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HIGHLIGHTS

Incidence

- The incidence of cancer among adolescents (i.e., 15-19 year-olds) in SEER areas for 1986-95 was 202.2 per million, which was similar to the incidence of cancer among 0-4 year-olds and substantially greater than the incidence for 5-9 and 10-14 year-olds (Table XIII.1).
- The spectrum of cancers that occurred among 15-19 year-olds was distinctive from those that occurred in young children. For SEER areas from 1986-95, the most common tumors among adolescents were Hodgkin's disease (16.1%), germ cell tumors (15.2%), CNS tumors (10.0%), non-Hodgkin's lymphoma (NHL) (7.6%), thyroid cancer (7.2%), malignant melanoma (7.0%), and acute lymphoblastic leukemia (ALL) (6.4%) (Figure XIII.1 and Table XIII.1).
- The embryonal cancers that predominated among young children (e.g., neuroblastoma, Wilms tumor, retinoblastoma, and hepatoblastoma) (Figure XIII.2) were distinctly uncommon among 15-19 year olds (Figure XIII.1 and Table XIII.1).

Trends in Incidence

- The annual incidence of cancer for adolescents increased from 183.0 per million in 1975-79 and to 203.8 per million in 1990-95 (Table XIII.4 and Figure XIII.3).
- The largest contributor to this increase was the germ cell, trophoblastic, and other gonadal tumor category (specifically testicular and ovarian germ cell tumors).
- Smaller increases in incidence were observed for non-Hodgkin's lymphoma (NHL), osteosarcoma, and acute lymphoblastic leukemia (ALL).
- No significant increases in incidence were observed for CNS tumors, melanoma, thyroid cancer, Hodgkin's disease, or soft tissue sarcomas.

Incidence by Gender and Race

- Rates of specific cancer types differed substantially by gender and by race among adolescents.
- For gender, these differences were most remarkable for thyroid cancer (much more common in females) and for the bone tumors, ALL, and NHL (the latter three more common among males) (Table XIII.2).
- Black 15-19 year olds had much lower incidence rates for Ewing's sarcoma, testicular germ cell tumors, and melanoma than did whites. Black adolescents also had modestly lower incidence of ALL and thyroid cancer compared to white 15-19 year olds (Table XIII.3).

Survival

- Overall 5-year survival rates for adolescents with cancer improved from 69% to 77% from 1975-84 to 1985-94 (Table XIII.5).
- For some cancer types (Hodgkin's disease, germ cell tumors, thyroid cancer, and melanoma), 5-year survival rates were 90% or better for the most recent time period (1985-94).
- For other cancer types (e.g., osteosarcoma, Ewing's sarcoma, ALL, and AML) survival rates for adolescents remained less than 60%.

INTRODUCTION

The adolescent population (here defined as age 15-19 years) have variably been included in analyses and reports of childhood cancer. An NIH Policy concerning inclusion of children in clinical research defines children as being younger than 21 years of age, while the Food and Drug Administration considers children to be 15 years and younger. Regardless of the definition of children that is applied for regulatory or reporting purposes, it is instructive to consider the 15-19 year old population separately because the types of tumors that occur in this population differ substantially from those that predominate in younger children and in adults. Additionally, the 15-19 year old age group is one whose participation rate in cancer clinical trials has been noted to be much lower than that for younger children [1].

In this chapter, differences in cancer types and their incidence between the 15-19 year group and younger children will be highlighted. Additional points for emphasis are the changes in cancer incidence for this older age group from 1975 to 1995 and the distinctive sex distribution for individual tumor types. The chapter concludes with a summary of survival rates for the 15-19 year old population, illustrating that survival for many tumor types has improved from 1975-84 to 1985-94.

INCIDENCE

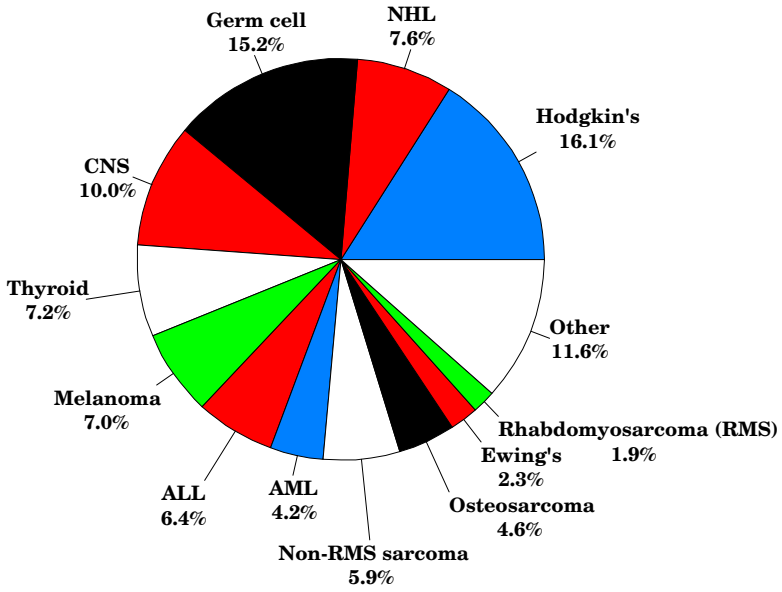
Distribution of tumor types by 5-year age groups

The incidence of specific cancers by International Classification of Childhood Cancer (ICCC) codes for the period 1986-1995 is shown in Table XIII.1 by 5-year age groups. Figure XIII.1 shows that the most common tumors in the adolescent population were Hodgkin's disease (16.1%), germ cell tumors (15.2%), CNS tumors (10.0%),

Table XIII.1: Age-specific cancer incidence rates per million and percentage of total cases by ICCC category and age group, all races, both sexes, SEER, 1986-95

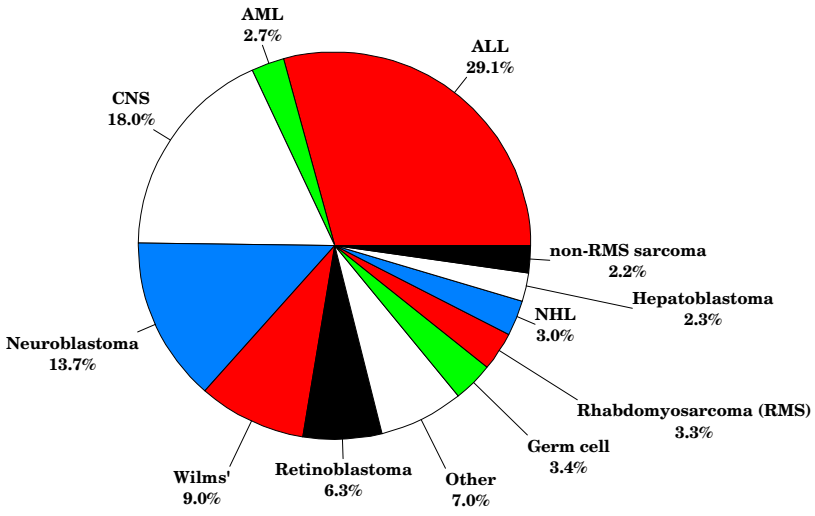
Age (in years) at diagnosis Tumor category	<5 Rate	5-9 Rate	10-14 Rate	15-19 Rate	% of Total for 15-19 Group
All Sites	199.9	110.2	117.3	202.2	100.0%
Acute lymphoblastic leukemia (ALL)	58.2	30.3	17.8	12.9	6.4%
Acute myeloid leukemia (AML) (Ib)	10.1	4.5	5.7	8.5	4.2%
Hodgkin's disease (IIa)	0.8	3.9	11.7	32.5	16.1%
Non-Hodgkins lymphoma (NHL) (IIb,c,e)	5.9	8.9	10.3	15.3	7.6%
CNS tumors (III(total))	36.0	31.9	24.6	20.2	10.0%
Ependymoma (IIIa)	5.6	1.6	1.3	1.1	0.5%
Astrocytoma (IIIb)	15.0	15.9	15.1	12.3	6.1%
Medulloblastoma/PNET (IIIc)	9.6	7.3	4.0	2.5	1.2%
Neuroblastoma & ganglioneuroblastoma (IVa)	27.4	2.6	0.8	0.5	0.2%
Retinoblastoma (V(total))	12.5	0.5	0.0	0.1	0.0%
Wilms', rhabdoid, clear cell sarcoma (VIa)	18.0	5.8	0.6	0.4	0.2%
Hepatic tumors (VII(total))	4.8	0.4	0.4	1.0	0.5%
Hepatoblastoma (VIIa)	4.6	0.2	0.1	0.0	0.0%
Osteosarcoma (VIIIa)	0.3	2.8	8.3	9.4	4.6%
Ewing's sarcoma (VIIIc)	0.3	1.9	4.1	4.6	2.3%
Soft tissue sarcoma (IX(total))	10.9	8.3	10.9	15.9	7.9%
Rhabdomyosarcoma and embryonal sarcoma (IXa)	6.5	4.4	3.5	3.9	1.9%
Non-rhabdo soft tissue sarcoma (IXb-e)	4.4	4.0	7.4	11.9	5.9%
Germ Cell, trophoblastic, & other gonadal tumors (X (total))	6.9	2.4	6.7	30.8	15.2%
Thyroid carcinoma (XIb)	0.1	1.0	4.1	14.6	7.2%
Malignant melanoma (XId)	0.8	0.6	2.8	14.1	7.0%
Other and unspecified carcinomas (XIf)	0.4	0.8	2.8	10.5	5.2%

Figure XIII.1: Distribution of cancer types, age 15-19 all races, both sexes, SEER, 1986-95



non-Hodgkin's lymphoma (NHL) (7.6%), thyroid cancer (7.2%), malignant melanoma (7.0%), and acute lymphoblastic leukemia (ALL) (6.4%). Table XIII.1, as well as comparison of Figures XIII.1 and XIII.2, illustrates that a group of tumors that occurred commonly among children younger than 5 years of age were virtually absent among 15-19 year olds, including: neuroblastoma, Wilms' tumor, retinoblastoma, ependymoma, and hepatoblastoma. These 5 tumor types accounted for approximately 35% of cases among children younger than 5 years of age (Figure XIII.2),

Figure XIII.2: Distribution of cancer types, age <5 all races, both sexes, SEER, 1986-95



but less than 1% of cases among 15-19 year olds.

The distribution of tumor types within several ICCC categories for 15-19 year olds compared with children younger than 15 years of age warrants specific comment. The distribution of soft tissue sarcoma diagnoses differed by age. Rhabdomyosarcoma accounted for 60% of soft tissue sarcoma cases among children younger than 5 years of age. However, the incidence of rhabdomyosarcoma decreased with age, while the incidence of non-rhabdomyosarcoma soft tissue sarcomas increased with age, so that among 15-19 year olds, rhabdomyosarcoma accounted for only 25% of soft tissue sarcoma diagnoses (Table XIII.1). The annual incidence of ALL also decreased with age: among children younger than 5 years of age the rate was 58.2 per million, while for 15-19 year olds the rate was nearly 5-fold less (12.9 per million) (Table XIII.1). Although ALL accounted for nearly 30% of cancer cases among children younger than 5 years of age, it represented only 6.4% of cases among the 15-19 year olds. The incidence of NHL was higher among 15-19 year olds than among younger age groups (Table XIII.1). This increase was largely the result of much higher rates for diffuse large cell lymphoma among 15-19 year olds, while rates for Burkitt's lymphoma and lymphoblastic lymphoma for 15-19 year olds were similar to or less than those observed for children less than 15 years of age (see Lymphoma chapter for details).

Sex-specific incidence

The overall incidence of cancer cases was similar among males and females in the 15-19 year old age group for the years 1986 to 1995 (Table XIII.2). However, the overall similarity masked marked differences in rates for individual tumor types. There was a strong male predominance for ALL, NHL, osteosarcoma, and Ewing's sarcoma, with 60% to over 100% higher rates occurring in males than females. Additionally, rates of CNS tumors and germ cell tumors were 30-40% higher in males than in females. On the other hand, there was a female predominance for Hodgkin's disease, thyroid carcinoma, and melanoma.

The rates by sex for the 15-19 year olds were distinct from those for children younger than 15 years of age. For ALL, there was only a 20% excess of male cases among the children younger than 15 years of age, compared to a nearly 120% excess for the 15-19 year olds. There was a male predominance for Hodgkin's disease in the 0-14 year olds, compared to a female predominance in 15-19 year olds. The situation was reversed for the germ cell, trophoblastic, and other gonadal tumors, which were more common among females

Table XIII.2: Age-adjusted cancer incidence rates per million by ICCC group sex, and age, all races, both sexes, SEER, 1986-95

Age (in years) at diagnosis Tumor category	0-14 Male*	0-14 Female*	0-14 Ratio: M/F	15-19 Male	15-19 Female	15-19 Ratio: M/F
ALL SITES	149.5	128.7	1.2	204.3	199.9	1.0
Acute lymphoblastic leukemia	37.1	30.9	1.2	17.5	8.0	2.2
Acute myeloid leukemia (Ib)	6.6	6.5	1.0	8.4	8.5	1.0
Hodgkin's disease (IIa)	6.5	5.0	1.3	28.8	36.5	0.8
Non-Hodgkin's lymphoma (IIb,c,e)	12.3	4.5	2.7	19.4	11.0	1.8
CNS (III)	33.0	27.9	1.2	23.0	17.3	1.3
Osteosarcoma (VIIIa)	3.8	4.3	0.9	11.5	7.1	1.6
Ewing's sarcoma (VIIIc)	2.3	2.2	1.1	5.8	3.3	1.8
Soft tissue sarcomas (IX)	10.9	9.1	1.2	17.4	14.3	1.2
Germ cell tumors (X)	4.3	6.2	0.7	35.2	26.1	1.4
Thyroid carcinoma (XIb)	0.9	2.9	0.3	3.7	26.2	0.1
Melanoma (XId)	1.3	1.6	0.8	10.5	17.9	0.6

*Adjusted to the 1970 US standard population

in children younger than 15 years of age, but more common among males in the 15-19 year old age group. The male predominance for bone tumors observed in adolescents was absent in the younger than 15 year old age group. For NHL, there was a marked male predominance for both 0-14 year olds and for 15-19 year olds.

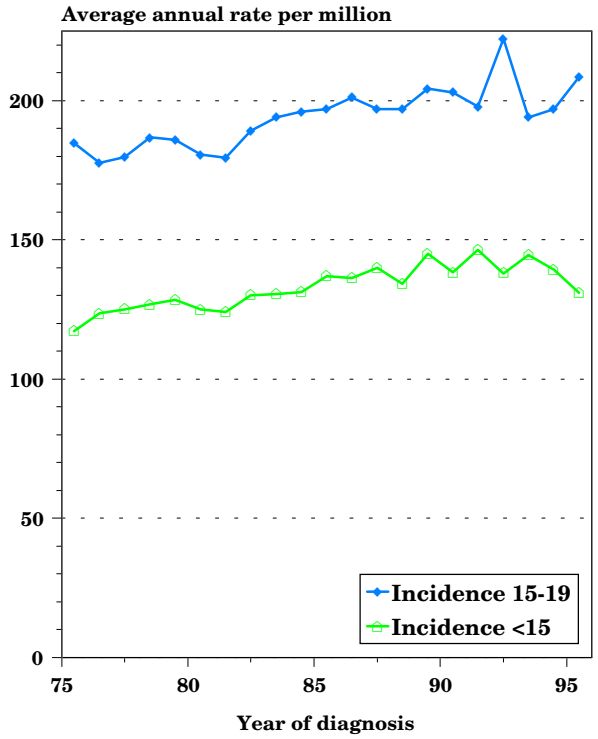
Black-white differences in incidence

The incidence of cancer among whites age 15-19 years for 1986-95 was approximately 1.5-fold higher than that among blacks age 15-19 years (Table XIII.3). In comparing cancer incidence for white and black 15-19 year olds, incidence rates at least 2-fold higher were observed among whites, compared to blacks for ALL, germ cell tumors, thyroid cancer, Ewing's sarcoma, and melanoma. The low incidence for germ cell tumors among blacks was restricted to testicular germ cell tumors in males. White females and black females had similar rates for germ cell tumors (see Germ Cell, Trophoblastic, and Other Gonadal Tumor chapter for additional details). While the very high ratio of white to black cases for melanoma may be explained by the protection afforded from ultraviolet light by melanin, the reasons that blacks have lower rates of Ewing's sarcoma, ALL, testicular germ cell tumors, and thyroid cancer are not apparent.

Table XIII.3: Age-specific cancer incidence rates per million by ICCC group and race age 15-19, SEER, 1986-95

Tumor category	White	Black	W/B Ratio
Total	213.5	144.8	1.5
Acute lymphoblastic leukemia	14.3	6.4	2.2
Acute myeloid leukemia (Ib)	8.3	7.1	1.2
Hodgkin's disease (IIa)	36.5	26.9	1.4
Non-Hodgkin's lymphoma (IIb,c,e)	16.1	9.4	1.7
CNS (III)	21.8	15.8	1.4
Osteosarcoma (VIIIa)	9.2	8.4	1.1
Ewing's sarcoma (VIIIc)	5.4	0.3	18.0
Soft tissue sarcomas (IX)	14.5	20.5	0.7
Germ cell tumors (X)	33.9	13.8	2.5
Thyroid carcinoma (XIb)	15.5	6.7	2.3
Melanoma (XId)	16.1	0.3	53.7

Figure XIII.3: Trends in age-adjusted* cancer incidence rates by age group, all races, both sexes, SEER, 1975-95



*Adjusted to the 1970 US standard population

TRENDS

The average annual age-adjusted cancer incidence among 15-19 year olds increased from 183 per million in 1975-79 to slightly over 203.8 per million in 1990-95 (Figure XIII.3 and Table XIII.4). By comparison, the incidence of cancer for children younger than 15 years of age increased from 124.3 per million in 1975-79 to 139.9 per million in 1990-95. The greatest numeric increase in annual incidence for the 15-19 year group occurred for the germ cell,trophoblastic, and other gonadal (GCTOG) tumors. This increase was primarily the result of an increase in the incidence of testicular germ cell tumors among males (increasing from 22.1 to 28.4 per million) and ovarian germ cell tumors among females (increasing from 7.9 to 13.3

Table XIII.4: Average annual age-specific incidence rates per million adolescents 15-19 years old for selected tumors, all races, both sexes, SEER, 1975-95

Tumor type (ICCC Category)	1975-79 Rate	1980-84 Rate	1985-89 Rate	1990-95 Rate
All Sites	183.0	187.7	199.3	203.8
Acute Lymphoblastic Leukemia (Ia)	10.6	13.2	12.4	13.0
Non-Hodgkin's lymphoma (IIb,c,e)	10.7	14.5	14.4	16.3
Osteosarcoma (VIIIa)	6.6	8.9	9.7	9.3
Germ cell, trophoblastic and other gonadal tumors (X)	23.2	24.0	28.6	32.0
Testicular germ cell tumor (Xc, male)	22.1	26.7	24.9	28.4
Ovarian germ cell tumor (Xc, female)	7.9	8.3	11.8	13.3
Gonadal carcinoma (Xd)	2.7	2.4	4.3	5.3

Rates are per 1,000,000.

per million). As discussed in the chapter for GCTOG tumors, the increase in gonadal carcinomas is likely artifactual and attributable to changes in reporting of ovarian tumors during this time period, specifically inclusion of borderline tumors of the ovary. The incidence of ALL, NHL, and osteosarcoma also increased from 1975-79 to 1990-95 (Table XIII.4). These four tumor types accounted for the majority of the increase in cancer incidence for the 15-19 year old group. No significant increases or decreases in incidence were observed for CNS tumors, melanoma, thyroid cancer, Hodgkin's disease, or soft tissue sarcomas.

SURVIVAL

Table XIII.5 shows 5-year relative survival rates for different cancer types for 15-19 year olds , with comparison made between an earlier time period (1975-84)

Table XIII.5: 5-Year Relative Survival Rates by ICCC group and time period, age 15-19, all races, both sexes SEER, 1975-84 and 1985-94

TUMOR CATEGORY	1975-84	1985-94
Total	69%	77%
Acute lymphoblastic leukemia (ALL)	35%	51%
Acute myeloid leukemia (AML) (Ib)	22%	42%
Hodgkin's (IIa)	88%	90%
NHL (IIb,c,e)	56%	69%
Astrocytoma (IIIb)	62%	75%
Medulloblastoma (IIIc)	63%	75%
Osteosarcoma (VIIIa)	49%	59%
Ewing's sarcoma (VIIIc)	36%	56%
Soft tissue sarcoma (IX)	70%	63%
Rhabdomyosarcoma (IXa)	40%	45%
Germ cell tumors (X)	79%	90%
Thyroid carcinoma (XIb)	99%	99%
Melanoma (XId)	84%	92%

and a recent reporting period (1985-94). Important observations concerning survival rates include:

- For all cancer diagnoses in the 15-19 year old age group, the 5-year survival rate for the recent reporting period was 77%, which was higher than that for the other five-year age groups younger than 20 years of age.

- Five-year survival rates of 90% or higher were observed for Hodgkin's disease, germ cell tumors, thyroid carcinoma, and melanoma. For germ cell tumors and melanoma, the survival rates improved between the earlier and recent time period.

- Five-year survival rates for NHL improved between 1975-84 and 1985-94 from approximately 56% to 69%.

- Five-year survival rates for both ALL and AML improved substantially for the 15-19 year old group, with survival rates for 1985-94 of 51% and 42%, respectively, compared to only 35% and 22% for 1975-84.

Five-year survival rates for Ewing's sarcoma improved from 36% to 56% between the earlier and the recent reporting period.

The mortality burden is a function of the survival and the incidence rates. The leukemias are the primary contributor to the cancer mortality burden for cancers developing in the 15-19 year olds. In addition to leukemia, bone cancer, soft tissue sarcoma, CNS cancer, NHL, and Hodgkin's disease are the most common causes of cancer death among this group - see the mortality chapter. Although thyroid carcinoma and melanoma are among the more common cancers in this age group, they contribute little to the overall cancer mortality burden for the 15-19 year old age group.

SUMMARY

The spectrum of malignancies that occur in adolescents is distinctive when compared to those that occur in young children and those that occur in older adults. The embryonal cancers that predominate among young children (e.g., neuroblastoma, Wilms' tumor, retinoblastoma, ependymoma, and hepatoblastoma) are very uncommon among 15-19 year olds. Similarly, the epithelial carcinomas of adults (e.g., lung, breast, colon) rarely occur in 15-19 year olds. While some types of acute leukemias and CNS cancers are shared with both the older adult and the young childhood populations, the 15-19 year old group experiences high rates of a set of tumors (including germ cell tumors, Hodgkin's disease, and the bone cancers) that are relatively characteristic of the adolescent/young adult age group.

The annual incidence of cancer in adolescents increased from 183 per million for 1975-79 to 203.8 per million from 1990-95. The largest contributor to this increase was the germ cell, trophoblastic, and other gonadal tumor category (specifically testicular and ovarian germ cell tumors), with smaller contributions from NHL, osteosarcoma, and ALL.

Rates of specific cancer types differed substantially by sex and by race. For sex, these differences were most remarkable for thyroid cancer (much more common in females) and for the bone tumors, ALL, and NHL (the latter three more common among males). Black 15-19 year olds had much lower incidence rates of Ewing's sarcoma, testicular germ cell tumors, and melanoma than did whites, and modestly lower

incidence rates of ALL and thyroid cancer.

Five-year survival for 15-19 year olds increased from 69% to 77% from 1975-84 to 1985-94, with a 90% survival rate or better for several diagnoses (Hodgkin's disease, germ cell tumors, thyroid cancer, and melanoma). However, for some cancers, the survival rates remained less than 60% (including osteosarcoma, Ewing's sarcoma, ALL, and AML).

Reference List

1. Bleyer W, Tejada H, Murphy S, et al: National cancer clinical trials: Children have equal access; adolescents do not. J Adolesc Health 21:366-373, 1997.