

# **Epidemiology of Cancers in Zambia: A Significant Variation in Cancer Incidence and Prevalence across the Nation**

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## ABSTRACT

### Background

Cancers are 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 cancers in Zambia.

### Methods

We conducted a retrospective observational study nested on Zambia National Cancer Registry (ZNCR) histopathological and clinical data from 2007 to 2014. Zambia Central Statistics Office (CSO) demographic data were 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 top seven most cancer prevalent districts in Zambia have been Luangwa, Kabwe, Lusaka, Monze, Mongu, Katete and Chipata. Cervical cancer, prostate cancer, breast cancer and Kaposi's sarcoma were the top four most prevalent cancers as well as major causes of cancer related deaths in Zambia. Standardised Incidence Rates and 95% CI for the top four 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%). Cancers were associated with HIV with  $p$ - value of 0.000 and Pearson correlation coefficient of 0.818.

### Conclusions

The widespread distribution of cancers with high prevalence in the southern zone has been perpetrated by lifestyle and sexual culture 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 cancers has been on the increase over the past few decades despite some remarkable advances in early cancer detection, treatment and prevention [1]. Cancers have continued to claim human lives and are one of the leading causes of death worldwide hence the realization by many organizations and researchers to make advancements in conventional medicine as well as anticancer nanomedicine and nanotechnology to broaden the spectrum of combating the scourge [2-4]. In the year 2013, cancers caused over 8 million deaths worldwide and have moved from the third leading cause of death in 1990 to the second leading cause behind cardiovascular diseases in 2013[5-7]. More than two thirds of deaths due to cancers occur in low- and middle- income countries [8]. 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 globally [9-11].

The global increase in the number of cancer cases is due to multiple factors such as lifestyle trends that are associated with economic development and the increasing adoption of risk behaviour such as consumption of unhealthy diets, lack of physical exercise, harmful use of alcohol and tobacco as well as exposures to environmental pollutants [12-15]. Third world countries have 26% cancers attributable to infection while developed countries have 8% which is one third of cancers attributable to infection in third world countries [16]. 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 third world countries. Incidence rates remain highest in developed countries, but mortality is relatively much higher in third world countries due to lack of early detection and access to treatment facilities[8]. 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 Continent [8]. The most common cancers in the African region are cervical, breast, liver and prostate as well as Kaposi's sarcoma and non-Hodgkin's lymphoma [8].

Zambia is one of the sub-Saharan African countries that have 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 strategies [8]. This study therefore sought to assess the epidemiology of cancers in Zambia with a view of finding amicable solution.

## MATERIALS AND METHODS

### Study site

The Republic of 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<sup>2</sup> [22].

### Study design

We conducted a retrospective observational study nested on Zambia National Cancer Registry (ZNCR) histopathological and clinical data from 2007 to 2014. ZNCR collects and keeps medical records of all diagnosed cancers in Zambia. The collected information include core variables such as patients 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) and death details (alive or dead, date of death, cause(s) and place of death).

All health facilities countrywide submit reports of all diagnosed cancers to ZNCR. Medical records collected in form of hard copies are entered and stored in the ZNCR main database by data entry clerks. ZNCR ensures that cancer registrations data is stored securely, backed up and only accessible to authorised cancer registry staff. 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 was therefore approved by both the University of Zambia Biomedical Research Ethics Committee (UNZABREC) and the National Health Research Authority of Zambia.

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 Population [23] was used to determine Standardised Incidence Rates (SIR). *Case Fatality Rate (CFR)* =  $\frac{\text{Deaths}}{\text{Cases}} \times 100$ . We used a Poisson Approximation for calculating 95% confidence intervals. The 95% confidence interval for the age standardised rate is given by:

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

Where the variance for the age standardised rate is given by:

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

- is the number of events in age group  $i$  in the study population
- 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. 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 basically 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 cancer situation and determine some risk factors contributing to escalating cancer cases.

### **Statistical Analyses**

We used SPSS version 21 in our data analyses. A linear regression model was used to determine the association between cancers 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**

Cancers are widely distributed in Zambia with high prevalence concentrated in the southern zone comprising Eastern, Central, Lusaka, Western and Southern Provinces. The southern zone can be divided into high prevalence and medium prevalence regions. Eastern and Lusaka Provinces form the high prevalence region while Central, Southern and Western Provinces form the medium prevalence region. The northern zone comprising North Western, Copperbelt, Luapula, Northern and Muchinga Provinces has relatively low prevalence of cancers. **Figure 1** shows the distribution of all types of cancers in Zambia by region and province per 100,000 population.

By sex, cancers have been 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. Cancers in males were more prevalent in Lusaka, Eastern, Central and North Western Provinces. Cancers in females were more prevalent in Lusaka, Eastern, Central,

Southern, Western and Copperbelt Provinces. **Figure 2** shows details of provincial distribution of cancers by sex.

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

Prevalence Rate Per 100,000 Population			
Province	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

### Distribution of cancers by district

The distribution of cancers at district level is 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. The prevalence of cancers in the original districts reflects cancer prevalence in the new districts.

Luangwa has been the most cancer prevalent district in Zambia with the rate of 1014 per 100,000 population, seconded by Kabwe with the prevalence rate of 379 per 100,000 population. Lusaka has been the third district with prevalence rate of 311 per 100,000, Monze ranks 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 and Chipata district ranked seventh with prevalence of 213 per 100,000 population. All these seven districts are from the southern zone.

The top four cancer prevalent districts in the northern zone are Kasempa with prevalence rate of 193 per 100,000, Kasama with prevalence rate of 168 per 100,000, Ndola with prevalence rate of 165 per 100,000 and Mansa with prevalence rate of 165 per 100,000 population. The least four cancer prevalent districts in Zambia were Lufwanyama with prevalence rate of 16 per 100,000, Itezhezezi with prevalence rate of 16 per 100,000, Kazungula with prevalence rate of 14 per 100,000 and Chiengwe with prevalence rate of 12 per 100,000 population during the study period. **Table 2** shows details of ranked prevalence of cancers by district per 100,000 population.

**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	KapiriMposhi	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	ItezHITEZHI	16	17	14
Senanga	93	84	101	Kazungula	14	13	16
Chingola	93	53	133	Chienge	12	9	15

With a few exceptions of districts such as Luwingu, Sinazongwe and Samfya where cancers are more prevalent in males than in females, most districts in Zambia have high cancer prevalence in

females than in males. The trend in the total district pattern (see Figure 3) remains 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

**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
<b>Totals</b>	<b>21512</b>	<b>142.8</b>	<b>7560</b>	<b>100</b>	<b>13952</b>	<b>100</b>	<b>100</b>



During our study period from 2007 to 2014, a total of 21,512 cancer cases have been notified to ZNCR of which 7,560 (35.14%) were males and 13,952 (64.86%) were females. The actual notified cases could slightly be higher than these figures but due to missing or incomplete information, some cases could not be linked to districts and provinces of origin as we employed Geographical Information System (ArcGIS) version 10.3.1 to map cancers. Cervical cancer is the most prevalent cancer in Zambia followed by prostate cancer, breast cancer and Kaposi's sarcoma in that order. The prevalence rate of cervical cancer has been 97.1 per 100,000 females and represents 34.3% of all cancers in Zambia. In proportional terms, Kaposi's sarcoma ranks second and represents 13.3%, prostate cancer ranks third and represents 7.7% while breast cancer ranks fourth and represents 6.8%. Myeloma and Other Pharynx are the least prevalent among other cancers, each representing 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 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.

**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	<b>186.3</b>	181.77	190.83
Prostate	0	0	0	0.07	0.89	5.52	22.83	21.92	8.8	<b>60.03</b>	57.03	63.03
Breast	0	0.03	1.29	4.03	9.46	8.53	9.09	4.38	1.26	<b>38.08</b>	36	40.16
Kaposi's Sarcoma	0.35	0.65	3.58	7.66	7.42	3.17	1.82	0.64	0.88	<b>26.18</b>	25.14	27.22
Oesophagus	0.01	0.01	0.11	0.64	1.6	1.67	2.49	1.45	0.4	<b>8.38</b>	7.66	8.38
Eye	0.7	0.1	0.57	1.97	2.27	1.06	0.85	0.25	0.52	<b>8.29</b>	7.69	8.89
Bladder	0.01	0.02	0.12	0.34	0.78	1.36	2.94	1.41	0.46	<b>7.45</b>	6.74	8.16
Large Bowel	0	0.03	0.32	0.64	1.63	1.53	1.93	0.87	0.24	<b>7.19</b>	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	<b>6.82</b>	6.23	7.41
Vulva/Vagina	0	0.01	0.31	0.8	1.61	1.22	1.23	0.46	0.3	<b>5.94</b>	5.14	6.74
Liver	0.02	0.09	0.27	0.56	1.21	1.22	1.3	0.83	0.36	<b>5.86</b>	5.28	6.44
Ovary	0.01	0.14	0.41	0.47	1.56	1.34	0.98	0.62	0.14	<b>5.66</b>	4.88	6.44
Stomach	0.01	0.02	0.12	0.41	0.93	1.23	1.53	1.04	0.32	<b>5.61</b>	5.02	6.2
Other Skin	0.05	0.08	0.28	0.53	0.81	1	1.26	0.69	0.38	<b>5.07</b>	4.53	5.61
Penis	0.02	0	0.03	0.26	0.98	1.28	1.38	0.58	0.41	<b>4.93</b>	4.13	5.73
Uterus	0	0.01	0.12	0.26	1.04	0.61	0.64	0.1	0.11	<b>2.89</b>	2.33	3.45
Corpus Uteri	0	0	0.06	0.12	0.42	0.85	1.15	0.2	0.07	<b>2.87</b>	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	<b>2.26</b>	1.87	2.65
Bone	0.1	0.38	0.25	0.22	0.36	0.22	0.52	0.12	0.07	<b>2.25</b>	1.92	2.58
Oral Cavity	0.04	0.05	0.08	0.13	0.36	0.55	0.63	0.34	0.07	<b>2.24</b>	1.87	2.61
Larynx	0.01	0	0.01	0.01	0.24	0.45	0.99	0.35	0.07	<b>2.14</b>	1.75	2.53
Lung	0	0	0.03	0.07	0.2	0.55	0.72	0.39	0.16	<b>2.12</b>	1.75	2.49
Pancreas	0	0	0.02	0.06	0.34	0.5	0.27	0.19	0.06	<b>1.45</b>	1.16	1.75
Hodgkin Disease	0.08	0.19	0.13	0.15	0.32	0.19	0.2	0.05	0.04	<b>1.34</b>	1.09	1.59
Thyroid	0	0.04	0.07	0.06	0.2	0.27	0.38	0.11	0.09	<b>1.22</b>	0.95	1.49
Kidney	0.45	0.09	0.01	0.1	0.13	0.12	0.11	0.07	0.07	<b>1.16</b>	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	<b>1.13</b>	0.9	1.36
Nasopharynx	0.03	0.05	0.04	0.11	0.21	0.25	0.29	0.02	0	<b>0.99</b>	0.75	1.23
Leukaemia	0.24	0.21	0.04	0.04	0.09	0.06	0.04	0.05	0	<b>0.78</b>	0.62	0.94
Other Pharynx	0	0.01	0.01	0.01	0.07	0.11	0.29	0.09	0.06	<b>0.65</b>	0.58	0.72
Myeloma	0	0.01	0.01	0.04	0.07	0.28	0.16	0.04	0.02	<b>0.63</b>	0.43	0.83
Others	0.35	0.52	0.84	1.07	1.98	2.47	2.88	1.32	0.68	<b>12.11</b>	11.29	12.93

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

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

<b>Cancer Type</b>	<b>International Classification of Diseases (ICD10)</b>	<b>Cases</b>	<b>Deaths</b>	<b>Case Fatality Rate (%)</b>
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
Others	C07-C08, C17,...	1054	154	14.6
<b>Totals</b>		<b>21512</b>	<b>2397</b>	<b>11.1</b>

Although CFR has been very high in Leukaemia,pancreatic cancer,lung cancer and cancers of the brain and nervous system, cancer mortality rates have been high in cervical cancer, prostate cancer, Kaposi's sarcoma, breast cancer and oesophageal cancer in that order. During our study

period 2007 to 2014, there were 543 cervical cancer deaths. Prostate cancer ranked second with 215 deaths followed by Kaposi's sarcoma with 332 deaths, then breast cancer and oesophagus cancer each with 113 deaths. Note: mortality rate for prostate cancer is higher than that of Kaposi's sarcoma despite the fact that Kaposi's sarcoma reported higher absolute number of 332 deaths while prostate cancer reported 215 deaths. The same principle applies for breast cancer and oesophagus cancer where breast cancer has a higher mortality rate than oesophageal cancer despite having the same absolute death figures. The reason is that the target population (denominator) for Kaposi's sarcoma and oesophageal cancer is the combined population figure for males and females while prostate cancer denominator is male population only or half the population of Kaposi's sarcoma. The smaller the denominator, the higher the mortality rate if the numerators remain equal.

### **Association between cancers and HIV in Zambia**

Most cancers in Zambia are associated with HIV or HIV defining malignancies. HIV positive patients are more susceptible to cancers due to their compromised immunity. Results of the linear 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**

Although cancers are widely distributed in Zambia, this study has established that cancers are more prevalent in the southern zone than the northern zone. The southern zone comprises the high prevalence region and medium prevalence region. Lusaka and Eastern provinces with very high cancer prevalent districts such as Luangwa, Katete, Chipata and Lusaka form the belt of the high prevalence region while Central, Southern and Western provinces with high cancer prevalent districts such as Kabwe, Mongu and Monze among others form the medium prevalence region. Although the northern zone has relatively low prevalence of cancers, there are 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 [24-26]. Our study however has established that geographic location plays 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 plays a role. Cultural practices and lifestyles are other contributing factors to the observed trends of cancer distribution in Zambia. For instance, cervical cancer which is the most prevalent cancer accounting for 34.3% of all cancers in Zambia has been perpetrated by the culture of polygamist marriages (multiple sexual partners) which has been more pronounced in the southern zone than the northern zone. This culture has led to the spread of human papilloma virus (HPV) which causes cervical cancer [24].

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

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

Our survey conducted between October 2017 and February 2018 across Zambia clearly showed that the southern zone of Zambia practices polygamist marriages (multiple sexual partners) far more than the northern zone hence the high prevalence of cervical cancer in the southern zone.

Similar trends in younger generations of European women have been observed and are thought to be due to increasing prevalence of high-risk HPV infection due to changing sexual practices [27,28].

By sex, cancers in Zambia affect 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 has been the leading cause of morbidity and mortality among cancers in Zambian women. This is contrary to other studies which established that cervical cancer is the third leading cause of cancer-related deaths in developing countries which is not the case with Zambia [29]. According to age specific rates of cancers (see Table 4), cervical cancer peak has been observed in 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 has been 5% in North America and 21% in Africa [24] implying that the risk of contracting HPV in Africa is 4 times higher than in North America. In sub-Saharan Africa, cervical cancer incidence has also been influenced by the high prevalence of HIV infection, which has been found to promote progression of cancerous lesions [30]. Cervical cancer incidence rates have decreased by as much as 4% annually, and 70% overall in developed countries where screening programs were introduced several decades ago [31,32]. The observed high prevalence rates of cervical cancer in Zambia is similar to observed trends in Zimbabwe, Uganda and some countries of Central and Eastern Europe [27,33,34].

Prostate cancer has been the second most prevalent cancer after cervical cancer and number one cancer in Zambian men with standardised incidence rate of 60.03 per 100,000 males. These results are similar to results of other studies which indicated that prostate cancer is the most prevalent cancer in men [29]. In this study, prostate cancer peak has been observed in the age range of 60 – 69 years. These results indicate that prostate cancer mostly occurs in ageing men. Age is a risk factor for prostate cancer.

Breast cancer ranks third among cancers in Zambia and second in women after cervical cancer. It has a standardised incidence rate of 38.08 per 100,000 females. Breast cancer peak has been observed in the age range of 40 – 49 years which is the productive age group for women; a double impact with cervical cancer in Zambia. 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 low rates [29]. This explains why breast cancer is ranked third in Zambia. Higher breast cancer incidence in developed countries reflects the use of breast cancer screening as well as higher prevalence of breast cancer risk factors [35]. 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, recent

use of oral contraceptives, and nulliparity or later age at first birth [36,37]. On the other hand, breastfeeding decreases the risk of breast cancer [37].

The distribution of some cancers in Zambia follows the trend of HIV epidemiology. This study has established a strong positive association between cancers and HIV with  $p$ -value of 0.000 and Pearson correlation coefficient of 0.818. 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 ranks fourth among cancers in Zambia with standardised incidence rate of 26.18 per 100,000 population. Kaposi's sarcoma peak has been observed in the age range of 30 – 39 years. This study has observed that Kaposi's sarcoma is 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 1960s [38], but with the emergence of HIV/AIDS, an atypical aggressive type has been reported in most African countries [39,40]. The incidence of Kaposi's sarcoma has increased simultaneously with the increased prevalence of HIV [41]. The high prevalence of HIV entails high resultant prevalence of cancers more especially Kaposi's sarcoma.

Although mortality rate has been high in cervical, prostate and breast cancers as well as oesophageal cancer and Kaposi's sarcoma, case fatality rate has been moderate in these cancers. This study observed high case fatality rate in Leukaemia, pancreatic cancer, lung cancer and cancers of the brain and nervous system. This means that Leukaemia and pancreatic cancer are more deadly than other cancers, the only holding factor being that their incidence rate is relatively low in Zambia.

This study had some limitations, firstly the missing information in the database made us leave some patients files as they could not be linked to districts of origin. Secondly, the Zambia National Cancer Registry has huge backlog of data due to understaffing. This brought about the adjustment of our study from 2007 - 2017 to 2007 to 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 does 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 has been perpetrated by lifestyle and sexual culture as well as geography. The top seven most cancer prevalent districts in Zambia are Luangwa, Kabwe, Lusaka, Monze, Mongu, Katete and Chipata. Cervical cancer, prostate cancer, breast cancer and Kaposi's sarcoma are the top four most prevalent cancers as well as major causes of cancer related deaths in Zambia although Leukaemia and pancreatic cancer have the highest case fatality rate in Zambia. 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 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.

## **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. LL approved the model and provided technical support in analyses. MK and HS conceived the study. All authors read and approved the manuscript.

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Cancers by Zones and Regions per 100,000



Legend  
Cancers in Zambia  
Zones and Regions

- 78 -104
- 105 - 125
- 126 - 281

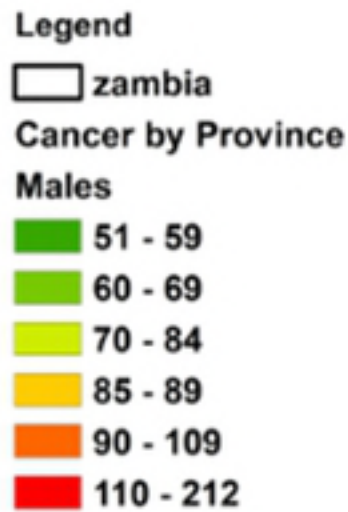
Cancers by Province\_Total per 100,000



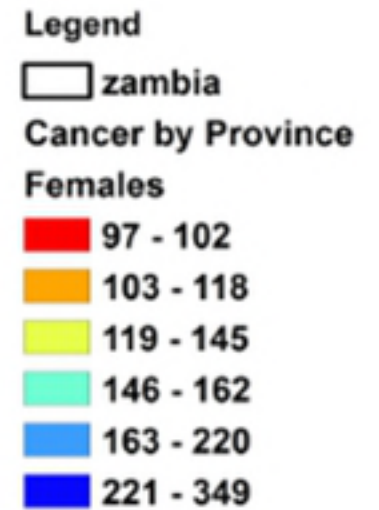
Legend  
Cancers by Province  
Both Sexes

- 78
- 79 - 90
- 91 - 104
- 105 - 125
- 126 - 165
- 166 - 281

Cancers by Province\_Males per 100,000

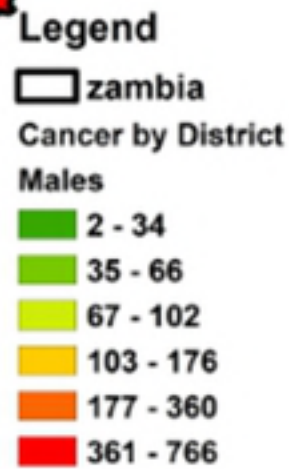
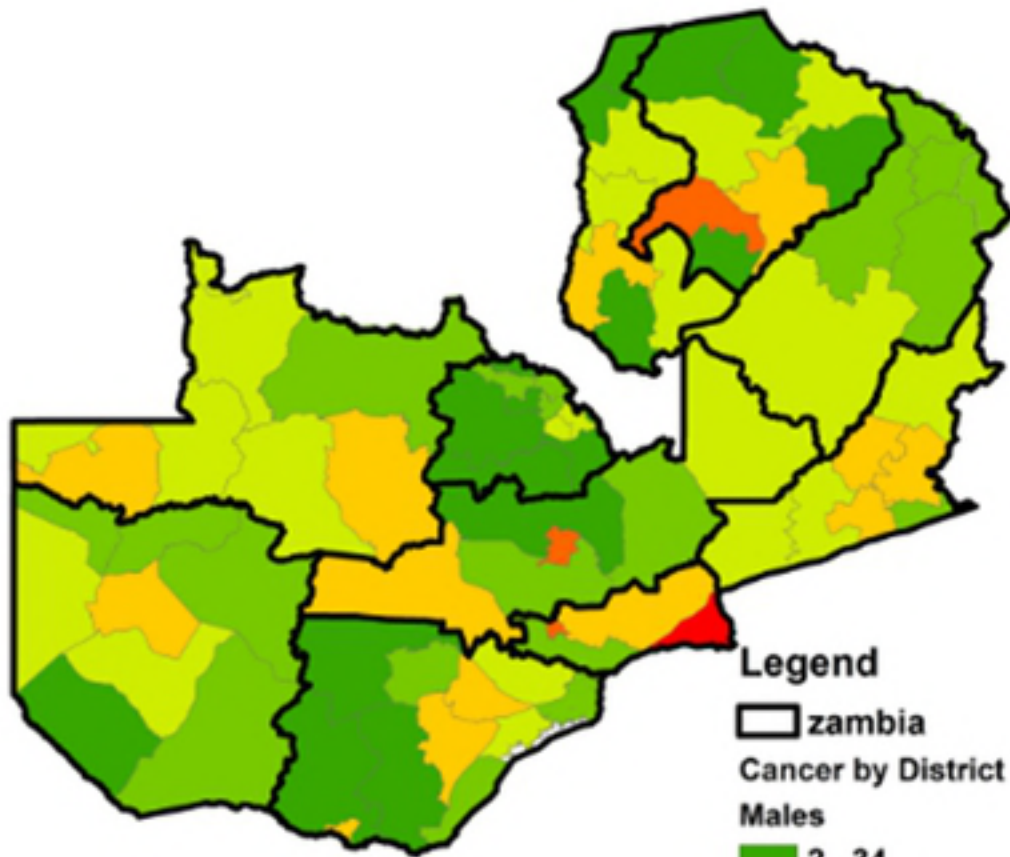


Cancers by Province\_Females Per 100,000





Cancers by District\_Males per 100,000



Cancers by District\_Females per 100,000

