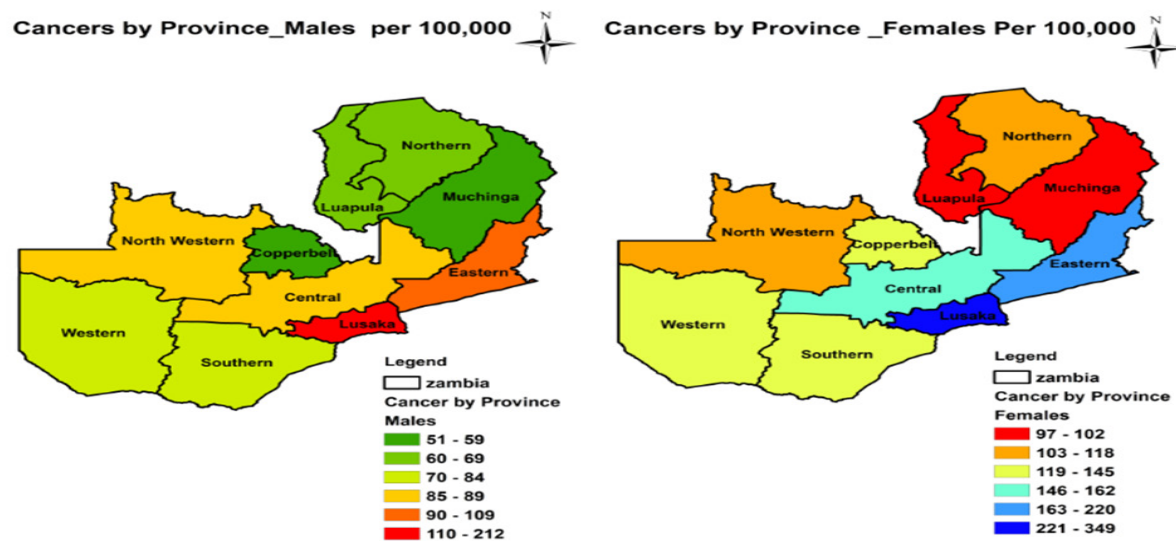


Figure 2: Provincial distribution of cancers (all types) by sex

Table 1: Distribution of cancers (all types) in Zambia by Province

Province	Prevalence Rate Per 100,000 Population		
	Total	Males	Females
Central	125	87	162
Copperbelt	97	51	143
Eastern	165	109	220
Luapula	84	66	102
Lusaka	281	212	349
Northern	90	69	118
Muchinga	78	59	97
North West	104	89	118
Southern	115	83	145
Western	114	84	142

for males, the prevalence was also more in Western Province. In addition, Southern, Copperbelt and Western Provinces had more prevalence of cancer in females
Figure 2 shows details of provincial distribution of cancers by sex.

Distribution of cancers by district

The distribution of cancers at district level was similar to the zonal pattern at provincial level. Figure 3 shows the geographical distribution of cancers by district in Zambia. Some districts such as Mafinga, Ikelenge andimba were still part of the original districts namely Isoka, Mwinilunga and Kalomo respectively at the beginning of our research period hence: are shown as combined districts in Table 2. Some big districts in Zambia were split to form new districts for effective administrative purposes. The prevalence of cancers in the original districts reflects cancer prevalence in the new districts.

Luangwa was the most cancer prevalent district in Zambia with the rate of 1,014 per 100,000 population, followed by Kabwe with the prevalence rate of 379 per 100,000 population. Lusaka was the third district with prevalence rate of 311 per 100,000, Monze ranked fourth with the rate of 282 per 100,000, Mongu ranked fifth with prevalence rate of 260 per 100,000, Katete ranked sixth with prevalence rate of 229 per 100,000 population and Chipata district ranked seventh with prevalence of 213 per 100,000 population. All these seven districts are from the southern zone.

The four most cancer prevalent districts in the northern zone were Kasempa (193 / 100,000), Kasama (168 / 100,000), Ndola (165 / 100,000) and Mansa (165 / 100,000 population). The least four cancer prevalent districts in Zambia were

Table 2: Ranked prevalence of cancers (all types) by district per 100,000 population

District	Total	Males	Females	District	Total	Males	Females
Luangwa	1014	766	1257	Chinsali	90	52	127
Kabwe	379	251	499	Mkushi	88	57	120
Lusaka	311	233	387	Mwense	88	76	99
Monze	282	157	404	Luwingu	87	360	114
Mongu	260	176	337	Kitwe	82	52	113
Katete	229	142	313	Kaoma	80	62	96
Chipata	213	133	291	Sesheke	78	64	91
Kasempa	193	176	210	Isoka/ Mafinga	77	62	91
Kasama	168	118	217	Kafue	77	66	88
Ndola	165	76	252	Lukulu	77	37	114
Mansa	165	110	217	Chadiza	74	49	99
Choma	158	126	189	Samfya	70	74	67
Luanshya	156	77	234	Siavonga	70	49	90
Chongwe	155	123	187	Namwala	69	66	71
Petauke	153	102	202	Solwezi	65	60	71
Mumbwa	144	116	171	Kapiri Mposhi	61	32	89
Mbala	142	96	187	Chibombo	56	45	68
Livingstone	138	118	157	Nakonde	53	36	70
Zambezi	135	116	155	Sinazongwe	48	49	47
Mazabuka	126	86	165	Chama	48	47	48
Lundazi	120	86	153	Kalomo/ Zimba	45	34	47
Gwembe	113	80	145	Mpongwe	44	19	70
Mambwe	112	110	113	Nchelenge	43	30	55
Kalabo	111	91	130	Chililabombwe	40	19	61
Mufumbwe	110	97	124	Kalulushi	35	13	57
Mwinilunga/Ikelenge	107	73	141	Milenge	29	20	38
Nyimba	107	72	141	Mpulungu	29	14	43
Kabompo	106	97	116	Mungwi	27	19	35
Serenje	105	78	132	Kaputa	26	16	35
Chavuma	105	102	108	Shang'ombo	19	18	20
Mufulira	104	60	148	Chilubi	18	14	22
Mpika	102	82	122	Masaiti	17	17	17
Mporokoso	100	77	123	Lufwanyama	16	2	31
Kawambwa	95	78	110	Itezhi tezhi	16	17	14
Senanga	93	84	101	Kazungula	14	13	16
Chingola	93	53	133	Chienge	12	9	15

Lufwanyama (16 / 100,000), Itezhi tezhi (16 / 100,000), Kazungula (14 / 100,000) and Chienge (12 / 100,000 population) during the study period. Table 2 shows details of ranked prevalence of cancers by district per 100,000 population.

With few exceptions of districts such as Luwingu, Sinazongwe and Samfya where cancers were more prevalent in males than in females, most districts in Zambia had high cancer prevalence in females than in males. The trend in the total district pattern (see Figure 3) remained the same as cancer distribution by sex at district level (see Figure 4). The detailed geographical distribution of cancers by sex at district level is shown in Figure 4.

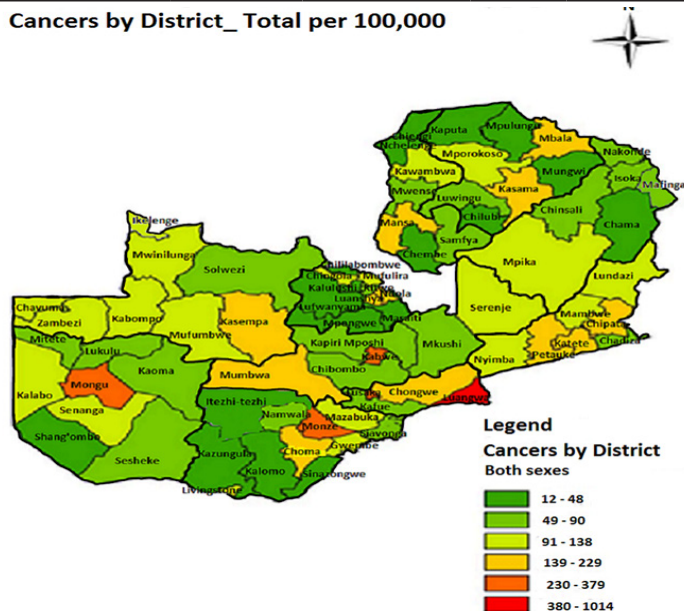
Morbidity and mortality of cancers in Zambia

Cervical cancer was the most prevalent cancer in Zambia followed by prostate cancer, breast cancer and Kaposi's sarcoma. The prevalence rate of cervical cancer was 97.1 per 100,000 females and represented 34.3% of all cancers in Zambia. In proportional terms, Kaposi's sarcoma ranked second and represented 13.3%, prostate cancer ranked third and represented 7.7% while breast cancer ranked fourth and represented 6.8%. Myeloma and Other Pharynx were the least prevalent among other cancers; each represented 0.2% of all cancers in Zambia. Table 3 shows details of prevalence and proportions of cancers in Zambia from 2007 to 2014.

Age specific rates, Standardised Incidence Rates (SIR) and the 95% confidence intervals (CI) for all cancers in Zambia

Table 3: The Prevalence and proportions of cancers in Zambia, 2007 - 2014

Cancer Type	Cases Both Sexes	Prevalence per 100, 000 pop.	Male		Female		Both Sexes Proportion (%)
			Cases	Proportion (%)	Cases	Proportion (%)	
Cervix Uteri	7389	97.1			7389	53	34.3
Kaposi's Sarcoma	2891	19.2	1759	23.3	1132	8.1	13.4
Prostate	1651	22.1	1651	21.8			7.7
Breast	1469	19.3	41	0.5	1428	10.2	6.8
Eye	909	6.0	431	5.7	478	3.4	4.2
Non-Hodgkin Lymphoma	665	4.4	358	4.7	307	2.2	3.1
Oesophagus	581	3.9	365	4.8	216	1.5	2.7
Large Bowel	539	3.6	278	3.7	261	1.9	2.5
Bladder	478	3.2	261	3.5	217	1.6	2.2
Liver	460	3.1	283	3.7	177	1.3	2.1
Other Skin	406	2.7	192	2.5	214	1.5	1.9
Stomach	395	2.6	210	2.8	185	1.3	1.8
Bone	252	1.7	130	1.7	122	0.9	1.2
Vulva/Vagina	246	3.2			246	1.8	1.1
Ovary	238	3.1			238	1.7	1.1
Kidney	171	1.1	80	1.1	91	0.7	0.8
Oral Cavity	168	1.1	95	1.3	73	0.5	0.8
Penis	166	2.2	166	2.2			0.8
Hodgkin Disease	151	1.0	99	1.3	52	0.4	0.7
Melanoma of the skin	145	1.0	56	0.7	89	0.6	0.7
Lung	135	0.9	90	1.2	45	0.3	0.6
Brain, Nervous System	126	0.8	69	0.9	57	0.4	0.6
Leukaemia	126	0.8	79	1	47	0.3	0.6
Larynx	125	0.8	102	1.3	23	0.2	0.6
Uterus	115	1.5			115	0.8	0.5
Pancreas	102	0.7	61	0.8	41	0.3	0.5
Corpus Uteri	95	0.6			95	0.7	0.4
Thyroid	92	0.6	30	0.4	62	0.4	0.4
Nasopharynx	85	0.6	51	0.7	34	0.2	0.4
Myeloma	45	0.3	27	0.4	18	0.1	0.2
Other Pharynx	42	0.3	29	0.4	13	0.1	0.2
Others	1054	7.0	567	7.5	487	3.5	4.9
Totals	21512	142.8	7560	100	13952	100	100



are shown in Table 4. Rates were adjusted using the world standard population [23]. The standardised incidence rates and 95% confidence intervals for the top four cancers in Zambia were: cervix uteri (186.3; 95% CI = 181.77 – 190.83), prostate (60.03; 95% CI = 57.03 – 63.03), breast (38.08; 95% CI = 36.0 – 40.16) and Kaposi's sarcoma (26.18; 95% CI = 25.14 – 27.22). Peaks of age specific rates were in the age range 40 – 49 years for cervix uteri, 60 – 69 years for prostate cancer, and 40 – 49 years for breast cancer and 30 – 39 years for Kaposi's sarcoma.

Like other diseases, various forms of cancers have been classified in the International Classification of Diseases known as ICD10.

Fig 3: Distribution of cancers (all types) by district

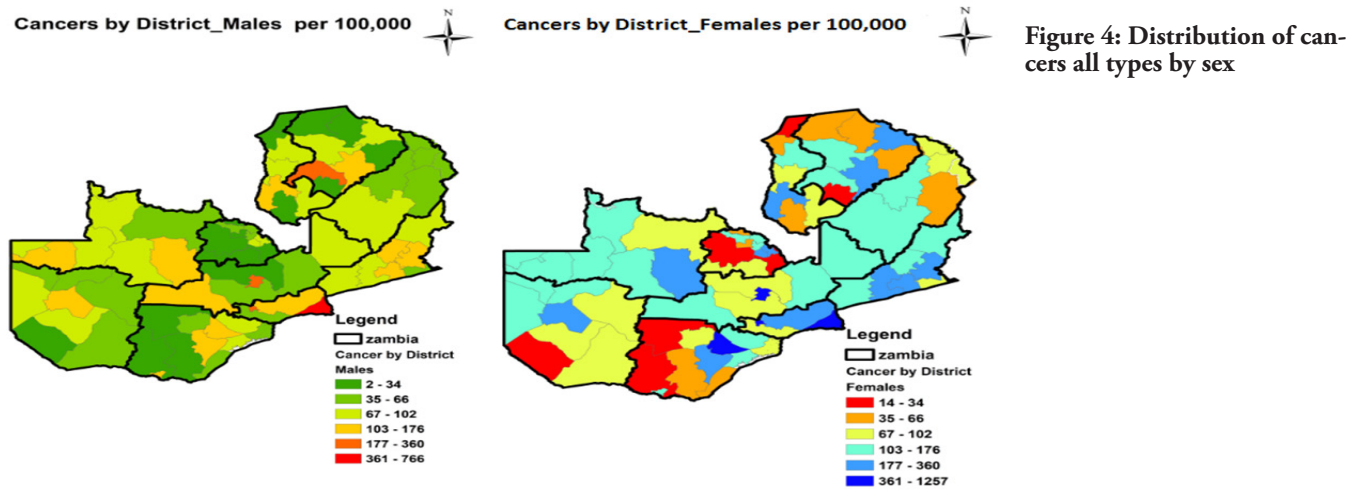


Table 4: Standardised Incidence Rates (SIR) for all cancers in Zambia, 2007 - 2014

CANCER TYPE	Age-specific Incidence Rate per 100,000 population									SIR all ages	95% CI	
	0-9yr	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+		Lower	Upper
Cervix Uteri	0	0.07	5.5	23.41	49.68	46.11	39.78	14.09	7.67	186.3	181.77	190.83
Prostate	0	0	0	0.07	0.89	5.52	22.83	21.92	8.8	60.03	57.03	63.03
Breast	0	0.03	1.29	4.03	9.46	8.53	9.09	4.38	1.26	38.08	36	40.16
Kaposi's Sarcoma	0.35	0.65	3.58	7.66	7.42	3.17	1.82	0.64	0.88	26.18	25.14	27.22
Oesophagus	0.01	0.01	0.11	0.64	1.6	1.67	2.49	1.45	0.4	8.38	7.66	8.38
Eye	0.7	0.1	0.57	1.97	2.27	1.06	0.85	0.25	0.52	8.29	7.69	8.89
Bladder	0.01	0.02	0.12	0.34	0.78	1.36	2.94	1.41	0.46	7.45	6.74	8.16
Large Bowel	0	0.03	0.32	0.64	1.63	1.53	1.93	0.87	0.24	7.19	6.54	7.84
Non-Hodgkin Lymphoma	0.31	0.45	0.51	0.8	1.46	1.33	1.28	0.48	0.2	6.82	6.23	7.41
Vulva/Vagina	0	0.01	0.31	0.8	1.61	1.22	1.23	0.46	0.3	5.94	5.14	6.74
Liver	0.02	0.09	0.27	0.56	1.21	1.22	1.3	0.83	0.36	5.86	5.28	6.44
Ovary	0.01	0.14	0.41	0.47	1.56	1.34	0.98	0.62	0.14	5.66	4.88	6.44
Stomach	0.01	0.02	0.12	0.41	0.93	1.23	1.53	1.04	0.32	5.61	5.02	6.2
Other Skin	0.05	0.08	0.28	0.53	0.81	1	1.26	0.69	0.38	5.07	4.53	5.61
Penis	0.02	0	0.03	0.26	0.98	1.28	1.38	0.58	0.41	4.93	4.13	5.73
Uterus	0	0.01	0.12	0.26	1.04	0.61	0.64	0.1	0.11	2.89	2.33	3.45
Corpus Uteri	0	0	0.06	0.12	0.42	0.85	1.15	0.2	0.07	2.87	2.26	3.48
Melanoma of the skin	0	0.02	0.02	0.1	0.28	0.48	0.88	0.39	0.09	2.26	1.87	2.65
Bone	0.1	0.38	0.25	0.22	0.36	0.22	0.52	0.12	0.07	2.25	1.92	2.58
Oral Cavity	0.04	0.05	0.08	0.13	0.36	0.55	0.63	0.34	0.07	2.24	1.87	2.61
Larynx	0.01	0	0.01	0.01	0.24	0.45	0.99	0.35	0.07	2.14	1.75	2.53
Lung	0	0	0.03	0.07	0.2	0.55	0.72	0.39	0.16	2.12	1.75	2.49
Pancreas	0	0	0.02	0.06	0.34	0.5	0.27	0.19	0.06	1.45	1.16	1.75
Hodgkin Disease	0.08	0.19	0.13	0.15	0.32	0.19	0.2	0.05	0.04	1.34	1.09	1.59
Thyroid	0	0.04	0.07	0.06	0.2	0.27	0.38	0.11	0.09	1.22	0.95	1.49
Kidney	0.45	0.09	0.01	0.1	0.13	0.12	0.11	0.07	0.07	1.16	0.95	1.37
Brain, Nervous System	0.16	0.08	0.1	0.08	0.23	0.2	0.18	0.09	0.02	1.13	0.9	1.36
Nasopharynx	0.03	0.05	0.04	0.11	0.21	0.25	0.29	0.02	0	0.99	0.75	1.23
Leukaemia	0.24	0.21	0.04	0.04	0.09	0.06	0.04	0.05	0	0.78	0.62	0.94
Other Pharynx	0	0.01	0.01	0.01	0.07	0.11	0.29	0.09	0.06	0.65	0.58	0.72
Myeloma	0	0.01	0.01	0.04	0.07	0.28	0.16	0.04	0.02	0.63	0.43	0.83
Others	0.35	0.52	0.84	1.07	1.98	2.47	2.88	1.32	0.68	12.11	11.29	12.93

Table 5: Cancer classification and their mortality and CFR in Zambia, 2007 - 2014

Cancer Type	International Classification of Diseases (ICD10)	Cases	Deaths	Case Fatality Rate (%)
Leukaemia	C91-C95	126	48	38.1
Pancreas	C25	102	37	36.3
Lung	C33-C34	135	45	33.3
Brain, Nervous System	C70-C72	126	38	30.2
Kidney	C64	171	38	22.2
Liver	C22	460	91	19.8
Stomach	C16	395	78	19.7
Oesophagus	C15	581	113	19.4
Bladder	C67	478	90	18.8
Ovary	C56	238	44	18.5
Myeloma	C90	45	8	17.8
Nasopharynx	C11	85	15	17.6
Corpus Uteri	C54	95	16	16.8
Bone	C40-C41	252	40	15.9
Melanoma of the Skin	C43	145	21	14.5
Non-Hodgkin Lymphoma	C82,C85,C96	665	89	13.4
Prostate	C61	1651	215	13.0
Large Bowel	C18-C21	539	68	12.6
Kaposi's Sarcoma	C46	2891	332	11.5
Thyroid	C73	92	10	10.9
Larynx	C32	125	12	9.6
Hodgkin Disease	C81	151	14	9.3
Uterus	C55	115	9	7.8
Breast	C50	1469	113	7.7
Cervix Uteri	C53	7389	543	7.3
Penis	C60	166	12	7.2
Oral Cavity	C00-C06	169	12	7.1
Other Skin	C44	406	25	6.2
Eye	C69	909	53	5.8
Vulva/Vagina	C51-C52	246	12	4.9
Other Pharynx	C09-C10, C12-C14	42	2	4.8

Table 5 shows details of ICD10 codes for cancers, their mortality and case fatality rates (CFR). Leukaemia (38.1%) and pancreatic cancer (36.3%) have the highest CFR among cancers in Zambia followed by lung cancer (33.3%) and brain, nervous system (30.2%).

Although CFR has been very high in Leukaemia, pancreatic cancer, lung cancer and cancers of the brain and nervous system, cancer morbidity rates were high in cervical cancer, prostate cancer, Kaposi's sarcoma, breast cancer and oesophageal cancer. During our study period 2007 to 2014, there were 543 cervical cancer deaths (CFR =7.3). Prostate cancer ranked second with 215 deaths (CFR=13) followed by Kaposi's sarcoma with 332 deaths (CFR=11.5), then breast cancer with 113 deaths (CFR=7.7) and oesophagus cancer with 113 deaths (CFR=19.4).

Association between cancers and HIV in Zambia

The cancer population in Zambia has high HIV prevalence. Results of the logistic regression analysis and Pearson

correlation indicated a strong association between cancer and HIV with p- value of 0.000 and correlation coefficient of 0.818. Cancer cases, HIV positive cases and percentage of HIV positive cancer cases are shown in Table 6.

Discussion

This study assessed the incidence and prevalence of major cancers in the Zambian population as well as the associated risk factors. The study makes an important contribution in showing the incidence and prevalence of cancers in Zambia, which will be important for primary and secondary prevention methods.

Although cancers were widely distributed in Zambia, this study established that cancers were more prevalent in the southern zone than the northern zone. The southern zone comprised the high and medium prevalence regions. Lusaka and Eastern provinces with very high cancer prevalent districts such as Luangwa, Katete, Chipata and Lusaka formed the belt of the high prevalence region while

Table 6: Association between cancers and HIV in Zambia, 2007 – 2014

ICD10	Cancer Type	Cases	H I V positive	Percentage of HIV +	r	p- value
C00-C06	Oral Cavity	169	20	12		
C09-C10, C12-C14	Other Pharynx	42	4	10		
C11	Nasopharynx	85	22	26		
C15	Oesophagus	581	71	12		
C16	Stomach	395	41	10		
C18-C21	Large Bowel	539	60	11		
C22	Liver	460	43	9		
C25	Pancreas	102	6	6		
C32	Larynx	125	14	11		
C33-C34	Lung	135	12	9		
C40-C41	Bone	252	6	2		
C43	Melanoma of the skin	145	11	8		
C44	Other Skin	406	65	16		
C46	Kaposi's Sarcoma	2891	1734	60		
C50	Breast	1469	169	12		
C51-C52	Vulva/Vagina	246	58	24		
C53	Cervix Uteri	7389	1331	18	0.818	0.000
C54	Corpus Uteri	95	8	8		
C55	Uterus	115	14	12		
C56	Ovary	238	25	11		
C60	Penis	166	29	17		
C61	Prostate	1651	99	6		
C64	Kidney	171	4	2		
C67	Bladder	478	22	5		
C69	Eye	909	154	17		
C70-C72	Brain, Nervous System	126	10	8		
C73	Thyroid	92	8	9		
C81	Hodgkin Disease	151	31	21		
C82,C85,C96	Non-Hodgkin Lymphoma	665	161	24		
C90	Myeloma	45	3	7		
C91-C95	Leukaemia	126	5	4		
C07-C08, C17,...	Others	1054	97	9		
	Totals	21512	4337	20		

Central, Southern and Western provinces with high cancer prevalent districts such as Kabwe, Mongu and Monze among others formed the medium prevalence region. Although the northern zone had relatively low prevalence of cancers, there were notable districts such as Kasempa, Kasama, Ndola and Mansa with relatively high prevalence rates.

Some studies argue that the observed geographic variation in cancer distribution is due to differences in the availability of cancer screening and detection facilities as well as health seeking behaviour²⁴⁻²⁶. Our study however has established that geographic location played a big role in the pattern of cancer distribution in Zambia. This observation was made after mapping cancer cases based on patients' residential addresses. Distinct patterns were geographically displayed implying that geographic distribution played a role.

This study also observed that the northern belt of Zambia practices childhood male circumcision unlike the southern

belt. Previous studies have shown that male circumcision reduces the spread of HPV, which causes cervical cancer²⁹. Low uptake of childhood circumcision in the southern region could therefore be linked with the observed high prevalence of cervical cancer in that region. Furthermore, lack of awareness and education of cervical cancer and HPV coupled with low screening uptake led to the spread of human papilloma virus (HPV) which causes cervical cancer²⁴.

Sex disaggregated data showed that cancers in Zambia affected more females than males in the ratio 64.86% to 35.14% (F/M = 1.85). This is mostly because of the high prevalence of cervical cancer in Zambian women. This study identified cervical cancer, prostate cancer, breast cancer and Kaposi's sarcoma as the top four most prevalent cancers in Zambia. Cervical cancer, with standardised incidence rate of 186.3 per 100,000 females was the leading cause of

morbidity and mortality among cancers in Zambian women. This is contrary to other studies, which established that cervical cancer was the third leading cause of cancer-related deaths in developing countries, which is not the case with Zambia³⁰. Age standardized incidence rates (Table 4) show that cervical cancer rates peak around the age range of 40-49 years implying that this age group is the high-risk group for cervical cancer in Zambia.

The prevalence of HPV infection was 5% in North America and 21% in Africa. This is as a result of high screening uptake and vaccine which are more available in the west compared to Africa^{24,27}. In sub-Saharan Africa, cervical cancer incidence has been influenced by the high prevalence of HIV infection, which has been found to promote progression of cancerous lesions³⁰. Cervical cancer incidence rates decreased by as much as 4% annually, and 70% overall in developed countries where screening programs were introduced several decades ago^{32,33}. The observed adjusted incidence rates of cervical cancer in Zambia is similar to observed trends in Zimbabwe and Uganda^{27,4,35}.

Prostate cancer was the second most prevalent cancer after cervical cancer and number one cancer in Zambian men with adjusted standardised incidence rate of 60.03 per 100,000 males. These results are similar to the results of other studies, which indicated that prostate cancer was the most prevalent cancer in men³⁰. In this study, prostate cancer peak ranged from 60 – 69 years. These results indicate that prostate cancer is more prevalent in ageing men.

Breast cancer ranked third among cancers in Zambia and second in women after cervical cancer. It had an adjusted standardised incidence rate of 38.08 per 100,000 females. Breast cancer peak ranged from 40 – 49 years, which is the productive age group for women. On the global scale, breast cancer is the leading cause of cancer-related deaths among females. It is highest in the United States and Western Europe while Africa and Asia have relatively low rates^{30,36}. Risk factors for breast cancer include weight gain after age 18 years, excess body weight (for postmenopausal breast cancer), use of menopausal hormone therapy (MHT), physical inactivity, alcohol consumption, and reproductive and hormonal factors, such as a long menstrual history, and nulliparity or later age at first birth. Risk factors for breast cancer also include inherited changes in BRCA1 and BRCA2 genes^{37,38}. On the other hand, breastfeeding decreases the risk of breast cancer³⁸.

The distribution of some cancers in Zambia followed the trend of HIV epidemiology. This study established a strong positive association between cancers and HIV with p-value of 0.000. These results indicate that HIV is a risk factor of cancers in Zambia. Some cancers such as Kaposi's sarcoma are HIV defining malignancies. Kaposi's sarcoma ranked fourth among cancers in Zambia with adjusted incidence rate of 26.18 per 100,000 population. Kaposi's sarcoma peak ranged from 30 – 39 years. This study observed that Kaposi's sarcoma was more prevalent in males than in females (see Table 3). The incidence of Kaposi's sarcoma is higher in Sub-Saharan Africa than in developed countries. The endemic African form of Kaposi's sarcoma was reported in the 1960s³⁹, but with the emergence of HIV/AIDS, an atypical aggressive type was reported in most African countries^{40,41,42}. Although morbidity rate was high in cervical, prostate and breast cancers as well as oesophageal cancer and Kaposi's sarcoma, case fatality rate was moderate in these cancers compared to Leukaemia, pancreatic cancer, lung cancer and

cancers of the brain and nervous system where case fatality rates were high.

This study had some limitations, firstly, the missing information in the database due to challenges in active cancer surveillance made us leave some patients' files, as they could not be linked to districts of origin. Secondly, the Zambia National Cancer Registry had huge backlog of data due to understaffing. This brought about the adjustment of our study from 2007 - 2017 to 2007 - 2014 period. Lastly, registry based studies have challenges to provide precise data as registries data capturing system do not always suit all study designs. ZNCR did not fully capture risk factors for all cancers hence; we could not critically determine all risk factors in this study.

In conclusion, the widespread distribution of cancers with high prevalence in the southern zone was perpetrated by lifestyle and sexual culture as well as geography. Traditional male circumcision known to prevent STIs is practiced in the northern belt (particularly North Western Province) and not the southern belt. The seven most cancer prevalent districts in Zambia were Luangwa, Kabwe, Lusaka, Monze, Mongu, Katete and Chipata. Cervical cancer, prostate cancer, breast cancer and Kaposi's sarcoma were the four most prevalent cancers as well as major causes of cancer related deaths in Zambia; although Leukaemia and pancreatic cancer had, the highest case fatality rate. Most cancers in Zambia are HIV defining malignancies and their upward trend is due to the increase in HIV cases. Changing the lifestyle and sexual culture (multiple sexual partners) would greatly help in the prevention of rampant spread of HPV, HIV, HBV and EBV among others which would result in the reduction of cancer cases in Zambia. Furthermore, intensifying cancer screening and early detection countrywide would help to drastically reduce cancer prevalence in Zambia over time.

Competing Interests

Authors declare that they have no competing interests.

Authors' Contributions

MK designed the study, developed and programmed the model and drafted the manuscript. HS and LL approved the model and provided technical support in analyses. All authors read and approved the manuscript.

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