Racial and Ethnic Disparities in the Incidence and Trends of Soft Tissue Sarcoma Among Adolescents and Young Adults in the United States, 1995–2008

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Purpose: The aim of this study was to examine racial/ethnic disparities in the incidence rates and trends of soft tissue sarcoma (STS) by gender, age, and histological type among adolescents and young adults (AYAs) aged 15–29 years.

Methods: The 1995–2008 incidence data from 25 population-based cancer registries, covering 64% of the United States population, were obtained from the North American Association of Central Cancer Registries. The Surveillance, Epidemiology and End Results AYA site recode and International Classification of Diseases for Oncology, 3rd Edition, were adopted to categorize STS histological types and anatomic groups. Age-adjusted incidence rates and average annual percent change (AAPC) were calculated.

Results: The incidence of all STSs combined was 34% higher in males than females (95% CI: 1.28, 1.39), 60% higher among blacks than whites (95% CI: 1.52, 1.68), and slightly higher among Hispanics than whites. Compared with whites, blacks had significantly higher incidence of fibromatous neoplasms, and Hispanics had significantly higher incidence of liposarcoma. Whites were more likely to be diagnosed with synovial sarcoma than blacks. Black and Hispanic males had significantly higher Kaposi sarcoma incidence than white males. The AAPC of all STSs combined showed a significant decrease from 1995 to 2008 (AAPC = –2.1%; 95% CI: –3.2%, –1.0%). However, after excluding Kaposi sarcoma, there was no significant trend.

Conclusion: The incidence rates of STS histological types in AYAs vary among racial/ethnic groups. The declining trends of STS are due mainly to decreasing incidence of Kaposi sarcoma in all races/ethnicities. Research to identify factors associated with racial/ethnic disparities in AYA STS is necessary.

Keywords: soft tissue sarcoma, race/ethnicity, disparities, epidemiology

SOFT TISSUE SARCOMA (STS) is the sixth most commonly diagnosed cancer among adolescents and young adults (AYAs) aged 15–29 years old, accounting for approximately 8% of all invasive cancers in this age group.^{1,2} This heterogeneous group of tumors originates from primitive mesenchymal cells, and consists of a broad diversity of histological types, including fibrosarcoma, rhabdomyosarcoma, synovial sarcoma, liposarcoma, and Kaposi sarcoma. Previous studies have indicated that histological patterns of STS among 15–29 year olds differ from those among children (aged 0–14 years) and among adults aged 30 and older. For example, rhabdomyosarcoma occurs much more frequently among children, especially those under 5 years old, than among AYAs;³ synovial sarcoma occurs more frequently among young adults aged 19–29 than among those younger or older;⁴ and leiomyosarcoma, liposarcoma, and fibrous histiocytoma are less predominant among

AYAs than those aged 30 and older.⁵ Race and gender variations in STS incidence have been reported previously, with studies finding that blacks have higher incidence rates of STS than whites and other races,¹ and males have slightly higher incidence than females.^{1,6}

It is known that AYAs with cancer have not received adequate attention in many aspects of the cancer control spectrum as compared with pediatric and adult cancer patients.^{7,8} STS patients aged 15–29 years old—particularly those aged 25–29—are less likely to take advantage of clinical trials than other age groups^{2,9} and also have lower 5-year relative survival rates than younger STS patients.^{2,8} Most studies on STS histological types and outcomes with the AYA population have focused on the comparison of this age group with younger and/or older populations,^{1,2,4,5,7–10} with less focus on quantifying the differences among racial/ethnic groups within this age group.¹ Our aims were to examine the racial/

ethnic differences in incidence of STS histological types by gender and to assess the incidence trends of STS for AYAs aged 15–29 using data from 25 U.S. population-based cancer registries.

Methods

Data sources

STS data were obtained from the North American Association of Central Cancer Registries (NAACCR), an organization that develops and provides uniform data standards, training, and certification of high data quality for population-based registries, and promotes the use of cancer surveillance data and cancer research to reduce the burden of cancer in North America. NAACCR compiles data submitted from 13 Canadian central registries and 53 U.S. central registries (50 statewide registries, the District of Columbia, and the U.S. territories of Guam and Puerto Rico).¹¹ STS incidence data diagnosed between 1995 and 2008 were selected from 25 U.S. statewide cancer registries that met the NAACCR criteria for high-quality incidence data^{12,13} for the study period, nine of which were also Surveillance, Epidemiology and End Results (SEER) program registries. The 25 registries that consented to have their data included in this study were: Arizona, California, Colorado, Connecticut, Delaware, Florida, Hawaii, Idaho, Illinois, Iowa, Kentucky, Louisiana, Maine, Michigan, Minnesota, Nebraska, New Jersey, New Mexico, New York, Pennsylvania, Rhode Island, Texas, Utah, Washington, and Wyoming, together covering approximately two-thirds of the U.S. population. The analysis was restricted to white, black, and Hispanic patients aged 15–29 years old who were diagnosed with an invasive STS between 1995 and 2008. The classification of race/ethnicity was based on the SEER race recode,¹⁴ which integrates the NAACCR Hispanic Identification Algorithm (NHIA)¹⁵ version 2 for Hispanic ethnicity. Since ethnicity is coded separately from race, those with ethnicity coded as Hispanic could be of any race. Data on American Indian/Alaska Natives and Asian/Pacific Islanders ($n=513$) were not included due to the small number of cases in gender and histological subtype groups. Cases with unknown race and ethnicity ($n=210$) were also excluded.

Grouping of histological types and site groups

STS among AYAs is more diverse in histological types and anatomic sites than it is among children.^{1,3} To characterize types of STS for AYAs properly, we used the SEER site and morphology AYA site recode.¹⁶ This was specifically developed to define the major cancer sites for individuals aged 15–39 better, based on the classification scheme proposed by Barr *et al.*¹⁷ We further separated liposarcoma (International Classification of Diseases for Oncology, 3rd Edition¹⁸ [ICD-O-3] morphologies 8850–8858), leiomyosarcoma (ICD-O-3 morphologies 8890, 8891, 8896), and synovial sarcoma (ICD-O-3 morphologies 9040–9043), which occur more commonly in AYAs, from the specified sarcoma group. STS cases were then reclassified into the following categories: fibromatous neoplasms, rhabdomyosarcoma, liposarcoma, leiomyosarcoma, synovial sarcoma, Kaposi sarcoma, other specified STSs, and unspecified STSs. Cancer anatomic sites were classified into 10 groups using the ICD-O-3 topography code¹⁸ as

follows: head and neck, limbs, lung and respiratory tract, heart and mediastinum, trunk, gastrointestinal tract, pelvis, urinary system, genitals, and other sites, which includes all site codes not listed in another category.

Statistical analysis

Age-adjusted STS incidence rates were calculated for gender, race/ethnicity, age group, and anatomic site. All incidence rates were age-adjusted to the 2000 U.S. standard population and were expressed as the number of cases per million persons per year. Average annual percent change (AAPC) of incidence rates, based on weighted least squares regression, was used to describe incidence trends by age group, gender, and race/ethnicity.¹⁹ The relevant rate ratios (RRs), AAPCs, and their corresponding 95% confidence intervals (CIs) were computed, and tests of statistical significance for comparisons were set at a p -value of <0.05 . Incidence rates were suppressed when the count of a specific category was fewer than 16 cases. All analyses were carried out using the SEER*Stat version 7.0.9.²⁰

Results

A total of 10,289 eligible STS cases diagnosed among AYAs in 1995–2008 were included in this study; 97% had microscopically confirmed histology. Males, blacks, and those aged 25–29 years old had the highest incidence among AYAs (Table 1). The overall incidence rate of STS was 34% higher in males than females, 60% higher in blacks than whites, and two-fold higher in 25–29 year olds than in 15–19 year olds. The most common anatomic sites were limbs (39%), followed by trunk (19%) and head and neck (11%; Table 1).

Histological type by gender and race/ethnicity

Males had higher incidence rates than females across all histological types among the three racial/ethnic groups except for fibromatous neoplasms and leiomyosarcoma (Table 2). The three most common histological types for all males were fibromatous neoplasms, rhabdomyosarcoma, and Kaposi sarcoma. For females, the three most common histological types differed by race/ethnicity: fibromatous neoplasm was the most common type for all racial/ethnic groups, followed by synovial sarcoma and rhabdomyosarcoma in whites, rhabdomyosarcoma and Kaposi sarcoma in blacks, and synovial sarcoma and liposarcoma in Hispanics (Table 2). Figure 1 shows the incidence of Kaposi sarcoma versus non-Kaposi sarcomas by gender and age group. Kaposi sarcoma dominated in males aged 25–29, accounting for 83% of all Kaposi sarcoma cases in males; it was also the most common STS histological type among black and Hispanic males (Table 2).

Compared with white males, black males had a five-fold excess rate of Kaposi sarcoma, a 46% higher rate of fibromatous neoplasms, and a 35% higher rate of rhabdomyosarcoma. Hispanic males had significantly higher rates of liposarcoma and Kaposi sarcoma and significantly lower rates of fibromatous neoplasms and leiomyosarcoma than white males. Black females had a 72% higher rate of fibromatous neoplasms and 31% lower rate of synovial sarcoma than white females. However, rates among Hispanic females did not

TABLE 1. FREQUENCY DISTRIBUTIONS AND AGE-ADJUSTED^a INCIDENCE RATES OF SOFT TISSUE SARCOMAS BY GENDER, RACE/ETHNICITY, AGE GROUP, AND ANATOMIC SITE AMONG 15–29 YEAR OLDS IN THE UNITED STATES, 1995–2008

	Number of cases	% ^b	Incidence rate ^{b,c}	Rate ratio (95% CI) ^b
Gender				
Male	6,033	58.64	23.31	Ref
Female	4,256	41.36	17.42	0.75 (0.72, 0.78)
Race/ethnicity				
White	5,868	57.03	18.69	Ref
Black	1,899	18.46	29.89	1.60 (1.52, 1.68)
Hispanic	2,522	24.51	20.04	1.07 (1.02, 1.12)
Age at diagnosis				
15–19	2,423	23.55	14.22	Ref
20–24	3,112	30.25	18.99	1.34 (1.27, 1.41)
25–29	4,754	46.20	28.87	2.03 (1.93, 2.13)
Anatomic site				
Limbs	4,016	39.03	7.98	Ref
Trunk	1,925	18.71	3.82	0.48(0.45, 0.51)
Head and neck	1,178	11.45	2.34	0.29 (0.28, 0.31)
Pelvis	607	5.90	1.22	0.15 (0.14, 0.17)
Male/female genital	481	4.67	0.97	0.12 (0.11, 0.13)
Gastrointestinal tract	250	2.43	0.49	0.06 (0.05, 0.07)
Heart and mediastinum	148	1.44	0.29	0.04 (0.03, 0.04)
Lung and respiratory tract	102	0.99	0.20	0.03 (0.02, 0.03)
Urinary system	64	0.62	0.13	0.02 (0.01, 0.02)
Other sites	1,518	14.75	2.99	0.37 (0.35, 0.40)

^aAdjusted to the 2000 United States standard population.^bPercentages, incidence rates, rate ratios, and 95% CI values are rounded.^cRates are per million persons per year.

CI, confidence interval; Ref, reference.

statistically differ from those for whites except for liposarcoma, which was 45% higher (Table 2). Unlike other histological types, rhabdomyosarcoma was more likely to occur in genital sites (29%) for males versus head and neck (31%) for females (data not shown).

Incidence trends in 1995–2008

The trend for all STSs combined significantly declined during the study period (AAPC = –2.1%; 95% CI: –3.2%, –1.0%). However, after excluding Kaposi sarcoma, there was

TABLE 2. AGE-ADJUSTED^a INCIDENCE RATES OF SOFT TISSUE SARCOMAS BY GENDER, RACE/ETHNICITY, AND HISTOLOGICAL TYPE AMONG 15–29 YEAR OLDS IN THE UNITED STATES, 1995–2008

Gender	Histological subtype	Number of cases	Incidence rates ^{b,c}			Rate ratio (95% CI) ^c	
			White	Black	Hispanic	Black/white	Hispanic/white
Male	Fibromatous neoplasms	1,273	5.04	7.37	3.53	1.46 (1.26, 1.69)	0.70 (0.60, 0.81)
	Rhabdomyosarcoma	668	2.60	3.52	2.30	1.35 (1.09, 1.67)	0.88 (0.72, 1.07)
	Liposarcoma	320	1.15	0.89	1.59	0.77 (0.50, 1.15)	1.38 (1.08, 1.77)
	Leiomyosarcoma	247	1.06	0.84	0.76	0.80 (0.51, 1.21)	0.72 (0.52, 0.99)
	Synovial sarcoma	562	2.30	1.72	2.13	0.75 (0.55, 1.00)	0.92 (0.76, 1.13)
	Kaposi sarcoma	1,413	2.86	14.38	7.14	5.02 (4.40, 5.73)	2.49 (2.19, 2.83)
	Other specified soft tissue sarcomas	882	3.51	4.28	2.82	1.22 (1.00, 1.47)	0.80 (0.68, 0.95)
	Unspecified soft tissue sarcomas	668	2.25	3.88	2.79	1.73 (1.40, 2.13)	1.24 (1.04, 1.49)
Female	Fibromatous neoplasms	1,430	5.42	9.33	4.92	1.72 (1.50–1.97)	0.91 (0.79, 1.04)
	Rhabdomyosarcoma	391	1.62	2.00	1.47	1.23 (0.92–1.63)	0.90 (0.70, 1.16)
	Liposarcoma	273	1.04	0.75	1.51	0.72 (0.45, 1.11)	1.45 (1.11, 1.90)
	Leiomyosarcoma	310	1.20	1.52	1.25	1.26 (0.90, 1.74)	1.04 (0.78, 1.34)
	Synovial sarcoma	497	2.17	1.49	2.01	0.69 (0.50, 0.93)	0.92 (0.74, 1.14)
	Kaposi sarcoma	81	0.11	1.58	^d	14.80 (8.39, 7.34)	^d
	Other specified soft tissue sarcomas	768	3.07	3.99	2.90	1.30 (1.06, 1.58)	0.94 (0.79, 1.13)
	Unspecified soft tissue sarcomas	506	1.92	2.58	2.22	1.35 (1.04, 1.72)	1.16 (0.93, 1.43)

^aAdjusted to the 2000 United States standard population.^bRates are per million persons per year.^cPercentages, incidence rates, rate ratios, and 95% CI values are rounded.^dStatistic not displayed due to fewer than 16 cases.

CI, confidence interval.

FIG. 1. Incidence of Kaposi sarcoma versus non-Kaposi sarcomas by gender and age group among 15–29 year olds in the United States, 1995–2008.

no significant trend change for all AYAs combined (AAPC = -0.2% ; 95% CI: -0.7% , 0.5%) or by gender, race/ethnicity, or age group. The incidence of Kaposi sarcoma in males aged 25–29 decreased dramatically from 1995 to 1999 for all racial/ethnic groups; whites and Hispanics had similar incidence trend patterns (Fig. 2).

Discussion

Different patterns of STS incidence and trends among AYA-aged racial/ethnic groups were observed in this study. Blacks had the highest incidence rates of fibromatous neoplasms, rhabdomyosarcoma, and Kaposi sarcoma among all racial/ethnic groups, which is consistent with previous reports.¹ This study also revealed that Hispanic males and females had significantly higher liposarcoma rates than other racial/ethnic groups. Liposarcoma is one of the common histological types of adult STS,⁵ but is rare in children.^{3,5} While white males and females tended to have higher incidence of synovial sarcoma than blacks and Hispanics, the

difference was significant only when comparing white females with black females (rate ratio: 1.45; 95% CI: 1.07, 2.01). As noted in a previous report,⁴ limbs were the most common primary site for synovial sarcoma (about 67%). Increasing trends of incidence of non-Kaposi sarcomas in males and females from 1975 to 2000 were reported in the SEER AYA monograph;¹ this pattern was not observed in our study. In contrast, we found a statistically significant decreasing trends for black males aged 25–29 (AAPC = -3.0% ; 95% CI: -5.8% , -0.2%) and white females aged 20–24 (AAPC = -1.9% ; 95% CI: -3.1% , -0.6%) from 1995 to 2008.

The incidence of Kaposi sarcoma in the AYA population observed in this study was much lower than that reported by Bleyer *et al.*¹ This may result from the different study time periods. Bleyer's study included AYA patients diagnosed between 1975 and 2000, which covers the Acquired Immune Deficiency Syndrome (AIDS) epidemic period of the 1980s, whereas the data reported here refer to the years 1995–2008, when the Kaposi sarcoma epidemic had subsided considerably. In addition, our study showed that incidence trends of

FIG. 2. Incidence trends and average annual percent change (AAPC) of Kaposi sarcoma by race/ethnicity in males aged 25–29 years old in the United States, 1995–2008.

Kaposi sarcoma in males aged 25–29 declined dramatically between 1995 and 1999 for all racial/ethnic groups (Fig. 2). This finding is consistent with previous studies,^{21,22} which noted that Kaposi sarcoma incidence rates in males declined precipitously after the mid-1990s. Possible factors that contributed to this decline were the reduction in high-risk sexual behavior among homosexual men^{23,24} and the effects of antiretroviral treatment on AIDS-related Kaposi sarcoma.^{25,26} Throughout the 14-year period of 1995–2008 in this study, the incidence rate of Kaposi sarcoma in black males aged 25–29 was consistently higher than those for white and Hispanic males, except for 2005, when incidence among Hispanics was slightly higher than blacks (Fig. 2). The reasons for this excess among black males may include continually higher human immunodeficiency virus rates due to high-risk sexual behavior and/or substance drug use and lower levels of antiretroviral therapy adherence among blacks than in whites and Hispanics.^{27–29}

The strengths of this study include the study population covering 64% of the U.S. population, a large number of cases (more than 10,000), the availability of data collected and coded uniformly according to NAACCR rules, and the use of NHIA to improve Hispanic identification. In addition, we classified the STS histological type using the SEER AYA site recode, which was developed to define major cancer sites and morphologies better for the AYA oncology population.

Like other studies using population-based registry data, our study has some limitations. First, the Hispanic origin status in cancer registry data may not be reliable due to a lack of ethnicity information on the medical record. A study by Clegg *et al.* showed moderate to substantial agreement for Hispanic ethnicity between SEER registry data and self-reported data.³⁰ Incorrect reporting of Hispanic origin in registry data directly affects the results of NHIA ethnicity. Second, because of the small number of AYA STSs for some histological types, we were unable to make comparisons at the race/ethnicity level for each age group and gender. Third, although data used in this study covered more than half of the U.S. population, the results may not represent the entire United States.

Conclusion

Our study found variations in incidence rates and trends of STS histological type among racial/ethnic groups of adolescents and young adults in the United States. Kaposi sarcoma was the primary contributor for both the excess in STS rates noted among blacks and the observed decreasing trends during the 14-year period studied, especially for males aged 25–29. Although the incidence of Kaposi sarcoma has declined dramatically in the last decade, it remained the most common STS in young adult males aged 25–29. During the 14-year period studied, black and Hispanic males continued to have significantly higher incidence rates of Kaposi sarcoma than white males, as noted previously in other studies.

To date, Kaposi sarcoma is the only type among all STSs that is amenable to prevention through appropriate interventions. Further efforts should focus on developing effective racially and ethnically sensitive and culturally acceptable interventions in order to minimize the disparities and ultimately reduce incidence of Kaposi sarcoma in young adults of all races/ethnicities. While disparities are also observed for

common non-Kaposi sarcoma histological types—such as higher incidence rates of fibromatous neoplasms and rhabdomyosarcoma in blacks, liposarcomas in Hispanics, and synovial sarcoma in whites—no well-established cancer controls are currently in place. Unlike Kaposi sarcoma, factors for racial and ethnic disparities in non-Kaposi sarcoma incidence among AYAs are less clear. More research on factors contributing to the racial and ethnic disparities of non-Kaposi sarcomas is needed.

Acknowledgments

The authors would like to thank the North American Association of Central Cancer Registries for the use of its Cancer in North America (CINA) Deluxe Data files. This work was supported in part by the Louisiana State University Health Sciences Center, the Centers for Disease Control and Prevention under National Program of Cancer Registries (NPCR) cooperative agreement number 5U58DP000769, and the National Cancer Institute's SEER contract number HHSN261201000030C.

Author Disclosure Statement

No competing financial interests exist.

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