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Childhood Cancer in the Republic of Suriname (1980 Through 2008)

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Abstract: Childhood cancer incidence in Suriname (South-America) was estimated using secondary data from 1980 to 2008, and these findings were stratified according to gender; age groups < 1, 1-4, 5-14, and 15-19 years; and the largest ethnic groups (Hindustanis, Maroons, Creoles, and Javanese). Data were expressed as total numbers, proportions, average yearly numbers, and/or crude incidence rates per 1,000,000 population per year. There were 290 malignancies in the period covered, *i.e.*, about 10 new cases per year or 24 per 1,000,000 per year. The average yearly number of overall cancer increased from approximately 1 every two years in newborns to 3-4 per year in adolescents and young adults. Thirty to 35% of patients were Hindustani or Creole; the proportions of Javanese and Maroons patients were about twice and five times, respectively, lower. Leukemias and lymphomas comprised almost half of cases, each occurring 2 to 3 times per year. Bone tumors, soft-tissue sarcomas, and carcinomas were the most common non-hematological malignancies, occurring once or twice per year. Central nervous system tumors, neuroblastoma, retinoblastoma, renal tumors, primary hepatic tumors, and germ cell tumors were exceedingly rare. In conclusion, childhood cancer incidence in Suriname was relatively low; the individual histiotypes displayed an unusual ranking; and there were differences in the sex, age, and ethnic distribution of overall cancer as well as certain histiotypes. However, these observations might be biased by the use of crude rates, and underdiagnosis and incomplete registration of cases due to the absence of specialized (pediatric) cancer facilities in the country.

Keywords: Age distribution, childhood malignancies, ethnic distribution, histology, incidence, Republic of Suriname, sex distribution.

INTRODUCTION

Childhood cancers are malignant neoplasms in newborns (younger than 1 year of age), infants (1 to 4 years old), children between 5 and 14 years, and adolescents and young adults (15 to 19 years of age) [1]. These malignancies are responsible for more than 175,000 new patients younger than 15 years and account for 1.4% of all cancers worldwide [1, 2]. They encompass a broad range of histiotypes including hematological malignancies (about 40% of cases) and central nervous system tumors (about 20% of cases), followed by neuroblastoma, retinoblastoma, Wilms' tumor, primary liver cancers, malignant bone cancers, soft-tissue sarcomas such as rhabdomyosarcoma, germ cell tumors, and a number of carcinomas, each comprising 2 to 7% of cases [2, 3].

Childhood cancers can be treated successfully with multi-modal therapies which result in average five-year survival rates of 80%, and for children with leukemia, Hodgkin's disease, or Wilms' tumor even close to 90% [4]. However, these improvements may occur at the cost of serious adverse effects later in life such as acute myeloid leukemia [4-6]. For this reason, children who survive cancer must often remain under medical supervision for the rest of their lives [6, 7].

So far, the exact causes of most childhood cancers are not known. Oncogenic mutations and life-style and environmental factors implicated in the development of many adult cancers are probably not responsible for that of childhood malignancies, as these factors require extended periods of time to inflict sufficient DNA damage to cause carcinogenic lesions [8]. Rather, childhood malignancies have been associated with constitutional molecular defects such as Beckwith-Wiedemann and Down syndrome involved in the development of embryonic cancers and leukemia, respectively [9, 10], and heriditary conditions such as Li-Fraumeni syndrome implicated in that of acute leukemia, brain tumors, osteosarcoma, and rhabdomyosarcoma [11].

Depite their infrequency in children, adolescents, and young adults, malignancies are a leading cause of death in these age groups in many parts of the world [1, l2]. However, more than 85% of the global burden of childhood cancer lies in developing rather than industrialized countries [1, 12]. The former countries in general cannot afford modern diagnostic techniques, treatment methods, supportive care, cancer recognition facilities, and data management systems to benefit from the advances in pediatric oncology seen in the industrialized countries [13-

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15]. Many of them also have to cope with rapidly growing populations, poverty, poor hygiene, lack of education, and various other health problems such as infectious diseases and malnutrition [13-15]. These factors are responsible for considerable variations between industrialized and developing countries with respect to reporting on incidence, pathology, mortality, and clinical characteristics of childhood malignancies [13-15].

For instance, Trinidad & Tobago and Jamaica reported relatively low childhood cancer incidence rates when compared with developed countries such as the USA (75 and 69, respectively, per 1,000,000 per year *versus* more than 143 per 1,000,000), and frequency rankings of the individual histiotypes [1, 16, 17] that differed from the above-mentioned average global rankings [2, 3]. However, a base-line survey on the sex and age distribution of childhood cancer in Aden (Yemen) suggested that such results might be attributable to underdiagnosis and underregistration of a considerable number of cases [18]. As well, overall survival of children with acute lymphoblastic leukemia in Pakistan was worse than that reported in the literature (only 65%), which was probably attributable to the lack of proper supportive care causing high rates of infections and relapses [19].

Furthermore, cancer incidence in Nigeria was comparable to that seen in most other sub-Saharan African countries, but the ranking of the individual histologies differed substantially from that in industrialized countries: the most common cancers were retinoblastoma, Burkitt's lymphoma, and acute leukemia [20] rather than leukemia, central nervous system tumors, lymphoma, and neuroblastoma [1, 2]. An unusual ranking of histiotypes was also seen in Mali, where the most common pediatric cancers were non-Hodgkin's lymphoma, retinoblastoma, and nephroblastoma [21]. However, high losses to follow-up were among the major reasons for concern [21].

The Republic of Suriname is situated on the north coast of South America and has a population of over 550,000 [22]. The country is renowned for its cultural and ethnic diversity, and is home to Hindustanis (originating from East India), Maroons (descendants from runaway slaves shipped from Africa in the seventeenth and eighteenth century), Creoles (those from mixed black and white origin), Javanese (originating from the Indonesian island of Java), as well as Amerindians (the original inhabitants), Chinese, as well as immigrants from Lebanon, Syria, Brazil, and various European countries [22]. The largest ethnic groups are the Hindustanis, Maroons, Creoles, and Javanese, constituting about 27, 22, 18, and 14%, respectively, of the Surinamese population [22].

Suriname is on the World Bank's list of upper-middle-income economies, but reserves only 5.9% of its Gross Domestic Product for health expenditure [23]. For comparison, the USA and most Western European countries spent 17.9 and around 10%, respectively, of their Gross Domestic Product to health-related activities [23]. Although there is universal health care access for all children under 16 years of age, the potential of medical care is limited. As a result, children diagnosed with cancer are usually referred to tertiary clinics in mainly Colombia, The Netherlands, and the USA for further diagnosis and induction treatment. Once the maintenance phase of therapy has been reached, they return to Suriname for follow-up treatment. Sadly, many individuals living in the hinterland - including a substantial proportion of Maroons and Amerindians [22] - do not share such services due to the limited diagnostic facilities in that part of the country, and rely instead on their traditional forms of treatment [22].

Several investigators have reported on various aspects of the epidemiology of adult malignancies - particularly carcinomas - in Suriname [24-27]. Up till now, no comprehensive data are available on the occurrence of cancer in Surinamese newborns, infants, young children, adolescents, and young adults. For this reason, we undertook the current study to obtain base-line data on the incidence as well as the sex, age, and ethnic distribution of this group of neoplasms in Suriname. Our results have been discussed within the framework of international data.

PATIENTS AND METHODS

Patient and Population Data

In this study, the incidence of malignancies in Surinamese individuals aged 0 to 19 years over the period between 1980 and 2008 was assessed. Benign neoplasms, *in situ* carcinomas, as well as non-malignant skin cancers were excluded.

Details about the diagnoses, including information about the histology of the malignancy, the gender of patients, their age at the time of diagnosis, as well as their ethnic background, were obtained from the Pathologic Anatomy Laboratory of the Academic Hospital Paramaribo. This is the national pathology-based cancer registry that covers all histopathologically diagnosed cancers in the country since 1980 with reporting estimated to be around 85% complete [25]. For comparison, a recognized cancer registry such as the Dutch registry for childhood leukemia reported 95% accuracy and completeness for the period between 1989 and 1992 [28].

Approximations of the mid-year population size of Suriname in the period covered by this study were provided by the Section Population Statistics of the General Bureau for Statistics, Ministry of Planning and Developmental Cooperation [22].

Data Processing

For each year between 1980 and 2008, the total number of cancer diagnoses and the total number for each histiotypes was calculated. The latter data were classified using the International Classification of Childhood Cancer, third edition [2], and further stratified according to patients' gender, age at the time of diagnosis (under 1 year, between 1 and 4 years, between 5 and 14 years, and between 15 and 19 years), and ethnic background (Hindustanis, Maroons, Creoles, and Javanese.

Unfortunately, no comprehensive and reliable data are available about the age composition of the Surinamese population for the period covered by this study, prohibiting the estimation of age-adjusted incidence rates. Therefore, proportions, average yearly numbers, and/or yearly crude incidence per 1,000,000 population per year rates were calculated. The data obtained were expressed as means (95%

CI), and compared for statistically significant differences by SPSS version 16 using Student's *t* test. P values < 0.05 were taken to indicate statistically significant differences.

Ethical Considerations

The Ethics Committee of our institution granted ethical approval for conducting this study with the understanding that patients' data must be kept conficential.

RESULTS

Generalities

A total of 290 childhood tumors was recorded in Suriname in the period between 1980 and 2008 (Table **1**). This corresponded with 10.0 (8.7 - 11.3) new cases per year and an annual crude rate of about 24 per 1,000,000 population (Table **1**). Each year, there were on average 6.0 (5.1 - 6.8) cases in males and 3.9 (2.9 - 4.9) in females, which corresponded with average crude incidence rates of 14.6 (12.2 - 17.0) and 9.6 (7.1 - 12.1), respectively, per 1,000,000 population per year (Table **1**). Apparently, childhood cancer was approximately 1.5 times more common in males than females.

The overall crude incidence rate clearly increased with older age, *i.e.*, from 1.2 (0.6 - 1.8) cases per 1,000,000 population per year in children under 1 year of age, to 5.7 (4.2 - 7.1) and 10.1 (8.1 - 12.2) per 1,000,000 population per year in individuals aged between 1 and 4 years, and 5 and 14 years, respectively (Table **1**). These values differed statisticaly significantly from each other (Table **1**).

Average crude incidence rates in Hindustanis and Creoles were 7.0 (5.1 - 8.8) and 8.5 (5.8 - 11.1), respectively, per 1,000,000 population per year, and did not differ statistically significantly from each other (Table **1**). However, these values were roughly twice higher that that of 3.9 (2.4 - 5.3) per 1,000,000 population per year in Javanese (Table **1**). The lowest rates were in Maroons, namely 1.5 (0.8 - 2.3) per 1,000,000 population per year (Table **1**).

Distribution According to Histiotype

Leukemias and lymphomas were the most numerous histiotypes, comprising together 50% of the total number of cancers between 1980 and 2008 (Table **2**). There were no statistically significant difference between the incidence of overall leukemias and lymphomas: they occurred on average 2.7 (1.9 - 3.5) and 2.3 (1.8 - 2.9) times, respectively, per year, or at crude rates of 6.6 (4.6 - 8.6) and 5.7 (4.3 - 7.1), respectively, per 1,000,000 population per year (Table **2**). The most common subtypes were acute lymphocytic leukemia, non-Hodgkin's lymphoma, and Hodgkin's lymphoma, appearing at comparable average yearly numbers, namely 1.5 (0.8 - 2.3), 0.8 (0.4 - 1.1), and 0.8 (0.5 - 1.2) times, respectively, per year (Table **2**). The average yearly numbers of acute lymphocytic leukemia was statistically significantly higher than that of acute myelo-genous leukemia or chronic lymphocytic leukemia, the latter occurring on average 0.2 (0.0 - 0.4) and 0.2 (0.0 - 0.4) times, respectively, per year (Table **2**). Sixteen percent of hematological malignancies was not further specified (Table **2**).

Malignant bone tumors, soft-tissue sarcomas, and carcinomas were the most common non-hematological malignancies (Table **2**). Malignant bone tumors and soft-tissue sarcomas constituted each about 10% of overall childhood cancers, occurring on average 0.9 (0.5 - 1.3) and

Table 1. Numbers, proportions, average yearly numbers (95% CI), and average crude incidence rates (per 1,000,000 per year; 95% CI) of overall childhood cancer; cases in males and females; cases in individuals younger than 1 year, 1 to 4 years, 5 to 14 years, and 15 to 19 years; and cases in individuals from Hindustani, Maroon, Creole, and Javanese background in Suriname between 1980 and 2008.

	Total Number of Cases	Proportion (%)	Average Yearly Numbers of Cases (95% CI)	Average Crude Incidence Rates (95% CI)
Total	290	100	10.0 (8.7 - 11.3)	24.4 (20.7 - 28.1)
Males	173	60	6.0 (5.1 - 6.8)[a]	14.6 (12.2 - 17.0)[a]
Females	114	39	3.9 (2.9 - 4.9)	9.6 (7.1 - 12.1)
Unidentified gender	3	1	0.1 (0.0 - 0.2)	0.3 (0.0 - 0.6)
< 1 year	14	5	0.5 (0.2 - 07)	1.2 (0.6 - 1.8)
1 - 4 years	67	23	2.2 (1.6 - 2.8)[b]	5.7 (4.2 - 7.1)[b]
5 - 14 years	121	42	4.2 (3.4 - 5.1)[b,c]	10.1 (8.1 - 12.2)[b,c]
15 - 19 years	88	30	3.0 (2.5 - 3.6)[b]	7.4 (6.0 - 8.8)[b]
Unidentified age groups	0	-	-	-
Hindustanis	83	29	2.9 (2.1 - 3.6)[d,e]	7.0 (5.1 - 8.8)[d,e]
Maroons	19	7	0.7 (0.3 - 1.0)	1.5 (0.8 - 2.3)
Creoles	100	34	3.4 (2.5 - 4.4)[d,e]	8.5 (5.8 - 11.1)[d,e]
Javanese	46	16	1.6 (1.0 - 2.2)[d]	3.9 (2.4 - 5.3)[d]
Other/unidentified ethnic groups	42	14	1.4 (0.9 - 2.0)	3.6 (2.3 - 4.9)

[a]Significantly different from 'Females' ($p < 0.01$, Student's *t* test); [b]significantly different from '< 1 year' ($p < 0.0001$; Student's *t* test); [c]significantly different from ' 1 - 4 years' ($p < 0.001$, Student's *t* test); [d]significantly different from 'Maroons' ($p < 0.01$, Student's *t* test); [e]significantly different from and 'Javanese' ($p < 0.01$, Student's *t* test).

Table 2. Total number of cancer cases, average number (95% CIs) of cases per year, as well as average crude incidence rates (95% CIs) of cancer in Surinamese individuals aged 0 to 19 years between 1980 and 2008. Crude rates are per 1,000,000 population per year. ALL: acute lymphoblastic leukemia; AML: acute myelogenous leukemia; CLL: chronic lymphocytic leukemia; CNS: central nervous system; RCC: renal cell carcinoma.

Histiotype	Total Number of Cases	Proportion	Average Yearly Numbers of Cases (95% CI)	Average Crude Incidence Rates (95% CI)
Overall leukemias	79	27	2.7 (1.9 - 3.5)	6.6 (4.6 - 8.6)
ALL	44	15	1.5 (0.8 - 2.3)[a]	3.7 (1.8 - 5.6)[a]
AML	6	2	0.2 (0.0 - 0.4)	0.2 (0.0 - 0.4)
CLL	7	2	0.2 (0.0 - 0.5)	0.6 (0.0 - 1.1)
Other/not further specified leukemias	22	8	0.7 (0.3 - 1.0)[a]	1.8 (0.9 - 2.7)[a]
Overall lymphomas	68	23	2.3 (1.8 - 2.9)	5.7 (4.3 - 7.1)
Hodgkin's lymphoma	22	8	0.8 (0.4 - 1.1)	1.8 (2.0 - 1.6)
Non-Hodgkin's lymphoma	24	8	0.8 (0.5 - 1.2)	2.0 (1.1 - 2.9)
Other/unspecified lymphomas	22	8	0.8 (0.4 - 1.1)	1.9 (0.9 - 2.8)
CNS tumors	4	1	0.1 (0.0 - 0.2)	0.4 (0.0 - 0.7)
Astrocytoma	2	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.4)
Medulloblastoma	2	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.4)
Neuroblastoma	2	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.4)
Retinoblastoma	2	1	0.1 (0.0 - 0.2)	0.1 (0.0 - 0.3)
Overall renal tumors	11	4	0.4 (0.1 - 0.6)	1.0 (0.4 - 1.6)
Wilms' tumor	9	3	0.3 (0.1 - 0.5)	0.8 (0.2 - 1.4)
RCC	2	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.4)
Primary hepatic tumors	7	2	0.2 (0.1 - 0.4)	0.6 (0.2 - 1.0
Overall malignant bone tumors	26	9	0.9 (0.5 - 1.3)	2.2 (1.3 - 3.1)
Ewing's sarcoma	13	4	0.4 (0.2 - 0.7)	1.0 (0.5 - 1.6)
Osteosarcoma	10	3	0.3 (0.1 - 0.6)	0.9 (0.2 - 1.7)
Chondrosarcoma	3	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.5)
Overall soft-tissue sarcomas	30	10	1.0 (0.6 - 1.4)	2.5 (1.5 - 3.5)
Rhabdomyosarcoma	6	2	0.2 (0.0 - 0.4)	0.5 (0.0 - 1.0)
Other/not further specified soft-tissue sarcomas	24	8	0.8 (0.5 - 1.2)[b]	2.0 (2.1 - 2.9)[b]
Germ cell tumors	3	1	0.1 (0.0 - 0.2)	0.3 (0.0 - 0.6)
Overall carcinomas	56	19	1.9 (1.4 - 2.5)	4.7 (3.4 - 5.9)
Nasopharyngeal carcinoma	15	5	0.5 (0.3 - 0.8)	1.2 (0.6 - 1.8)
Other/not further specified carcinomas	41	14	1.4 (1.0 - 1.8)[c]	3.4 (2.4 - 4.4)[c]
Other/not further specified malignant neoplasms	2	1	0.1 (0.0 - 0.2)	0.2 (0.0 - 0.4)

[a]Significantly different from 'AML' ($p < 0.001$, Student's *t* test) and 'CML' ($p < 0.02$, Student's *t* test); [b]significantly different from 'Rhabdomyosarcoma' ($p < 0.004$, Student's *t* test); [c]significantly different from 'Nasopharyngeal carcinoma' ($p < 0.0005$; Student's *t* test).

1.0 (0.6 - 1.4) times, respectively, per year, or at crude rates of 2.2 (1.3 - 3.1) and 2.5 (1.5 - 3.5), respectively, per 1,000,000 population per year (Table **2**). There were no statistically significant differences among yearly numbers of Ewing's sarcoma, osteosarcoma, and chondrosarcoma (0.4 (0.2 - 0.7), 0.3 (0.1 - 0.6), and 0.1 (0.0 - 0.2 cases, respectively; Table **2**). Rhabdomyosarcoma comprised about one-fifth of overall soft-tissue sarcomas, appearing 0.2 (0.0 - 0.4) times per year (Table **2**). However, a substantial number of soft-tissue sarcomas (24 of 30) was not further specified (Table **2**).

With 19% of all malignancies (Table **2**), carcinomas were the third most common group of neoplasms in the period covered by this study, ranking behind leukemias and lymphomas (Table **2**). Carcinomas were approximately twice more common than malignant bone tumors and soft-tissue sarcomas, appearing on average 1.9 (1.4 - 2.5) times per year

and at a crude rate of 4.7 (3.4 - 5.9) per 1,000,000 per year (Table **2**). About one-quarter of overall carcinomas was from the nasopharyngeal region (Table **2**). A substantial number of carcinomas was not further specified (Table **2**), although there were a handful of thyroid and gastrointestinal tract carcinomas (not shown).

Central nervous system tumors (astrocytoma and medulloblastoma), neuroblastoma, retinoblastoma, renal tumors (Wilms' tumor and renal cell carcinoma), primary hepatic tumors, and germ cell tumors were exceedingly rare, appearing only 2 to 11 times in the 29 years covered by this study (Table **2**). This corresponded with averages of 1 to 4 case(s) per 10 years, and crude incidence rates of at the most 1 per 1,000,000 population per year (Table **2**).

Distribution According to Gender

As shown in Table **3**, overall lymphomas occurred statistically significantly more often in males than in females (1.6 (1.1 - 2.1) *versus* 0.8 (0.4 - 1.1) times, respectively, per year) (Table **3**). Thus, these histiotypes might have a preference of males over females, even though Hodgkin's, non-Hodgkin's, and not further specified lymphomas were as common in males as in females (Table **3**).

On the other hand, the average yearly number of overall

Table 3. Total number of cancer cases and average number (95% CIs) of cases per year in Surinamese males and females aged 0 to 19 years between 1980 and 2008. ALL: acute lymphoblastic leukemia; AML: acute myelogenous leukemia; CLL: chronic lymphocytic leukemia; CNS: central nervous system; RCC: renal cell carcinoma.

Histiotype	Males		Females	
	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year
Overall leukemias	48	1.6 (1.1 - 2.1)	30	1.0 (0.6 - 1.4)
ALL	30	1.0 (0.6 - 1.5)	14	0.5 (0.1 - 08)
AML	2	0.1 (0.0 - 0.2)	4	0.1 (0.0- 0.3)
CLL	5	0.2 (0.0 - 0.3)	2	0.1 (0.0 - 0.2)
Other/not further specified leukemias	11	0.4 (0.1 - 0.6)	10	0.3 (0.1 - 0.6)
Overall lymphomas	46	1.6 (1.1 - 2.1)[a]	22	0.8 (0.4 - 1.1)
Hodgkin's lymphoma	16	0.6 (0.2 - 0.9)	6	0.2 (0.0 - 0.4)
Non-Hodgkin's lymphoma	15	0.5 (0.3 - 0.8)	9	0.3 (0.1 - 0.5)
Other/not further specified lymphomas	15	0.5 (0.2 - 0.8)	7	0.2 (0.1 - 0.4)
CNS tumors	3	0.1 (0.0 - 0.2)	1	0.0 (0.0 - 0.1)
Astrocytoma	2	0.1 (0.0 - 0.2)	0	-
Medulloblastoma	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)
Neuroblastoma	0	-	2	0.0 (0.0 - 0.1)
Retinoblastoma	2	0.1 (0.0 - 0.2)	0	-
Overall renal tumors	5	0.2 (0.0 - 0.4)	5	0.2 (0.0 - 0.3)
Wilms' tumor	4	0.1 (0.0- 0.3)	5	0.2 (0.0 - 0.3)
RCC	1	0.0 (0.0 - 0.1)	0	-
Primary hepatic tumors	3	0.1 (0.0 - 0.2)	4	0.1 (0.0- 0.3)
Overall malignant bone tumors	18	0.6 (0.3 - 0.9)	8	0.3 (0.1 - 0.5)
Ewing's sarcoma	9	0.3 (0.1 - 0.5)	4	0.1 (0.0 - 0.3)
Osteosarcoma	6	0.2 (0.0 - 0.4)	4	0.1 (0.0 - 0.3)
Chondrosarcoma	3	0.1 (0.0 - 0.2)	0	-
Overall soft-tissue sarcomas	17	0.6 (0.3 - 0.9)	13	0.4 (0.2 - 0.7)
Rhabdomyosarcoma	6	0.2 (0.0 - 0.4)	0	-
Other/not further specified soft-tissue sarcomas	11	0.4 (0.1 - 0.6)	13	0.4 (0.2 - 0.7)
Germ cell tumors	0	-	3	0.1 (0.0 - 0.2)
Overall carcinomas	30	1.0 (0.7 - 1.4)	25	0.9 (0.5 - 1.3)
Nasopharyngeal carcinoma	7	0.2 (0.1 - 0.4)	8	0.2 (0.0 - 0.4)
Other/not further specified carcinomas	23	0.8 (0.5 - 1.1)	17	0.6 (0.3 - 0.9)
Other/not further specified malignant neoplasms	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)

[a]Significantly different from 'Females' ($p < 0.0092$, Student's *t* test).

leukemias in males (1.6 (1.1 - 2.1 cases) did not differ statistically significantly from that in females (1.0 (0.6 - 1.4) cases). This also held true for acute lymphocytic leukemia, that occurred on average 1.0 (0.6 - 1.5) times per year in males and 0.5 (0.1 - 0.8) times per year in females (Table **3**). There were also as many malignant bone tumors, soft-tissue sarcomas and carcinomas in males (on average 0.6 (0.3 - 0.9), 1.0 (0.7 - 1.4), and 0.6 (0.3 - 0.9) cases, respectively, per year) as in females (on average 0.4 (0.2 - 0.7), 0.9 (0.5 - 1.3, and 0.3 (0.1 - 0.5) cases, respectively, per year) (Table **3**).

Central nervous system tumors, neuroblastoma, retinoblastoma, renal tumors, hepatic tumors, and germ cell tumors were too infrequent to make inferences about their possible sex distribution.

Distribution According to Age Group

As shown in Table **4**, overall leukemias were statistically significantly more common in individuals aged 1 to 4 and 5

Table 4. Total number of cancer cases and average number (95% CIs) of cases per year in Surinamese individuals younger than 1 year, 1 to 4 year, 5 to 14 years, and 15 to 19 years between 1980 and 2008. ALL: acute lymphoblastic leukemia; AML: acute myelogenous leukemia; CLL: chronic lymphocytic leukemia; CNS: central nervous system; RCC: renal cell carcinoma.

Histiotype	< 1 Year		1 to 4 Years		5 to 14 Years		15 to 19 Years	
	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year
Overall leukemias	5	0.2 (0.0 - 0.3)	34	1.2 (0.7 - 1.6)[a,b]	30	1.0 (0.6 - 1.4)[a,b]	10	0.3 (0.1 - 0.6)
ALL	2	0.1 (0.0 - 0.2)	20	0.7 (0.2 - 1.1)[a,b]	17	0.6 (0.3 - 0.8)[a,b]	5	0.2 (0.0 - 0.3)
AML	0	-	1	0.0 (0.0 - 0.1)	3	0.1 (0.0 - 0.2)	2	0.1 (0.0 - 0.2)
CLL	1	0.0 (0.0 - 0.1)	3	0.1 (0.0 - 0.2)	3	0.1 (0.0 - 0.3)	0	-
Other/not further specified leukemias	2	0.1 (0.0 - 0.2)	10	0.3 (0.2 - 0.5)[a,b]	7	0.2 (0.1 - 0.4)	3	0.1 (0.0 - 0.2)
Overall lymphomas	0	-	8	0.3 (0.1 - 0.5)	34	1.2 (0.8 - 1.5)[c]	26	0.9 (0.4 - 1.4)[c]
Hodgkin's lymphoma	0	-	2	0.1 (0.0 - 0.2)	15	0.5 (0.3 - 0.8)[a,b]	5	0.2 (0.0 - 0.3)
Non-Hodgkin's lymphoma	0	-	2	0.1 (0.0 - 0.2)	12	0.4 (0.2 - 0.6)[c]	10	0.3 (0.1 - 0.6)[c]
Other/not further specified lymphomas	0	-	4	0.1 (0.0 - 0.3)	7	0.2 (0.1 - 0.5)	11	0.4 (0.1 - 0.7)[c]
CNS tumors	0	-	1	0.0 (0.0 - 0.1)	2	0.1 (0.0 - 0.2)	1	0.0 (0.0 - 0.1)
Astrocytoma	0	-	0	-	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)
Medulloblastoma	0	-	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)	0	-
Neuroblastoma	0	-	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)	0	-
Retinoblastoma	0	-	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)	0	-
Overall renal tumors	0	-	6	0.2 (0.1 - 0.4)	3	0.1 (0.0 - 0.2)	2	0.1 (0.0 - 0.2)
Wilms' tumor	0	-	6	0.2 (0.1 - 0.4)	3	0.1 (0.0 - 0.2)	0	-
RCC	0	-	0	-	0	-	2	0.1 (0.0 - 0.2)
Primary hepatic tumors	0	-	2	0.1 (0.0 - 0.2)	2	0.1 (0.0 - 0.2)	3	0.1 (0.0 - 0.2)
Overall malignant bone tumors	1	0.0 (0.0 - 0.1)	2	0.0 (0.0 - 0.1)	13	0.4 (0.2 - 0.7)[a,c]	10	0.3 (0.1 - 0.6)[a,c]
Ewing's sarcoma	1	0.0 (0.0 - 0.1)	2	0.1 (0.0 - 0.2)	7	0.2 (0.1 - 0.4)	3	0.1 (0.0 - 0.2)
Osteosarcoma	0	-	0	-	6	0.2 (0.0 - 0.4)	4	0.1 (0.0 - 0.3)
Chondrosarcoma	0	-	0	-	0	-	3	0.1 (0.0 - 0.2)
Overall soft-tissue sarcomas	2	0.1 (0.0 - 0.2)	5	0.2 (0.0 - 0.3)	14	0.5 (0.2 - 0.7)[a,c]	9	0.3 (0.1 - 0.5)
Rhabdomyosarcoma	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)	2	0.1 (0.0 - 0.2)	2	0.1 (0.0 - 0.2)
Other/not further specified soft tissue sarcomas	1	0.0 (0.0 - 0.1)	4	0.1 (0.0 - 0.3)	12	0.4 (0.2 - 0.6)[a,c]	7	0.2 (0.0 - 0.5)
Germ cell tumors	0	-	0	-	2	0.1 (-0.03 - 0.2)	1	0.0 (0.0 - 0.1)
Overall carcinomas	6	0.2 (0.1 - 0.4)	4	0.1 (0.0 - 0.3)	23	0.8 (0.4 - 1.2)[a,c]	23	0.8 (0.5 - 1.1)[a,c]
Nasopharyngeal carcinoma	0	-	2	0.1 (0.0 - 0.2)	8	0.3 (0.1 - 0.4)	5	0.2 (0.0 - 0.4)
Other/not further specified carcinomas	6	0.2 (0.1 - 0.4)	2	0.1 (0.0 - 0.2)	15	0.5 (0.2 - 0.8)[c]	18	0.6 (0.4 - 0.9)[a,c]
Other/not further specified malignant neoplasms	0	-	0	-	1		1	

[a]Significantly different from '< 1 year' ($p < 0.02$, Student's *t* test); [b]significantly different from '15 - 19 years' ($p < 0.05$, Student's *t* test); [c]significantly different from '1 - 4 years' ($p < 0.03$, Student's *t* test).

to 14 years (on average 1.2 (0.7 - 1.6) and 1.0 (0.6 - 1.4) cases, respectively, per year), when compared to those younger than 1 year or between 15 and 19 years old (on average 0.2 (0.0 - 0.3) and 0.3 (0.1 - 0.6) cases, respectively, per year). This apparent preference for the intermediate age groups might also hold true for acute lymphoblastic leukemia and Wilms' tumor: 37 of the 44 cases of acute lymphoblastic leukemia and all nine cases of Wilms' tumor were encountered in these age groups (Table **4**).

On the other hand, lymphomas displayed a predilection for the older age goups. Average yearly numbers of overall lymphomas in the age groups 5 to 14 and 15 to 19 years (1.2 (0.8 - 1.5) and 0.9 (0.4 - 1.4), respectively) were statistically significantly higher than that in the group of 1 to 4 years old (0.3 (0.1 - 0.5) (Table **4**). This also held true for Hodgkin's lymphoma, non-Hodgkin's lymphoma, and other/not further specified lymphomas, more than 80% of which were in individuals of 5 to 14 and 15 to 19 years of age (Table **4**).

Malignant bone tumors, soft-tissue sarcomas, and carcinomas also displayed an apparent predilection for the older age goups. Bone tumors occurred on average 0.4 (0.2 - 0.7) and 0.3 (0.1 - 0.6) times per year in age groups 5 to 14 and 15 to 19 years, respectively, *versus* 0.0 (0.0 - 0.1) and 0.0 (0.0 - 0.1) times per year in individuals younger than 1 year and 1 to 4 years old, respectively (Table **4**). Overall soft-tissue sarcomas were more common in individuals of 5 to 14 years (on average 0.5 (0.2 - 0.7) times per year) than in those under 1 year or between 1 and 4 years old (on average 0.1 (0.0 - 0.2) and 0.2 (0.0 - 0.3) times, respectively, per year) (Table **4**). And carcinomas appeared annually on average more often in age groups 5 to 14 and 15 to 19 years than in those under 1 year or 1 to 4 years old (on average 0.8 (0.4 - 1.2), *versus* 0.2 (0.1 - 0.4) and 0.1 (0.0 - 0.3) times, respectively, per year) (Table **4**).

There were too few cases of central nervous system tumors, neuroblastoma, retinoblastoma, hepatic, and germ cell tumors to draw conclusions about their possible age distribution.

Distribution According to Ethnic Group

Average yearly numbers of leukemias in Hindustanis and Creoles were 1.0 (0.6 - 1.4) and 0.9 (0.4 - 1.3), respectively, and did not differ statistically significantly from each other (Table **5**). These values were approximately twice lower in Javanese, and even lower in Maroons, namely 0.4 (0.1 - 0.7) and 0.1 (0.0 - 0.2), respectively (Table **5**). A comparable distribution was seen for acute lymphoblastic leukemia, that occurred 0.6 (0.3 - 0.9) and 0.6 (0.2 - 1.0) times per year in Hindustanis and Creoles, respectively, but at statistically significantly lower numbers in Maroons and Javanese (0.0 (0.0 - 0.1) and 0.1 (0.1 - 0.4), times, respectively, per year) (Table **5**). The same applied to overall lymphomas: there were on average 0.8 (0.4 - 1.2) and 0.9 (0.5 - 1.3) cases per year in Hindustanis and Creoles, respectively, *versus* 0.3 (0.1 - 0.5) in Javanese and 0.1 (0.0 - 0.2) in Maroons (Table **5**).

Malignant bone tumors, soft-tissue sarcomas, and carcinomas also displayed a distinctive ethnic distribution: overall bone tumors were less common in Maroons than in Creoles (0.1 (0.0 - 0.2) *versus* 0.3 (0.1 - 0.6) cases, respectively, per year); not further specified soft-tissue sarcomas were less common in Javanese than in Creoles (0.0 (0.0 - 0.1) *versus* 0.4 (0.1 - 0.6) cases, respectively, per year); and overall carcinomas were less common in Maroons than in Hindustanis and Creoles (0.1 (0.0 - 0.3) *versus* 0.5 (0.3 - 0.8) and 0.7 (0.4 - 1.0) cases, respectively, per year) (Table **5**).

Due to their relatively small numbers, no inferences could be made about a possible racial distribution of central nervous system tumors, neuroblastoma, retinoblastoma, renal tumors, primary hepatic tumors, and germ cell tumors.

DISCUSSION

In this study spanning the period between 1980 and 2008, some base-line epidemiological aspects of childhood cancer (individuals between 0 and 19 years of age) in the Republic of Suriname have been assessed, both overall and after stratification according to histiotype. Our results suggest that childhood cancer occurred at a relatively low rate in Suriname and that the ranking of the individual histiotypes differed from the average global ranking. Furthermore, there were in general more cases in males than females; the incidence increased with older age although certain histiotypes had a predilection for younger children; and childhood cancer might be more common in Hindustanis and Creoles than in Javanese and particularly Maroons.

In the 29-year period covered by the current study, 290 childhood malignancies have been recorded. Thus, with a reported yearly average of approximately 300 overall cancers in Suriname [25], childhood neoplasms comprised about 3% of all malignancies in the country. This is higher than the estimated global average of about 1.4% [1]. This apparent inconsistency may be attributable to the incomplete cancer registry in Suriname (as mentioned before, around 85%). In analogy to a previous study [18], this may have led to incorrect estimations of the proportion of childhood cancers with respect to overall malignancies in the country. In addition, the higher upper age limit applied in the current study (19 years of age) when compared to that applied in various international studies (14 or 18 years of age; see for instance references 2 and 29) might have contributed to this discrepancy.

The estimated annual crude incidence rate of childhood cancer in Suriname was about 24 per 1,000,000 population. This suggests at first glance that the incidence of childhood cancer in Suriname is well below the global estimate of up to 160 per million children [29], and closer to that of 40, 69, and 75 per 1,000,000 population per year reported for the Indian community of Fiji [30], Jamaica, and Trinidad & Tobago, respectively [16, 17]. However, in the current study, crude incidence rates have been used instead of age-adjusted incidence rates, which prohibits comparisons with international incidence rates.

The most common childhood malignancies in Suriname in the period covered by this study were leukemias and lymphomas, comprising together half of all childhood cancers, followed by carcinomas (19%), soft-tissue sarcomas (10%), and malignant bone tumors (9%). The relatively high proportion of hematological malignancies (particularly acute lymphocytic leukemia, as well as Hodgkin's and non-Hodgkin's lymphoma) is well in accordance with literature

Table 5. Total number of cancer cases and average number (95% CIs) of cases per year in Surinamese individuals of Hindustani, Maroon, Creole, and Javanese background between 1980 and 2008. ALL: acute lymphoblastic leukemia; AML: acute myelogenous leukemia; CLL: chronic lymphocytic leukemia; CNS: central nervous system; RCC: renal cell carcinoma.

Histiotype	Hindustanis		Maroons		Creoles		Javanese	
	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year	Total Number of Cases	Average Number of Cases Per Year
Overall leukemias	29	1.0 (0.6 - 1.4)[a,b]	2	0.1 (0.0 - 0.2)	25	0.9 (0.4 - 1.3)[a]	11	0.4 (0.1 - 0.7)[a]
ALL	17	0.6 (0.3 - 0.9)[a,b]	2	0.0 (0.0 - 0.1)	17	0.6 (0.2 - 1.0)[a,b]	4	0.1 (0.1 - 0.4)
AML	2	0.1 (0.0 - 0.2)	0	-	1	0.0 (0.0 - 0.1)	0	-
CLL	2	0.1 (0.0 - 0.2)	0	-	4	0.1 (0.0 - 0.3)	1	0.0 (0.0 - 0.1)
Other/not further specified leukemias	8	0.2 (0.0 - 0.4)	0	-	3	0.1 (0.0 - 0.2)	6	0.2 (0.0 - 0.4)
Overall lymphomas	23	0.8 (0.4 - 1.2)[a,b]	3	0.1 (0.0 - 0.2)	26	0.9 (0.5 - 1.3)[a,b]	9	0.3 (0.1 - 0.5)
Hodgkin's lymphoma	7	0.2 (0.0 - 0.4)	1	0.1 (0.0 - 0.2)	9	0.3 (0.1 - 0.5)	3	0.1 (0.0 - 0.3)
Non-Hodgkin's lymphoma	6	0.2 (0.0 - 0.4)	1	0.0 (0.0 - 0.1)	7	0.2 (0.1 - 0.4)	5	0.2 (0.0 - 0.3)
Other/not further specified lymphomas	9	0.3 (0.1 - 0.5)[a]	1	0.0 (0.0 - 0.1)	9	0.3 (0.1 - 0.5)[a]	3	0.1 (0.0 - 0.3)
CNS tumors	1	0.1 (0.0 - 0.2)	0	-	1	0.1 (0.0 - 0.2)	2	0.1 (0.0 - 0.2)
Astrocytoma	0	-	0	-	0	-	2	0.1 (0.0 - 0.2)
Medulloblastoma	1	0.0 (0.0 - 0.1)	0	-	1	0.0 (0.0 - 0.1)	0	-
Neuroblastoma	0	-	0	-	2	0.1 (0.0 - 0.2)	0	-
Retinoblastoma	0	-	0	-	1	0.0 (0.0 - 0.1)	0	-
Overall renal tumors	3	0.1 (0.0 - 0.2)	0	-	2	0.1 (0.0 - 0.2)	0	-
Wilms' tumor	2	0.1 (0.0 - 0.2)	0	-	2	0.1 (0.0 - 0.2)	0	-
RCC	1	0.0 (0.0 - 0.1)	0	-	0	-	0	-
Primary hepatic tumors	0	-	0	-	2	0.1 (0.0 - 0.2)	4	0.1 (0.0 - 0.3)
Overall malignant bone tumors	6	0.2 (0.0 - 0.4)	2	0.1 (0.0 - 0.2)	10	0.3 (0.1 - 0.6)[a]	4	0.1 (0.0 - 0.3)
Ewing's sarcoma	4	0.1 (0.0 - 0.3)	2	0.1 (0.0 - 0.2)	4	0.1 (0.0 - 0.3)	2	0.1 (0.0 - 0.2)
Osteosarcoma	2	0.1 (0.0 - 0.2)	0	-	5	0.2 (0.0 - 0.4)	1	0.0 (0.0 - 0.1)
Chondrosarcoma	0	-	0	-	1	0.0 (0.0 - 0.1)	1	0.0 (0.0 - 0.1)[2]
Overall soft-tissue sarcomas	5	0.2 (0.0 - 0.3)	5	0.2 (0.0 - 0.3)	12	0.4 (0.2 - 0.7)	5	0.2 (0.0 - 0.4)
Rhabdomyosarcoma	0	-	0	-	1	0.0 (0.0 - 0.1)	4	0.1 (0.0 - 0.3)
Other/not further specified soft-tissue sarcomas	5	0.2 (0.0 - 0.3)	5	0.2 (0.0 - 0.3)	11	0.4 (0.1 - 0.6)[b]	1	0.0 (0.0 - 0.1)
Germ cell tumors	2	0.1 (0.0 - 0.2)	0	-	0	-	0	-
Overall carcinomas	15	0.5 (0.3 - 0.8)[a]	4	0.1 (0.0 - 0.3)	20[a]	0.7 (0.4 - 1.0)	10	0.3 (0.1 - 0.6)
Nasopharyngeal carcinoma	1	0.0 (0.0 - 0.1)	4	0.1 (0.0 - 0.3)	5	0.1 (0.0 - 0.3)	2	0.1 (0.0 - 0.2)
Other/not further specified carcinomas	14	0.5 (0.2 - 0.7)	0	-	15	0.5 (0.3 - 0.8)	8	0.3 (0.1 - 0.5)
Other/not further specified malignant neoplasms	0	-	0	-	0	-	0	-

[a]Significantly different from 'Maroons' ($p < 0.05$, Student's *t* test); [b]significantly different from 'Javanese' ($p < 0.05$, Student's *t* test).

data mentioning that these histiotypes are among the most prevalent malignant neoplasms in children [3, 4, 31]. And the substantially lower rates of acute myelogenous leukemia, chronic lymphocytic leukemia, and chronic myelogenous leukemia in the current study is supported by their substantially lower global prevalence in children than adults [31]. The rates of malignant bone tumors and soft tissue sarcomas of about 1 case per year and roughly 3 cases every 2 years, respectively, are also fairly well in ranges estimated for the USA [32-34].

However, the unusual positioning of childhood histiotypes when compared with average global rankings [2, 3] might be attributable to the suboptimal diagnostic and registration facilities of (childhood) cancer in Suriname [18]. This might have led to underdiagnosis of more frequently

reported histiotypes such as central nervous system tumors, neuroblastoma, retinoblastoma, and renal tumors [2, 3], which were hardly recorded in the current study. These factors might also have been responsible for the comparable numbers of leukemias as lymphomas noted in the current study (27 and 23%, respectively of overall childhood cancers), whereas frequencies of these malignancies are typically 34% and 8%, respectively, in large parts of the world [35]. They might also explain the absence of a common childhood malignancy such as Burkitt's lymphoma [1-3, 12-14] in our dataset, as well as the relatively low proportion (2% of overall childhood malignancies) of a common soft-tissue sarcoma such as rhabdomyosarcoma in the current study [36].

Our data suggest further that cancer overall and lymphomas displayed a preference for males over females. These observations are in general in accordance with literature data [37], but must also be interpreted cautiously. Not only was the number of not further specified lymphomas and other cancer types - and thus improperly diagnosed cases - substantial (roughly one-third of all childhood malignancies), but the reported male-over-female excess of childhood cancer in many developing countries such as Suriname may be related to the degree of economic development of the country under study: boys seemed more likely than girls to be registered with increasing economic disadvantage [38].

The relatively high frequency of overall leukemias and Wilms' tumor in age groups 1 to 4 and 5 to 14 years when compared to the youngest and the oldest age groups is in accordance with the median age at diagnosis of 14 years for acute lymphocytic leukemia [39], and the preferential appearance of Wilms' tumor in children around 3 years of age [40]. And the occurrence of Hodgkin's and non-Hodgkin's lymphomas, malignant bone tumors, soft-tissue sarcomas, and carcinomas (including nasopharyngeal cancer) in adolescents and young adults rather than pre-teens and younger children, is consistent with their occurrence in individuals of 14 to 34 years of age, in addition to those older than 50 years [41]. Our observations are also in line with the relatively high numbers of adolescents and young adults with cancer in many developing countries [42]. This may be attributable to the relatively high birth rate, and thus relatively high rates of childhood and adolescence cancer in these countries [42].

Leukemia, Hodgkin's lymphoma, and Ewing's sarcoma have been reported to occur more commonly in (USA) caucasian adolescents and young adults than in (American) youngsters from other ethnic backgrounds [31, 33, 35, 43]. On the other hand, non-Hodgkin's lymphoma, Wilms' tumor, various soft-tissue sarcomas, and many carcinomas may have a predilection for African American children rather than white USA children [34, 40, 41, 44]. However, it remains to be seen whether the excess of leukemias and lymphomas, malignant bone tumors, soft-tissue sarcomas, and carcinomas in (a) certain ethnic group(s) when compared to (an)other(s) noted in the current study, was genuinely associated with their ethnic - *i.e.*, genetic - background. In the case of the Javanese, these differences may be attributable to their smaller population size when compared to that of the Hindustani and Creole [22]. And the lower cancer rates in Maroons - the second largest ethnic group is Suriname [22] - when compared to the other ethnic groups may be explained by the limited diagnostic and health care facilities in the interior of Suriname where many of them live [22]. Notably, several studies (see for instance references [45, 46]) have found that differential inclusion of racial groups in cancer registries may represent a potential source of bias in the interpretation of the results of cancer prevalence studies.

Summarizing, the results from this study suggest that childhood cancers may occur at a relatively low rate in Suriname, that the ranking of the different histiotypes may differ from the average global ranking, and that some malignancies may display gender, age, and ethnic preferences. However, these conclusions may to a certain extent be biased by the absence of specialized diagnostic facilities, the incomplete cancer registry, and differences in access to health facilities in the country. Still, the data from this study may help improve childhood cancer diagnosis, treatment, and registration in Suriname.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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