Childhood cancer incidence in South Africa, 1987 - 2007

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Background. Childhood cancer is an emerging problem in Africa. Its extent is hazy because data are scarce, but it should be addressed. This is the first report from the South African Children's Tumour Registry (SACTR), which covers the whole of South Africa (SA). It provides minimal estimates of cancer incidence and discusses the challenges of cancer surveillance and control in a child population in a middle-income country. Only about 2% of the African population is covered by cancer registries producing comparable incidence data.

Objective. To present and interpret incidence patterns and trends of childhood cancer over a 21-year period. The results should raise awareness of the problem of childhood cancer in an African population and provide sensible data for taking this problem in hand.

Methods. All eligible and validated cancer cases registered in the SACTR over the period 1987 - 2007 and classified according to the *International Classification of Childhood Cancer* were included. Population data were retrieved from official sources and estimated for the population subcategories. Incidence rates were standardised to the world standard and time trends were evaluated using joinpoint models, adjusting for sex and age.

Results. Based on the 11 699 cases, the overall age-standardised average annual incidence rate was 45 per million. Threefold differences in the overall incidence rates were observed between the ethnic groups, ranging from 116 for whites to 37 for black Africans, and they differed by diagnostic group. Differences between the nine provinces of SA relate to the ethnic composition and prevailing socioeconomic status. The overall incidence rate declined by 1.2% per year for the whole country (*p*<0.01). However, the decline was mainly observed during the first few years of the study period, after which rates stabilised or increased.

Conclusions. Diagnosis and notification of childhood cancer should improve. The differences in incidence between ethnic groups suggest the priorities for cancer control.

South Africa (SA), located at the southern tip of Africa, is divided into nine provinces (Fig. 1). The Western Cape and Gauteng provinces are the most densely populated regions and, together with KwaZulu-Natal Province, contribute two-thirds of the economy of the country.[1]

Of the total SA population of 52 million, 49% are males. About 79% are black African, 9% white, 2.5% Asian or Indian and 9% coloured. The population is young: 73% are aged under 40 years, 30% under 15 and 11% under 5. The birth rate is 19/1 000, with an infant mortality rate of 42/1 000 live births; the under-5 mortality rate is 60/1 000 live births. The most common causes of death in children under 5 years of age are diseases of infectious origin and malnutrition.[1]

Over 80% of South Africans have no health insurance, and 15% pay for private insurance.[2] In public hospitals treatment is free for all children below the age of 6 years, while modest income-based contributions are required for older children. A new National Health Insurance scheme to provide basic health cover for all will be implemented shortly, according to the policy Green Paper of the National Department of Health published in 2011. The Health System Trust assessed in 2012 that there are 3 880 primary public healthcare facilities. These may refer patients with a diagnosis of cancer to a secondary hospital. If the diagnosis is confirmed, paediatric patients are referred to the relevant paediatric oncology unit (POU) for treatment.

Africa has 1 billion inhabitants, of whom 41% are younger than 15 years of age.[3] Over 36 000 children are diagnosed with cancer annually, and their number is increasing with improving control of infectious diseases. In any given year, the ratio of children who die from cancer represents 60% of those diagnosed; the equivalent figure is 20% or less in developed countries of Europe and North America.[4] Data on which the above figures are based are extremely scarce. Only about 2% of the total population of Africa is covered by population-based cancer registries producing comparable incidence figures.[5]

Fig. 1. Map of SA showing the nine provinces and the location of the nine POUs. (Adapted from Htonl/ CC-BY-SA-3.0 of 25 January 2010, available from http://commons.wikimedia.org/wiki/File:Map_of_ South_Africa_with_English_labels.svg. 1 = Tygerberg Hospital (referral for the Western Cape); 2 = Red Cross War Memorial Children's Hospital (referral for the Western Cape and Eastern Cape); 3 = Universitas/Pelonomi Academic Hospital Complex (referral for the Free State, Northern Cape and parts of the Eastern Cape and North West); 4 = Kalafong Hospital (referral for Northern Gauteng and Mpumalanga); 5 = H F Verwoerd Hospital (referral for Northern Gauteng and Mpumalanga); 6 = Ga-Rankuwa/George Mukhari hospitals (referral for Limpopo); 7 = Chris Hani Baragwanath Hospital (referral for southern Gauteng and North West); 8 = Charlotte Maxeke Hospital (referral for southern Gauteng and North West); 9 = King Edward/Inkosi Albert Luthuli Central Hospital (referral for KwaZulu-Natal and parts of the Eastern Cape.)

Collection of data on childhood cancers throughout the country was started in 1987 by the South African Children's Cancer Study Group (SACCSG) as a collaboration between the nine referral POUs shown in Fig. 1.

The objective of the South African Children's Tumour Registry (SACTR) is to describe the cancer burden in the national childhood population. In this first report from the SACTR, we aimed to present and interpret incidence patterns and trends of childhood cancer over a 21-year period (1987 - 2007) in this ethnically diverse population. The results should raise awareness of the problem of childhood cancer in an African population and provide sensible data for dealing with this problem.

Methods
The South African Children's Tumour Registry
During 1987 - 2007, the nine POUs (Fig. 1) treated children with cancer and provid-ed data to the SACTR. More recently, the SACTR data sources have included two new satellite units in the Eastern Cape Province and one in KwaZulu-Natal. Each POU sends its data to the central SACTR office as electronic files or as physical records by registered post. In addition to the POU sites, data also come from several oncologists treating children with cancer in private healthcare institutions and from some private paediatricians.

In the central registry, the relevant information is recorded into the electronic database of a customised CanReg 4 computer program, adapted for childhood cancer by the International Agency for Research on Cancer (IARC). Data are validated in collaboration with the data originators. Duplicate registration is prevented by manual matching of new cases. Relapses are matched with earlier registration of the same patient and flagged. Since 2002, information on tumour site, morphology and behaviour has been coded according to the *International Classification of Diseases*

for Oncology, 3rd edition (ICD-O-3).[6] The cases originally coded to the ICD-O-2[7] were recoded to the ICD-O-3 in agreement with the original medical records. The registry respects confidentiality principles at all times. Identifying information is used for data input, quality control and follow-up. In all reports only grouped data are presented.

Cancer cases
The SACTR records all malignant tumours, as well as non-malignant central nervous system (CNS) tumours, occurring in children aged under 15 years of age who are resident in SA. Children are considered resident if their parents have been resident for >12 months or if they themselves have lived in SA for at least 6 months, according to the identity documents examined by designated administrative personnel.

Records of all patients registered during the period 1987 - 2007 included identification number, province of residence, gender, age in years, ethnic group, dates of birth and diagnosis, tumour site, histological classification, behaviour and most valid basis of diagnosis. The extracted data were verified in collaboration with the IARC and converted to the *International Classification of Childhood Cancer*, 3rd edition (ICCC-3).[8]

Population data
Population data were obtained from the United Nations[9] and from Statistics South Africa,[1] although these sources did not provide figures for all cross-categories of gender, age, ethnic group and province in each calendar year. We were able to extract 1 201 data cells within the study period and a further 122 from the preceding or succeeding years. We have estimated the missing population figures by linear interpolation or extrapolation of available data, using the relevant gender, age, ethnic and province categories. The derived population estimates are based on the assumptions of linear population growth within the population subcategories over the periods with unavailable data. The estimated population data used for calculating the incidence rates in this study are shown in Table 1.

Analysis of incidence rates
Incidence rates are expressed as an average annual number of cases per million person-years.[10] The age-standardised average annual incidence rate (ASR) for the age range 0 - 14 years is the weighted average of the age-specific incidence rates using the weights of the world standard population for the age groups 0 - 4, 5 - 9 and 10 - 14 years.

Table 1. Estimated average annual child population of SA in years 1987 - 2007, used for calculation of incidence rates

| | Age groups (years), n | | | |
	0 - 4	5 - 9	10 - 14	Total, N
Total	4 274 603	4 314 149	4 292 439	12 881 191
Gender				
Boys	2 142 583	2 162 443	2 145 146	6 450 172
Girls	2 132 020	2 151 706	2 147 293	6 431 019
Ethnic group				
Black	3 560 614	3 577 436	3 514 557	10 652 607
White	238 403	261 288	295 470	795 161
Coloured	370 882	368 748	370 591	1 110 221
Asian, Indian, Pakistani	77 068	82 929	90 287	250 284
Unknown	27 636	23 748	21 534	72 918
Province				
Limpopo	571 368	607 058	595 942	1 774 368
North West	290 603	288 152	281 377	860 132
Mpumalanga	352 128	361 048	357 870	1 071 046
Gauteng	706 054	633 142	605 502	1 944 698
Free State	239 321	255 150	261 922	756 393
KwaZulu-Natal	945 778	953 332	963 744	2 862 854
Northern Cape	106 282	106 617	108 427	321 326
Western Cape	372 527	359 440	359 916	1 091 883
Eastern Cape	690 542	750 210	757 739	2 198 491

The parameters of the incidence trends were estimated using software for analysis of trends using Jointpoint Regression Program 3.5.4 of 2012 developed at the National Cancer Institute, Bethesda, USA. These analyses were based on the crude rate, assuming Poisson variance of counts. The joinpoints were identified using the Hudson method and their optimal number was determined by the permutation test.

Results

During the period 1987 - 2007, there were 11 712 cancer cases reported to the registry. Thirteen of these were non-malignant tumours in sites other than the CNS and were excluded from the analyses. No second primary tumours were recorded. Overall, 93.7% of cases were microscopically verified and in 0.7% of cases (n=77) the basis of the diagnosis was unknown. There were no cases identified from a death certificate only. The date of birth was imprecise in approximately 13% of all cases (day and month missing). There were 301 cases (2.6%) in which the patient was considered too young or too old for the given cancer type. One case of mixed carcinoma of major salivary gland in an infant was checked and confirmed. Less than 4% of cases (n=452)

were classified into unspecified diagnostic categories. Of the tumours that occurred in the brain, 6.7% (n=90 cases) were non-malignant. Information on laterality was available for 61.2% of retinoblastomas, 56.9% of nephroblastomas and 64.3% of gonadal tumours.

Information on ethnicity was unavailable in 12 cases (0.1%). Of all cases, 67.9% occurred in black African, 15.0% in white, 13.8% in coloured and 3.2% in Asian/Indian children. The overall male/female ratio was 1.3, and varied by ethnic group (Table 3).

Based on the 11 699 cases included in the analyses, the overall ASR was 45.2 per million (Table 2). ASRs differed between the individual diagnostic groups and the ethnic groups (Table 3). The incidence rates were highest among white children in almost all diagnostic groups examined, except retinoblastoma and hepatic tumours (highest in coloured children), germ cell tumours (highest in Asian/Indian children) and Kaposi's sarcoma (highest in black Africans).

The incidence rates differed between the provinces fivefold (data not shown); the highest ASRs per million were seen in the Western Cape (88.4) and Gauteng (81.0). The Western Cape was the province with the

lowest proportion of black African (33%) and the largest proportion of coloured (49%) and white (16%) ethnicity. Gauteng also had a lower proportion of black African (77%) and a larger proportion of white (9%) populations compared with the other provinces. The lowest incidence rates were observed in the Eastern Cape (21.8) and Limpopo provinces (18.4). The overall ASRs were intermediate in the Northern Cape (52.9), Free State (64.3), KwaZulu-Natal (39.0), Mpumalanga (26.0) and North West (26.4) provinces.

A set of graphs (Fig. 2) shows the incidence trends for selected tumour groups. Over the 21-year study period, the overall incidence rate (adjusted for age group and gender) was seen to decline by 1.2% per year for the whole country (p<0.01). However, the decline was not homogeneous during the study period. Overall rates decreased markedly between 1987 and 1994 by 8.1% per year (p<0.001), and increased thereafter by 1.9% per year (p=0.002). Leukaemia dropped by 7.8% per year (p<0.001) to 1995 and increased by 1.7% per year (p=0.082) thereafter. The incidence of lymphomas decreased by 7% per year (p<0.004) until 1995 and then increased by 2.7% per year (p=0.03). The dramatic decline in the incidence of CNS tumours (–28.3; p=0.037) was reversed from 1990, with a sustained increase of 4.7% per year (p<0.001).

Discussion

This is the first report of the SACTR, a member of the African Network of Cancer Registries (http://afcrn.org/) since its creation in January 2011. Compared with Globocan 2012,[4] where the estimated incidence of all paediatric cancers (0 - 14 years) in Africa is 96 and 73 per million for boys and girls, respectively, the rates we observed are much lower. It should, however, be noted that the Globocan estimates are largely based on data from regional cancer registries, most of them urban, and they may therefore overestimate the national cancer incidence. The rural areas show lower rates.[11]

The observed overall ASR of 36.3 per million for black Africans is nevertheless low in comparison with the rates reported from Malawi (220 per million for males), Uganda (140 per million for females) or Zimbabwe[10] (Table 4). The lack of cases pertains predominantly to lymphomas, CNS tumours, retinoblastomas, bone tumours, carcinomas and possibly Kaposi's sarcomas. Burkitt's lymphoma is the most common childhood cancer in holoendemic malaria regions in Africa, with a strong association with both intense malaria infection and

Table 2. Numbers of cases and incidence rates by gender in the child population (0 - 14 years) for SA, 1987 - 2007

Diagnostic group		n	Age-specific rate			Crude rate	ASR	M/F	ASR		Cum. rate	MV, %
			0 - 4	5 - 9	10 - 14				Boys	Girls		
I	Leukaemia	3 113	15.5	11.3	7.7	11.5	11.9	1.3	13.5	10.3	173	100.0
Ia	Lymphoid leukaemias	2 081	11.1	7.7	4.4	7.7	8.0	1.4	9.4	6.7	115	100.0
Ib	Acute myeloid leukaemias	862	3.8	3.1	2.7	3.2	3.2	1.2	3.5	3.0	48	100.0
Ic	Chronic myeloproliferative diseases	119	0.4	0.4	0.5	0.4	0.4	1.0	0.4	0.4	7	100.0
Id	MDS and other diseases	18	0.2	0.0	0.0	0.1	0.1	1.6	0.1	0.1	1	100.0
Ie	Unspecified leukaemias	33	0.2	0.2	0.0	0.1	0.1	2.0	0.2	0.1	2	100,0
II	Lymphomas and related neoplasms	1 595	4.9	7.4	5.4	5.9	5.8	2.2	8.0	3.6	88	99.9
IIa	Hodgkin's lymphomas	612	1.0	3.2	2.6	2.3	2.2	2.9	3.2	1.1	34	99.8
IIb	Non-Hodgkin's lymphomas (except Burkitt's lymphoma)	563	1.6	2.5	2.1	2.1	2.0	1.7	2.6	1.5	31	99.8
IIc	Burkitt's lymphoma	378	2.0	1.6	0.6	1.4	1.5	2.4	2.1	0.9	21	100.0
IId	Miscellaneous lymphoreticular neoplasms	29	0.3	0.0	0.0	0.1	0.1	0.9	0.1	0.1	2	100.0
IIe	Unspecified lymphomas	13	0.0	0.1	0.0	0.0	0.0	3.3	0.1	0.0	1	100.0
III	CNS neoplasms	1 334	5.9	6.0	3.0	4.9	5.1	1.1	5.4	4.8	74	73.8
IIIa	Ependymomas and choroid plexus tumours	110	0.7	0.4	0.2	0.4	0.4	1.2	0.5	0.4	6	100.0
IIIb	Astrocytomas	352	1.5	1.6	0.9	1.3	1.3	1.1	1.4	1.3	20	99.1
IIIc	CNS embryonal tumours	323	1.7	1.1	0.7	1.2	1.2	1.4	1.4	1.1	18	100.0
IIId	Other gliomas	272	1.1	1.5	0.4	1.0	1.0	0.9	1.0	1.1	15	51.8
IIIe	Other specified CNS neoplasms	62	0.1	0.3	0.3	0.2	0.2	0.8	0.2	0.3	3	98.4
IIIf	Unspecified CNS neoplasms	215	0.8	1.0	0.5	0.8	0.8	1.3	0.9	0.7	12	0.0
IV	Neuroblastoma	748	6.3	1.3	0.6	2.8	3.1	1.3	3.4	2.7	42	94.3
IVa	Neuroblastoma and ganglioneuroblastoma	740	6.3	1.3	0.6	2.7	3.0	1.3	3.4	2.7	41	94.2
IVb	Other peripheral nervous cell tumours	8	-	0.0	0.1	0.0	0.0	1.7	0.0	0.0	0	100.0
V	Retinoblastoma	779	7.8	0.8	0.1	2.9	3.3	1.2	3.5	3.1	43	84.5
VI	Renal tumours	1 568	12.6	3.9	1.0	5.8	6.4	1.0	6.5	6.3	87	96.0
VIa	Nephroblastoma and other tumours	1 557	12.5	3.8	0.9	5.8	6.4	1.0	6.4	6.3	87	96.0
VIb	Renal carcinomas	11	0.0	0.1	0.0	0.0	0.0	0.6	0.0	0.0	1	100.0
VIc	Unspecified malignant renal tumours	0	-	-	-	-	-	-	-	-	-	-
VII	Hepatic tumours	240	1.6	0.4	0.6	0.9	0.9	1.5	1.1	0.8	13	92.9
VIIa	Hepatoblastoma	152	1.5	0.1	0.1	0.6	0.6	1.5	0.8	0.5	8	100.0
VIIb	Hepatic carcinomas	75	0.1	0.3	0.5	0.3	0.3	1.5	0.3	0.2	4	93.3

Continued ...

Table 2. (continued) Numbers of cases and incidence rates by gender in the child population (0 - 14 years) for SA, 1987 - 2007

Diagnostic group		n	Age-specific rate			Crude rate	ASR	M/F	ASR		Cum. rate	MV, %
			0 - 4	5 - 9	10 - 14				Boys	Girls		
VIIc	Unspecified malignant hepatic tumours	13	0.0	0.1	0.0	0.0	0.0	0.9	0.0	0.1	1	7.7
VIII	Malignant bone tumours	473	0.5	1.5	3.2	1.7	1.6	1.1	1.7	1.6	26	99.2
VIIIa	Osteosarcomas	359	0.3	1.1	2.7	1.3	1.2	1.0	1.2	1.2	20	100.0
VIIIb	Chondrosarcomas	3	-	-	0.0	0.0	0.0	0.0	-	0.0	0	100.0
VIIIc	Ewing tumour and sarcomas of bone	100	0.3	0.4	0.4	0.4	0.4	1.2	0.4	0.3	6	100.0
VIIId	Other specified bone tumours	3	0.0	0.0	-	0.0	0.0	2.0	0.0	0.0	0	100.0
VIIIe	Unspecified malignant bone tumours	8	-	0.0	0.1	0.0	0.0	1.7	0.0	0.0	0	50.0
IX	Soft-tissue sarcomas	1 087	5.7	3.7	2.7	4.0	4.2	1.5	4.9	3.4	60	96.7
IXa	Rhabdomyosarcomas	711	4.1	2.3	1.4	2.6	2.8	1.4	3.2	2.4	39	100.0
IXb	Fibrosarcomas	70	0.4	0.1	0.2	0.3	0.3	1.3	0.3	0.2	4	100.0
IXc	Kaposi's sarcoma	147	0.6	0.8	0.2	0.5	0.6	2.1	0.8	0.4	8	76.2
IXd	Other specified soft-tissue sarcomas	102	0.3	0.3	0.5	0.4	0.4	1.2	0.4	0.3	6	100.0
IXe	Unspecified soft-tissue sarcomas	57	0.2	0.2	0.2	0.2	0.2	1.7	0.3	0.2	3	98.2
X	Germ cell tumours	436	2.8	1.0	1.1	1.6	1.7	0.5	1.1	2.3	24	99.1
Xa	CNS germ cell tumours	13	0.0	0.0	0.1	0.0	0.0	1.6	0.1	0.0	1	100.0
Xb	Other extragonadal germ cell tumours	297	2.3	0.6	0.5	1.1	1.2	0.4	0.7	1.7	17	100.0
Xc	Malignant gonadal germ cell tumours	111	0.4	0.4	0.4	0.4	0.4	0.5	0.3	0.5	6	99.1
Xd	Gonadal carcinomas	4	0.0	-	0.0	0.0	0.0	1.0	0.0	0.0	0	100.0
Xe	Other, unspecified gonadal tumours	11	0.1	-	0.1	0.0	0.0	0.1	0.0	0.1	1	72.7
XI	Carcinomas and melanomas	223	0.6	0.6	1.3	0.8	0.8	1.0	0.8	0.8	12	97.3
XIa	Adrenocortical carcinomas	18	0.2	0.0	0.0	0.1	0.1	0.8	0.1	0.1	1	94.4
XIb	Thyroid carcinomas	20	0.0	0.1	0.1	0.1	0.1	0.8	0.1	0.1	1	100.0
XIc	Nasopharyngeal carcinomas	51	0.0	0.1	0.4	0.2	0.2	1.3	0.2	0.2	3	100.0
XId	Malignant melanomas	29	0.1	0.1	0.1	0.1	0.1	0.6	0.1	0.1	2	86.2
XIe	Skin carcinomas	27	0.1	0.1	0.1	0.1	0.1	2.0	0.1	0.1	1	96.3
XIf	Other and unspecified carcinomas	78	0.1	0.2	0.5	0.3	0.3	0.9	0.3	0.3	4	100.0
XII	Other and unspecified neoplasms	103	0.6	0.3	0.2	0.4	0.4	0.9	0.4	0.4	6	12.6
XIIa	Other specified malignant tumours	12	0.1	0.0	0.0	0.0	0.0	0.5	0.0	0.1	1	100.0
XIIb	Other unspecified malignant tumours	91	0.5	0.3	0.2	0.3	0.4	1.0	0.4	0.3	5	1.1
Total		11 699	64.8	38.1	26.9	43.2	45.2	1.3	50.4	40.0	649	93.7

ASR = age-standardised rate (all rates are expressed per million); M/F = male/female ratio; Cum. rate = cumulative rate; MV = microscopic verification.

Table 3. Cancer incidence in the childhood population (age 0 - 14 years) for SA, 1987 - 2007, according to ethnic group

	Ethnic group											
	Black			White			Coloured			Asian		
Diagnostic group	n	ASR	M/F	n	ASR	M/F	n	ASR	M/F	n	ASR	M/F
I	1 820	8.2	1.4	643	43.4	1.2	493	22.1	1.2	153	33.1	1.6
Ia	1 072	4.9	1.5	520	35.3	1.2	357	16.1	1.4	128	27.8	1.5
Ib	623	2.8	1.3	98	6.5	0.9	117	5.1	0.8	24	5.0	2.4
II	1 095	4.9	2.3	231	13.5	2.0	225	9.5	2.5	43	8.3	1.5
IIa	426	1.8	3.5	74	4.1	1.7	91	3.7	2.6	21	3.9	1.3
IIb, d, e	240	1.1	2.3	59	3.6	2.5	71	3.2	2.9	7	1.5	2.5
IIc	429	1.9	1.6	98	5.8	1.9	63	2.6	2.0	15	2.9	1.5
III	786	3.6	1.1	251	16.1	1.4	266	11.6	1.2	31	6.2	0.6
IIIa	63	0.3	1.1	25	1.7	1.5	20	0.9	1.5	2	0.5	0.0
IIIb	182	0.8	1.0	79	5.0	1.3	82	3.5	1.2	9	1.9	0.8
IIIc	170	0.8	1.5	73	4.7	1.7	72	3.2	0.9	8	1.5	0.3
IIId	178	0.8	0.8	44	2.9	1.3	44	1.9	1.3	6	1.2	0.5
IIIe	43	0.2	0.7	8	0.5	0.6	8	0.3	1.7	3	0.5	0.5
IIIf	150	0.7	1.3	22	1.4	1.4	40	1.7	1.4	3	0.6	2.0
IVa	444	2.2	1.3	156	11.3	1.3	112	5.4	1.3	26	5.9	1.2
V	664	3.4	1.2	37	2.8	1.1	67	3.3	0.7	11	2.6	1.2
VIa	1 256	6.2	1.1	126	9.2	0.7	143	6.8	0.9	30	6.8	1.1
VII	160	0.7	1.6	25	1.7	1.1	49	2.3	1.4	5	1.2	1.5
VIIa	90	0.4	1.4	16	1.2	2.2	40	2.0	1.9	5	1.2	1.5
VIIb	60	0.2	2.0	6	0.3	0.5	9	0.4	0.5	0	-	-
VIII	310	1.3	1.1	88	4.8	1.1	57	2.2	0.8	17	2.9	0.9
VIIIa	260	1.1	1.1	47	2.5	1.1	44	1.7	0.8	8	1.3	0.3
VIIIc	39	0.2	1.4	41	2.3	1.1	11	0.4	0.8	8	1.4	1.7
IX	861	4.0	1.4	98	6.5	1.5	97	4.3	1.3	30	6.6	3.3
IXa	560	2.6	1.3	66	4.4	1.8	60	2.7	1.4	24	5.4	3.0
IXb	52	0.2	1.4	10	0.7	0.7	8	0.4	3.0	0	-	-
IXc	140	0.6	2.2	1	0.1	-	5	0.2	0.7	1	0.2	-
IXd	68	0.3	1.1	15	0.8	1.5	14	0.6	0.8	5	1.0	4.0
IXe	41	0.2	2.2	6	0.4	1.0	10	0.4	1.0	0	-	-
X	298	1.4	0.4	56	3.6	0.8	59	2.7	0.4	23	5.1	1.9
Xb	219	1.1	0.4	28	1.9	0.5	37	1.8	0.3	13	3.0	1.6
Xc	69	0.3	0.4	18	1.2	1.0	16	0.7	0.3	8	1.7	3.0
XI	152	0.6	1.1	40	2.2	0.6	27	1.1	1.5	4	0.8	0.3
XIc	38	0.2	1.9	5	0.3	0.3	8	0.3	0.6	0	-	-
XIf	62	0.3	0.9	7	0.4	0.4	7	0.3	6.0	2	0.4	0.0
XII	84	0.4	1.1	6	0.4	0.2	13	0.6	0.6	0	-	-
Total	7 942	36.9	1.3	1 758	115.8	1.2	1 614	72.2	1.2	373	79.5	1.4

ASR = age-standardised rate per million; M/F = male/female ratio.

Epstein-Barr virus.[12,13] In SA, malaria is present only in very small areas and Burkitt's lymphoma is sporadic. In sub-Saharan Africa, with a high prevalence of HIV, the incidence of Kaposi's sarcoma in children has increased considerably over the past 30 years. However, even if the prevalence of HIV in SA (17.9%)[14] is higher than in Uganda (7.2%)[10] or Zambia (12.7%),[15] the incidence rates of Kaposi's sarcoma in SA are much lower than in other southern African countries.[11] This may be explained by the comparatively low rates of endemic Kaposi's sarcoma in SA[16] and the lower prevalence of human herpesvirus infection in SA than, for example, in Uganda.[17]

The overall incidence rates for the white population (ASR 116.2 per million) are rather low, but comparable with rates observed in the 1980s in some populations of South America (ASR 118 - 136
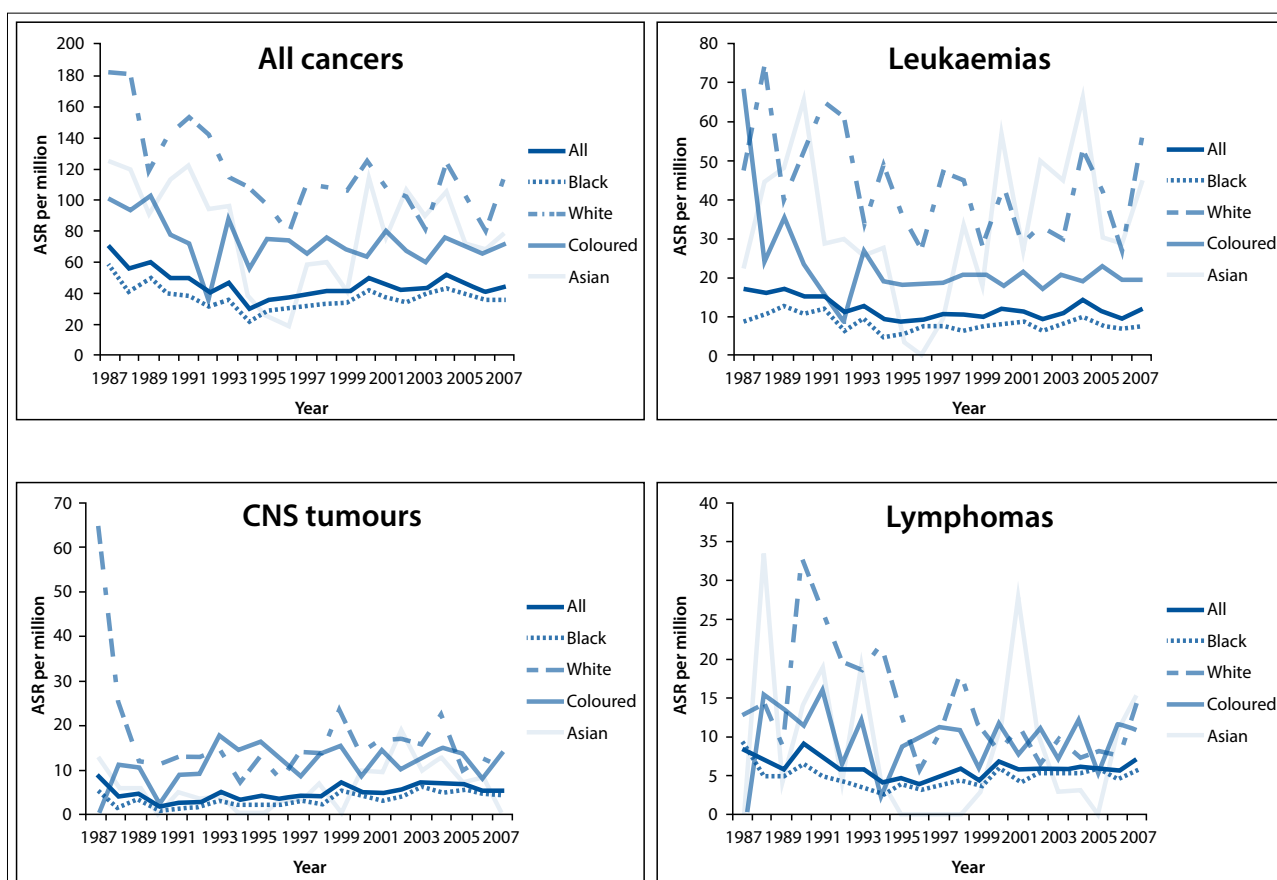
Fig. 2. Time trends of childhood cancer incidence (age 0 - 14 years) in SA.

per million) and Eastern Europe (ASR ~125 per million).[10] The higher incidence rates in the white compared with the black African population may be explained by a better rate of diagnosis and access to tertiary healthcare treatment in a POU. The cultural background and genetic factors may also be relevant, as the higher incidence rates in the white population, compared with the black, are also observed in the USA.[10] Our rates for the Asian/Indian ethnic group (ASR 79 per million) are at the lower end of the ASR range observed in India and the developing countries of South-East Asia in the 1980s or early 1990s (74 - 110 per million).[10] As black African children constitute two-thirds of the total dataset, their very low registration rates impact heavily on the national incidence estimates.

The low incidence rates may be partly explained by under-diagnosing, misdiagnosing or under-reporting. The diagnosis of many tumours, in particular those of the CNS, may be delayed as the appropriate technology required to confirm the diagnosis is not always available.[18] In many rural areas there is also cultural pressure that traditional healers should be consulted before modern medical services are accessed. All these obstacles lead to children dying without a proper diagnosis, referral and treatment. For the majority of SA citizens, the public health system is the only means to access the POUs. Once the diagnosis has been suspected or confirmed, patients are likely to be referred to and registered by a POU.

It is possible that some cases are diagnosed but not registered. The lack of medical services in some provinces impacts on both access to care and the likelihood of being diagnosed and registered. Although under-registration should not differ between the ethnic groups, reporting may be more difficult in more deprived areas where the proportion of black African population is larger. Limpopo and the Eastern Cape have the highest proportion of population (55%) with

no income, while in the two provinces with the highest incidence rates, Gauteng and Western Cape, this proportion is lower (41%).[1] Table 4 shows the impact of exclusion of the provinces with lowest rates.

There are a number of smaller centres and individual practices that are able to diagnose and treat children with cancer but do not necessarily send data to the SACTR. Although the SACCSG encourages reporting to the SACTR, the registration process remains challenging. As a consequence, the rates reported here should be considered minimal estimates of the true status.

Deaths are certified in SA, and there is a central collection of death certificates. The SACTR did not attempt to link these records with the registry database, as the quality of their information has been assessed as low.[19] In countries where death data are available to cancer registries, these may help to achieve higher registration completeness, provided the causes of death are correctly assessed and coded.

The correct incidence estimates depend on the registration quality as much as on the population data. We had to estimate figures for a large number of categories under many assumptions, which may have influenced the incidence rates in some ethnic groups and provinces more than others. There could also have been a mismatch of the classification of ethnic group or province between the official data and the SACTR, which would have affected the calculated rates in subgroups.

Internationally, ASRs for childhood cancers have tended to increase in recent decades, while our data show a decrease in incidence rates over the study period. The overall decline was caused by the high rates observed at the beginning of the period. In particular, the dramatic decline in the rates of the CNS tumours in whites between

Table 4. Comparison of the reported age-standardised (world) incidence rates in selected populations in Africa

Country		Mali	Namibia	Nigeria	Uganda	Zimbabwe	SA	SA	SA
Region		Bamako	National	Ibadan	Kampala	Harare, black Africans	SACTR	Selected regions*	Black Africans
Reporting period		1987 - 1995	1983 - 1992	1985 - 1992	1992 - 1995	1990 - 1994	1987 - 2007	1987 - 2007	1987 - 2007
Source		IICC-2	IICC-2	IICC-2	IICC-2	IICC-2	Current data	Current data	Current data
Cases, N		226	241	383	340	219	11 699	9 640	7 942
Diagnostic group, ASR									
I	Leukaemia	3.1	6.2	8.3	10.6	23.1	11.9	15.2	8.2
Ia	Lymphoid leukaemia	0.7	4.5	2.6	3.3	11.6	8.0	10.4	4.9
II	Lymphomas	17.2	5.8	27.1	52.9	12.5	5.8	7.9	4.9
IIa	Hodgkin's lymphoma	6.6	2.0	3.3	2.2	3.5	2.2	3.0	1.8
IIc	Burkitt's lymphoma	1.7	1.9	18.0	36.1	2.4	1.5	2.0	1.9
III	CNS tumours	1.4	7.3	11.1	2.3	12.0	5.1	7.2	3.6
IV	Symp. nervous system tumours	0.0	3.6	0.2	1.0	4.0	3.1	4.1	2.2
V	Retinoblastoma	24.5	4.5	7.4	11.1	10.5	3.3	4.0	3.4
VI	Renal tumours	12.2	6.4	4.9	8.0	16.5	6.4	8.0	6.2
VIa	Nephroblastoma	4.8	6.0	4.7	8.0	16.5	6.4	7.9	6.2
VII	Hepatic tumours	3.7	0.2	1.1	2.7	2.1	0.9	1.2	0.7
VIII	Bone tumours	2.7	3.4	2.1	5.6	4.3	1.6	2.2	1.3
IX	Soft-tissue sarcomas	2.7	4.6	5.4	73.4	19.7	4.2	5.5	4.0
IXc	Kaposi's sarcoma	0.0	0.7	0.0	67.5	10.6	0.6	0.8	0.6
X	Germ cell and gonadal tumours	2.7	1.1	0.4	1.7	2.5	1.7	2.4	1.4
XI	Epithelial and melanoma	5.5	2.4	1.7	7.3	2.7	0.8	1.1	0.6
XII	Other and unspecified neoplasms	2.0	0.4	0.8	6.2	1.6	0.4	0.6	0.4
Total		77.7	45.9	70.5	182.7	111.6	45.2	59.3	36.9

IICC-2 = International Incidence of Childhood Cancer, vol. 2;[10] ASR = age-standardised rate per million.
*Excluding Limpopo, Eastern Cape and North West.

1987 and 1989 may suggest a break in links between the registry and the neurosurgical departments. This pattern could also reflect inclusion of prevalent cases in the first years of registration, typical of new cancer registries. The annual rates stabilised for several tumour types from 1995, and further close monitoring of the trends is required.

National cancer registration for all ages was launched in SA in 1986 under the auspices of the National Health Laboratory Service. However, this initially relied on voluntary reporting, which mostly came from pathological laboratories and isolated physicians. Clinically diagnosed cases (6% in the present series) were therefore not registered. The National Cancer Registry (NCR) was revitalised on the initiative of the Department of Health on 26 April 2011 with Government Notice No. R.380, stipulating compulsory reporting of all cancers to the NCR based in Johannesburg.

Since 2011, POUs have submitted the same dataset to both the NCR and the SACTR every 3 months. The databases of both cancer registries should therefore be equally complete and include the same registered tumours. However, from a recently published report[20] based on data from the NCR for 2000 - 2006 it became evident that further efforts are required to unify the registration procedures and strengthen collaboration between the two cancer registries. Although the overall rate they reported (45.7 per million) was very similar to ours (45.2/million), there are differences in the incidence rates of several diagnostic groups. These differences may be caused by the use of additional data sources by the NCR, which would explain the higher incidence rates of lymphomas, epithelial neoplasms, soft-tissue sarcomas and bone tumours. The SACTR may be more efficient in excluding unconfirmed diagnoses, metastatic extension of primary tumours, duplicate registrations of such tumours, etc. On the other hand, the SACTR reports higher incidence rates of leukaemia and solid tumours characteristic of the paediatric age range, such as retinoblastoma, neuroblastoma or renal tumours.

The continued work of the SACTR is required for multiple reasons. First, the data on childhood cancers are collected through the network of the POUs that ensures a link to detailed clinical

information on each patient, which is not mandated by the NCR. Supporting the SACTR enables the SACCSG to have the feedback required for deciding on new treatment protocols, improving data quality and describing outcome results in terms of survival. The POUs also strive to acquire data on some patients from private practice through the paediatrician links, which would not necessarily be possible through the general cancer registry with an at least 20-fold higher volume of cases. Specific focus on childhood cancer helps to improve registration in this age range. The NCR continues to present itself as a pathology cancer registry,[21] and no report on cancer incidence for all ages has been produced to date. It is likely that only the childhood cancer data are of sufficient quality, to a large extent attributable to the work of the SACTR and SACCSG.

Conclusions

The SACTR is the first paediatric population-based cancer registry established in Africa, and it has national coverage. Despite uncertainties inherent in the presented data, the SACTR constitutes an invaluable resource of information for policy planning and research. This report challenges us to improve the diagnosis and notification of childhood cancer to both the NCR and the SACTR, and to tackle the ethnic inequalities in access to appropriate care. Continuous collection of data is indispensable for evaluation of demographic, geographical and temporal variations. Ultimately this will lead to earlier diagnosis, better management, and improved outcomes for children with cancer in SA.

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