Incidence of selected cancers in Non-Hispanic American Indian and Alaska Native adolescent and young adult populations, 1999–2019

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Abstract

Purpose: Studies have highlighted geographic variation in cancer incidence rates among American Indian and Alaska Native (AI/AN) populations. This is the first study to comprehensively evaluate incidence rates and trends among non-Hispanic AI/AN (NH-AI/AN) adolescents and young adults (AYAs) ages 15–39 years.

Methods: Using the United States Cancer Statistics AI/AN Incidence Analytic Database, we identified all malignant cancer cases for NH-AI/AN AYA populations for the years 1999–2019. We calculated age-adjusted incidence rates (per 100,000) for NH-AI/AN populations overall, by region, and by age group. We calculated the total percent change in the incidence of leading AYA cancers between 1999 and 2019, and trends by region and cancer type using Joinpoint analysis.

Results: Testicular (13.6) and breast (19.0) cancers had the highest incidence of all AYA cancers in NH-AI/AN males and females, respectively. Overall AYA cancer rates increased by 1.4% in NH-AI/AN males and 1.8% in NH-AI/AN females annually between 1999 and 2019. Increases were observed by age group and geographic region.

Conclusions: This study describes regional differences in incidence rates of AYA cancers among NH-AI/AN populations. This data can help inform resource and cancer control priorities

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and strategies to reduce cancer risk and enhance access to quality diagnostic and treatment services for this population.

Introduction

Previous studies have highlighted the importance of disaggregating cancer incidence data for American Indian and Alaska Native (AI/AN) populations in the United States by sex, cancer type, and geographic region [1-3] to fully characterize cancer incidence in this diverse racial group. Limited information is available on incidence rates and trends for cancers among AI/AN adolescent and young adult (AYA) populations, despite growing evidence that the overall incidence of AYA cancers is increasing across all racial and ethnic groups in the United States and globally [4,5]. Cancers among AYAs are defined in this article as cancers diagnosed at ages 15–39 years [6]. These cancers are often biologically distinct from cancers in older adults and children [7].

The purpose of this study is to describe cancer incidence rates and trends of the leading AYA cancers among non-Hispanic AI/AN (NH-AI/AN) AYA populations in the United States, by sex and geographic region, for the years 1999–2019. This is the first study to analyze cancer incidence rates and trends among the NH-AI/AN AYA populations utilizing data from central cancer registries linked with the Indian Health Service (IHS) patient registration database. This study may serve as a foundation for efforts aimed at reducing cancer risk and improving cancer outcomes among AI/AN AYA populations [8].

Methods

Cancer cases

We utilized cancer registry data from the Centers for Disease Control and Prevention's National Program of Cancer Registries (NPCR) [9] and the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program [10]. Incidence data from both registries must meet rigorous quality control standards for each diagnosis year [11]. Data from both registry programs are combined to create the *U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database*, the analytic database used for this study [11].

Previous data has shown that racial misclassification of AI/AN populations in cancer registry data can lead to an underestimation of cancer incidence rates [12]. To reduce racial misclassification, cancer registry data were linked with the IHS patient registration database using established and validated techniques to improve the accuracy of cancer incidence estimates among AI/AN populations [12,13]. All case records from each registry were linked with the IHS patient registration database to identify AI/AN cases that had been misclassified as non-AI/AN in the central cancer registry data.

Previous analyses also revealed that the updated bridged intercensal population estimates substantially overestimated AI/AN populations of Hispanic origin [14]. To avoid underestimating incidence rates in AI/AN populations, analyses were limited to NH-AI/AN populations. To further improve the racial classification of AI/AN populations, analyses were restricted to purchased/referred care delivery area (PRCDA) counties, which contain, or are adjacent to, federally recognized tribal lands [15]. Restricting to PRCDA counties provides more accurate correction for racial misclassification of the AI/AN population because these counties have a higher proportion of AI/AN people in relation to the total population than non-PRCDA counties [12,16]. Approximately 53% of the AI/AN population resides in these counties [16]. Counts and rates for the years presented in this study cover 98% of the U.S. population in PRCDA counties [17]. These counties are grouped by state into six geographic regions: the Northern Plains, Alaska, Southern Plains, Pacific Coast, East, and Southwest [18,19].

All cancer cases for NH-AI/AN populations aged 15–39 years were categorized according to the AYA site recode 2020 revision [6,20]. During the period covered by this study (1999–2019), tumor histology, tumor behavior, and primary cancer site were classified according to the International Classification of Diseases for Oncology (ICD-O) edition in use at the time of diagnosis and converted to the Third Edition (ICD-O-3) [21,22]. Only malignant cancers were included. AYA site recodes 1–8 and 10 were coded as is. Individual carcinomas (AYA recode site group 9) were categorized as individual sites. Site groups 9.3.4 (carcinoma of the colon) and 9.3.5 (carcinoma of the rectum) were combined into a single category (colorectal). In situ cancers (AYA site recode 11) were not included.

Statistical analysis

Cancer incidence rates for NH-AI/AN AYA cancers in the U.S. overall and by region were expressed per 100,000 population and were directly age-adjusted to the 2000 U.S. standard population. Using the age-adjusted incidence rates, we calculated standardized rate ratios (RRs) (not shown) comparing PRCDA rates in each region to the United States overall in order to measure geographic differences in incidence rates. We calculated confidence intervals for age-adjusted rates on the basis of methods described by Tiwari et al. [23]. Leading AYA cancers were identified based on rates and count in the NH-AI/AN population in PRCDA counties in the United States overall. The percent distribution of leading cancers was also calculated. Incidence rates for leading AYA cancers were calculated by region among non-Hispanic White (NHW) populations. RRs comparing (NH-AI/AN vs. NHW) by region were calculated and included as Supplemental data. All analyses were conducted using SEER*Stat software, version 8.3.9 (National Cancer Institute) [24].

Age-adjusted incidence rates for AYA cancers were calculated by age group. Age was divided into two categories: 15–29 years and 30–39 years. More granular age categorizations were not possible due to small numbers.

Cancer incidence trends (1999–2019) were estimated by joinpoint regression (Joinpoint Regression Program version 4.9.0.0 (National Cancer Institute)) [25] for all AYA sites combined by sex and age group. Additionally, incidence trends were calculated for selected cancer sites for the NH-AI/AN population overall. Average annual percent change (AAPC)

during 1999–2019 was calculated for each cancer site by sex and region for NH-AI/AN populations. Additionally, the total percent change in incidence rates between the 5-year intervals of 1999–2004 and 2015–2019 was calculated for all AYA sites combined by sex and for selected cancers.

Results

Age-adjusted incidence rates and percent distribution for all AYA cancers and the 10 leading cancers among NH-AI/AN males and females are described in Table 1. The most common cancers among NH-AI/AN males were testicular cancer, lymphomas, colorectal cancer, leukemias, and kidney cancer. The top five cancers among NH-AI/AN females were female breast cancer, thyroid cancer, cervical cancer, uterine cancer, and colorectal cancer.

Rates for all AYA sites combined among NH-AI/AN males ranged from 34.3 (East) to 72.4 (Southern Plains) (Table 2). Testicular cancer had the highest incidence rate out of all AYA cancers in every region, ranging from 8.3 (East) to 14.7 (Pacific Coast). These rates were consistent with rates in the U.S. overall except in the East, where rates were significantly lower. Rates of lymphoma ranged from 4.1 (Southwest) to 9.6 (Southern Plains). Rates of lymphoma were significantly higher in the Southern Plains compared to the US overall, but lower in the Southwest. Colorectal cancer rates varied by region and were significantly higher in the Southern Plains (7.0) compared to the U.S. overall. When compared to NHW males (Table A1), rates of all sites combined were significantly lower among NH-AI/AN people in the U.S. overall (RR = 0.96), East (RR = 0.54) and Southwest (RR = 0.84), but higher in Alaska (RR = 1.18) and the Southern Plains (RR = 1.38). RRs (NH-AI/AN vs. NHW) ranged from 0.08 (melanomas) in the Southwest to 2.64 (kidney cancers) in the Southern Plains.

Rates for all AYA cancers combined among NH-AI/AN females varied by region, ranging from 72.2 (East) to 117.9 (Southern Plains) (Table 3). Breast cancer rates were significantly higher in Alaska and the Southern Plains compared to the U.S. overall, but lower in the Southwest. Cervical cancer incidence rates ranged from 5.3 (Southwest) to 14.7 (Southern Plains). Rates of cervical cancer were significantly higher in the Southern Plains compared to the U.S. overall, but lower in the Southwest. When compared to NHW females (Table A1), rates of all AYA sites combined were significantly lower among NH-AI/AN females in the East (RR = 0.72), Southwest (RR = 0.79) and significantly higher in Alaska (RR = 1.35) and the Southern Plains (RR = 1.39). RRs (NH-AI/AN vs. NHW) females ranged from 0.14 (melanomas) in the East to 4.05 (uterine cancers) in the Southwest.

Age-adjusted incidence rates by age group for the leading cancers in NH-AI/AN males and females are shown in Table 4. Among NH-AI/AN males, incidence rates for the leading cancers ranged from 0.7 (kidney) to 11.2 (testis) in the 15–29 age group and from 3.5 (head and neck) to 16.7 (testis) in the 30–39 age group. Among NH-AI/AN females, incidence rates for the leading AYA cancers ranged from 0.9 (kidney) to 9.7 (thyroid) in the 15–29 age group and from 4.5 (leukemias) to 40.2 (female breast) in the 30–39 age group. Among NH-AI/AN males, testicular cancer had the highest incidence rate in both age groups. Following testicular cancer, lymphomas, leukemias, and sarcomas had the highest incidence

rates in the 15–29 age group, and lymphomas, colorectal, and kidney cancer were most common in the 30–39 age group. Among NH-AI/AN females, the most common cancers in the 15–29 age group were thyroid cancer, lymphomas, and cervical cancer. In the 30–39 age group, the most common cancers were female breast cancer thyroid, cervical, and uterine cancers.

Trends and AAPCs for all AYA cancers by sex, region, and age group are described in Figures 1 and 2 and Table A2. Significant increases in incidence rates for all AYA cancers between 1999 and 2019 in the United States were observed in both NH-AI/AN males (AAPC: 1.4) and females (AAPC: 1.8) (Fig. 1). Rates of all AYA cancers increased among NH-AI/AN females in the Southwest (AAPC: 1.6), Northern Plains (AAPC: 2.0), East (AAPC: 2.5), and Pacific Coast (AAPC: 2.8), and, while among AI/AN males, increases in incidence were observed in the Southern Plains (AAPC: 1.4) (Table A2). Changes were observed in the remaining regions but did not reach statistical significance. In NH-AI/AN females ages 30–39, rates increased by approximately 2.2% per year from 1999 to 2019. Similar increases were also seen in the 15–29 age group (AAPC: 1.3) and 30–39 age group (AAPC: 1.4) among NH-AI/AN males (Fig. 2).

Changes in incidence rates and AAPC between 1999 and 2019 by sex and cancer type are described in Figure 3 and Table A3. Testicular cancer incidence trends increased among NH-AI/AN males (AAPC: 1.6, Table A3). Testicular cancer rates had the second highest percentage increase of 27.9% after colorectal cancers which increased by 47.6% between the 1999–2004 and 2015–2019 time periods. All AYA cancers, leukemias, and lymphomas increased by 25.0%, 20.9%, and 6.2% respectively between the two time periods. Trends of thyroid cancer (AAPC: 4.7), uterine cancer (AAPC: 2.9), and colorectal cancer (AAPC: 3.3) increased among NH-AI/AN females. Thyroid cancer incidence rates had the largest percent increase of 92.8% followed by uterine and colorectal cancers which increased by 74.4% and 69.8%, respectively between the 1999–2004 and 2015–2019 time periods. Female breast and cervical cancers increased by 12.1% and 13.0% respectively between these time periods among NH-AI/AN females.

Discussion

Leading cancers among NH-AI/AN AYA populations varied by sex, with the top 10 cancers accounting for 86.8% (n = 2837) of AYA cancers among NH-AI/AN males and 82.8% (n = 4242) among NH-AI/AN females. These leading cancers were consistent with the general U.S. population, however, the relative ranks and rates varied [26]. The highest rate of all AYA cancers combined was in the Southern Plains and the lowest was in the East. Rates of sarcomas and central nervous system and other intracranial and intraspinal neoplasms in males and leukemias and lymphomas in females were higher in the 15–29 age group compared to the 30–39 age group. From 1999–2019, rates of several AYA cancers increased among NH-AI/AN males and females, consistent with previous findings in the broader U.S. population [27]. Select cancers and their trends will be discussed in more detail in the sections regarding female breast cancers, cancers of the genital system, colorectal cancers, and thyroid cancers.

Female breast cancers

Female breast cancers accounted for 1 in 5 of all new AYA cancers diagnosed in NH-AI/AN women between 1999 and 2019. Most of these cancers occurred in women ages 30–39, whose rates of breast cancer were nearly 10 times higher than women ages 15–29. While breast cancer was the most common AYA cancer in 5 out of 6 regions, rates varied from 11.9 in the Southwest to 30.8 in Alaska. Future research could help understand the underlying causes of geographic variation in cancer incidence rates. This variation could highlight environmental and social factors amenable to community-level interventions that may reduce breast cancer risk in younger women [8,28,29]. Additionally, previous studies have shown that AYA breast cancer patients show a poorer prognosis than older breast cancer patients [30-32]. Understanding the incidence of AYA breast cancers can provide important information regarding programs and interventions focused on younger breast cancer survivors. Studies have shown that a larger proportion of AI/AN women are diagnosed at a younger age compared to NHW populations [33,34].

Cancers of the genital system (testicular, cervical, uterine cancers)

Testicular cancer was the leading AYA cancer in NH-AI/AN males across all regions and accounted for nearly 25% of all new AYA cancers in this population. Few modifiable risk factors have been identified for testicular cancer [35] making it difficult to identify prevention strategies. While data is lacking on cancer survival for testicular cancer among AI/AN populations, previous studies show that 5-year survival is near or above 90%, even when examined by race or ethnicity [36]. Future studies could examine the survival of testicular cancer among NH-AI/AN populations.

Cervical cancers accounted for nearly 11% of new AYA cancers in NH-AI/AN females and were one of the most common cancers across all regions. Human papillomavirus (HPV) infections account for virtually all cervical cancer cases [37,38]. HPV vaccination with the 9-valent HPV vaccine can prevent approximately 92% of HPV-attributable cancers [39]. Recent data indicate relatively high vaccination coverage for AI/AN populations, with over 84% of adolescents 13–17 years of age having received one dose of the HPV vaccine [40]. Data from the National Immunization Survey—Teen also indicates that HPV vaccination update in AI/AN people is higher than in other racial or ethnic groups [41]. The present study shows stagnant trends in cervical cancer incidence for NH-AI/AN populations. If AI/AN populations continue to have relatively high HPV vaccination coverage, it is possible that future studies can show decreasing trends of cervical cancers in these populations.

Uterine cancers accounted for approximately 6% of all AYA cancers among NH-AI/AN females in the United States. The geographic variations in uterine cancer incidence rates could be due to differences in the prevalence of related risk factors and environmental and social determinants of health. Risk factors that have been associated with uterine cancer incidence include hypertension, adult onset of diabetes, and obesity [42].

Future research could aim to identify modifiable factors driving increases in cancers of the female genital system among AYA NH-AI/AN over time as well as work to identify improved cancer control strategies for genital cancers in this population overall.

Colorectal cancers

Colorectal cancer (CRC) was one of the leading cancers in both NH-AI/AN males and females. Previous studies have also shown that rates of CRC have been increasing in populations under the age of 50 [43-46] including among AYA populations [4] Early onset-CRC can be potentially attributed to a combination of risk factors including greater physical inactivity, increased prevalence of inflammatory bowel disease, westernization of diet (red and processed meats), increased alcohol and tobacco use, obesity, and diabetes [8,26,44,45,47,48]. The geographic variation seen in CRC incidence rates could be attributed to the variation and prevalence of these risk factors [44]. High-risk individuals can potentially be identified using prediction models that account for family history, risk factors, and symptoms of CRC like rectal pain and bleeding [43,49]. Future work may also educate the population on early-onset CRC and conduct more etiologic research on CRC in AYAs [43].

Thyroid cancers

Thyroid cancer makes up 17.6% of all cancers diagnosed among NH-AI/AN females and 4.8% of all AYA cancers in NH-AI/AN males. Rates of thyroid cancers have increased significantly in NH-AI/AN females over the last 20 years. Many studies have identified thyroid cancer as leading cancer in AYAs and have also noted its increase over the years [8,26,27,50,51]. Other authors have attributed increases in thyroid cancer incidence to enhanced detection by screening or tests that sometimes lead to overdiagnoses [27,50] or the identification of subclinical cancers [26]. However, many studies suggest that detection and overdiagnosis are not solely responsible for these increases [52].

A previous study in Alaska Native populations suggested that ease of access to care that may result in the detection of thyroid cancers is likely to vary for these populations due to geographic and other barriers to access to care [53]. Studies of thyroid cancers in other AYA populations have suggested a role for environment, exposure to radiation, dietary intake, birth weight, and obesity [53,54]. Future work might study whether community-level factors may be contributing to the observed increases in thyroid cancer.

Survivorship

There is a lack of research on AYA cancer survivorship in AI/AN populations. The potential long-term and late effects among AYA cancer survivors include physical issues, secondary malignancies, cardiovascular disease, endocrine dysfunction, neurocognitive deficits, fertility, and other physical and psychosocial impacts [55]. Understanding the incidence of these cancers is informative for predicting the long-term needs of survivors.

Limitations

This is the first analysis to comprehensively describe AYA cancer incidence among NH-AI/AN populations between the ages of 15–39, utilizing data corrected for racial misclassification. Several limitations should be acknowledged. Firstly, while the linkages with the IHS patient registration database address racial misclassification, these linkages only take into account AI/AN individuals who are members of federally recognized tribes or have previously accessed care through IHS. Because these analyses are limited to NH-

AI/AN populations living in PRCDA delivery areas, these results may not be generalizable to Hispanic AI/AN populations or other AI/AN populations not living in those areas. Finally, AYA cancers are rare and the AI/AN population is small, therefore many analyses were limited by small patient numbers.

Conclusion

This study describes rates of AYA cancers among NH-AI/AN populations and regional differences in the incidence of these cancers. Information on the incidence of AYA cancers can potentially be used to develop risk reduction strategies that are specific to this population. Strategies derived from research conducted in older or younger age groups may overlook important aspects of cancer risk among AYA populations. Additionally, work in this area may help researchers understand referral patterns for patients in this age group, which are generally not well understood [56]. For NH-AI/AN populations specifically, barriers to access to diagnostic services or evidence-based treatments could be explored in order to improve survivorship and outcomes related to AYA cancers [8].

Acknowledgments

Appendix

Table A1

Rates for leading cancer sites for AYAs [*] in NHW males and females and rate ratios comparing NH-AI/AN [†] to NHW, PRCDA counties, U.S. 1999–2019

| Site (in order based on overall U.S. rank[‡] in AI/AN) | U.S. total | | | Northern Plains | | Alaska | | Southern Plains | | Pacific Coast | | East | | South |
	Count	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)
Males														
All AYA sites	93,068	60.5	0.96[§]	59.0	1.04	54.4	1.18[§]	52.6	1.38[§]	60.9	0.99	63.4	0.54[§]	57.8
Testis	20,476	13.0	1.04	13.7	1.04	12.5	1.09	10.0	1.38[d]	13.5	1.09	13.1	0.64[d]	12.2
Lymphomas	14,711	9.4	0.73[§]	9.1	0.85	8.6	0.66	8.2	1.17	9.2	0.92	10.5	0.61[§]	8.3
Colorectal	6060	4.0	1.33[§]	3.9	1.48[§]	3.8	2.06[§]	4.4	1.59[§]	3.9	1.07	4.3	0.30[§]	3.6
Leukemias	5338	3.4	1.37[§]	3.4	1.48[§]	3.5	1.43	3.1	1.84[§]	3.3	1.49[§]	3.7	0.66	3.2
Kidney	3213	2.2	2.19[§]	2.3	2.16[§]	1.7	2.29[§]	2.4	2.64[§]	2.0	2.23[§]	2.4	0.50	1.9
Sarcomas	5092	3.3	1.11	3.4	0.76	3.3	1.52	3.0	1.55[§]	3.2	1.01	3.4	0.98	3.1
CNS	6448	4.1	0.82[§]	4.1	0.83	4.3	0.67	3.8	1.24	4.3	0.92	4.1	0.65	4.1
Thyroid	6259	4.1	0.70[§]	3.7	1.23	3.9	1.03	2.8	1.10	3.7	0.62[§]	4.8	0.11[§]	4.5

Site (in order based on overall U.S. rank[‡] in AI/AN	U.S. total			Northern Plains		Alaska		Southern Plains		Pacific Coast		East		Southw...
	Count	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)	RR (NH AI/AN: NHW)	NHW rate[‡] (95% CI)
Melanoma	12,486	8.2	0.34[§]	7.1	0.34[§]	5.2	0.66	5.8	0.95	9.4	0.33[§]	7.8	0.30[§]	9.1
Head and neck	2763	1.8	1.06	1.8	1.36	1.7	1.97	2.0	1.09	1.9	1.40	1.9	0.42	1.5
Females														
All AYA sites	140,124	94.5	0.98	94.2	1.03	83.5	1.35[§]	85.1	1.39[§]	92.3	1.02	100	0.72[§]	91.2
Female breast	30,948	21.5	0.88[§]	21.1	0.91	18.6	1.66[§]	19.0	1.37[§]	20.4	0.91	23.7	0.77[§]	20.0
Thyroid	27,023	18.0	0.87[§]	17.4	1.02	17.4	1.06	13.8	1.28[§]	16.1	1.04	19.8	0.69[§]	21.3
Cervical	9569	6.5	1.52[§]	6.6	1.59[§]	5.4	2.45[§]	8.5	1.72[§]	6.8	1.57[§]	6.2	1.27	5.3
Uterine	3891	2.7	2.25[§]	3.1	1.40	2.3	1.31	3.1	1.48[§]	2.4	2.22[§]	2.8	1.02	2.4
Colorectal	5750	3.9	1.41[§]	4.1	1.21	3.6	2.07[§]	4.2	1.89[§]	3.8	1.26	4.1	0.92	3.5
Lymphomas	11,417	7.5	0.69[§]	7.4	0.79	7.1	0.75	6.0	1.21	7.3	0.73[§]	8.3	0.59[§]	6.6
Melanoma	20,972	14.0	0.32[§]	13.9	0.26[§]	8.0	0.65	9.2	0.78[§]	16.1	0.39[§]	13.4	0.30[§]	13.0
Sarcomas	4489	3.0	1.31[§]	3.0	1.55[§]	3.2	1.09	2.7	1.56[§]	3.0	1.17	3.1	0.79	2.7
Leukemias	4059	2.7	1.43[§]	2.6	1.93[§]	2.8	1.1	2.6	1.80[§]	2.5	1.70[§]	2.9	0.44	2.7
Kidney	2292	1.6	2.14[§]	1.8	2.38[§]	1.4	3.25[§]	1.8	2.46[§]	1.4	1.62[§]	1.7	1.51	1.4

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

CI = confidence interval: CNS = central nervous system and other intracranial and intraspinal neoplasms: RR = rate ratio.

[*] AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only.

[†] AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

[‡] Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39).

[§] NH-AI/AN rate is significantly different than NHW rate ($P < .05$).

Table A2

AAPC[*] for all AYA[†] cancer sites in NH-AI/AN[‡] populations, by sex, PRCDA counties, U.S. 1999–2019

	Male					Female				
	1999–2014 Rate	2015–2019 Rate	Total percent change[§] (%)	AAPC (1999–2019)	P-value	1999–2014 Rate	2015–2019 Rate	Total percent change[§] (%)	AAPC (1999–2019)	P-value
Total U.S.	50.5	63.1	25.0	1.4	< .001	79.5	106.3	33.7	1.8	< .001
Age group										
15–29	29.5	36.3	23.1	1.3	.017	37.2	42.2	13.4	0.6	.282
30–39	78.5	98.9	26.0	1.4	.002	136.1	192.2	41.2	2.2	< .001
Region										
Northern Plains	60.4	64.8	7.3	0.1	.938	80.5	107.9	34.0	2.0	.002
Alaska	49.7	69.4	39.6	1.4	.165	101.1	123.7	22.4	1.1	.132
Southern Plains	67.8	84.8	25.1	1.4	.008	110.4	132.0	19.6	1.0	.088
Pacific Coast	51.6	60.5	17.2	1.4	.085	74.7	117.9	57.8	2.8	< .001
East	29.9	31.3	4.7	-0.2	.896	58.6	95.1	62.3	2.5	.039
Southwest	38.6	53.0	37.3	0.9	.503	61.3	78.9	28.7	1.6	.011

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

[*] AAPC refers annual average percentage change (1999–2019) and is calculated using Joinpoint Regression.

[†] AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only.

[‡] AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

[§] The change in rates was calculated as the total percent change from the 5-year rate for 1999–2004 to the 5-year rate for 2015–2019.

Table A3

Change in rates[*] in selected AYA[†] cancers in NH-AI/AN[‡] populations, by sex, PRCDA counties, U.S., 1999–2019

	1999–2014 Rate	2015–2019 Rate	Total percent change[§] (%)	AAPC[‖] (1999–2019)	P-value
Males					
All AYA sites	50.5	63.1	25.0	1.4	< .001
Testis	11.1	14.2	27.9	1.6	.026
Lymphomas	6.5	6.9	6.2	0	.972
Colorectal	4.2	6.2	47.6	2.6	.078
Leukemias	4.3	5.2	20.9	0.9	.211

	1999–2014 Rate	2015–2019 Rate	Total percent change§ (%)	AAPC‖ (1999–2019)	P-value
Females					
All AYA sites	79.5	106.3	33.7	1.8	< .001
Female breast	18.2	20.4	12.1	0.8	.15
Thyroid	11.1	21.4	92.8	4.7	< .001
Cervical	9.2	10.4	13.0	0.4	.658
Uterine	4.3	7.5	74.4	2.9	.007
Colorectal	4.3	7.3	69.8	3.3	.001

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

*
Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39). The change in rates was calculated as the total percent change from the rate in 1999 to the rate in 2019.

†
AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only. Cancers selected based on top five cancers in males and females. Kidney is excluded due to small counts for males.

‡
AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

§
The change in rates was calculated as the total percent change from the 5-year rate for 1999–2004 to the 5-year rate for 2015–2019.

‖
AAPC refers annual average percentage change and is calculated using Joinpoint Regression.

References

[1]. Melkonian SC, Jim MA, Haverkamp D, Wiggins CL, McCollum J, White MC, et al. Disparities in cancer incidence and trends among American Indians and Alaska Natives in the United States, 2010–2015. Cancer Epidemiol Biomark Prev 2019;28(10):1604–11. 10.1158/1055-9965.EPI-19-0288

[2]. Melkonian SC, Jim MA, Pete D, Poel A, Dominguez AE, Echo-Hawk A, et al. Cancer disparities among non-Hispanic urban American Indian and Alaska Native populations in the United States, 1999–2017. Cancer 2022;128(8):1626–36. 10.1002/cncr.34122 [PubMed: 35119703]

[3]. Melkonian SC, Weir HK, Jim MA, Preikschat B, Haverkamp D, White MC. Incidence of and trends in the leading cancers with elevated incidence among American Indian and Alaska Native Populations, 2012–2016. Am J Epidemiol 2021;190(4):528–38. 10.1093/aje/kwaa222 [PubMed: 33506248]

[4]. Islami F, Ward EM, Sung H, Cronin KA, Tangka FKL, Sherman RL, et al. Annual report to the nation on the status of cancer, Part 1: National Cancer Statistics. JNCI: J Natl Cancer Inst 2021;113(12):1648–69. 10.1093/jnci/djab131 [PubMed: 34240195]

[5]. Ugai T, Sasamoto N, Lee HY, Ando M, Song M, Tamimi RM, et al. Is early-onset cancer an emerging global epidemic? Current evidence and future implications. Nat Rev Clin Oncol 2022;19(10):656–73. 10.1038/s41571-022-00672-8 [PubMed: 36068272]

[6]. National Cancer Institute. Surveillance, Epidemiology and End Results Program. AYA Site Recode 2020 Revision. Available at ⟨https://seer.cancer.gov/ayarecode/aya-2020.html⟩. Accessed June 2022.

[7]. Ries L, Trama A, Nakata K, Gatta G, Botta L, Bleyer A. Cancer incidence, survival, and mortality among adolescents and young adults. In: Bleyer A, Barr R, Ries L, Whelan J, Ferrari A, editors. Cancer in adolescents and young adults. Cham: Springer International Publishing; 2017. p. 7–42.

[8]. Weir HK, Jim MA, Marrett LD, Fairley T. Cancer in American Indian and Alaska Native young adults (ages 20-44 years): US, 1999-2004. Cancer 2008;113(S5):1153–67. 10.1002/cncr.23731 [PubMed: 18720386]

[9]. Centers for Disease Control and Prevention. National Program of Cancer Registries. ⟨https://www.cdc.gov/cancer/npcr/about.htm⟩ Accessed February 12, 2022.

[10]. National Institutes of Health. Surveillance, Epidemiology and End Results Program. ⟨https://seer.cancer.gov/⟩ Accessed February 11, 2022.

[11]. U.S. Cancer Statistics; Data Visualizations Tool. Technical Notes. Diagnosis Years 1999–2016. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute. November 2018 Submission. Retrieved from ⟨https://www.cdc.gov/cancer/uscs/technical_notes/index.htm⟩. Accessed January 1, 2022.

[12]. Jim MA, Arias E, Seneca DS, Hoopes MJ, Jim CC, Johnson NJ, et al. Racial misclassification of American Indians and Alaska Natives by Indian Health Service Contract Health Service Delivery Area. Am J Public Health 2014;104(Suppl 3):S295–302. 10.2105/AJPH.2014.301933 [PubMed: 24754617]

[13]. Espey DK, Wiggins CL, Jim MA, Miller BA, Johnson CJ, Becker TM. Methods for improving cancer surveillance data in American Indian and Alaska Native populations. Cancer 2008;113(5 Suppl):1120–30. 10.1002/cncr.23724 [PubMed: 18720372]

[14]. Arias E, Heron M. National Center for Health Statistics, Hakes J, Bureau USC. The validity of race and Hispanic-origin reporting on death certificates in the United States: an update. Vital Health Stat 2 2016;172:1–21.

[15]. Indian Health Service. Requirements: Purchased/Referred Care [PRC] Delivery Areas. Available at ⟨https://www.ihs.gov/prc/eligibility/requirements-purchased-referred-care-prc-delivery-areas/⟩. Accessed November 2022.

[16]. Centers for Disease Control and Prevention. United States Cancer Statistics (USCS). Data Visualizations Tool Technical Notes. Interpreting Race and Ethnicity in Cancer Data. Available at ⟨https://www.cdc.gov/cancer/uscs/technical_notes/interpreting/race.htm⟩. Accessed November 2022.

[17]. Centers for Disease Control and Prevention. U.S. Cancer Statistics. Registries that met U.S. Cancer Statistics Publication Criteria. ⟨https://www.cdc.gov/cancer/uscs/technical_notes/criteria/registries.htm⟩. Accessed October 2022.

[18]. Espey DK, Jim MA, Richards TB, Begay C, Haverkamp D, Roberts D. Methods for improving the quality and completeness of mortality data for American Indians and Alaska Natives. Am J Public Health 2014;104(S3):S286–94. 10.2105/AJPH.2013.301716 [PubMed: 24754557]

[19]. U.S. Cancer Statistics Working Group. U.S. Cancer Statistics Data Visualizations Tool, based on 2021 submission data (1999–2019): U.S Department of Health and Human Services, Centers for Disease Control and Prevention and National Cancer Institute; www.cdc.gov/cancer/dataviz, released in June 2022.

[20]. Barr RD, Holowaty EJ, Birch JM. Classification schemes for tumors diagnosed in adolescents and young adults. Cancer 2006;106(7):1425–30. 10.1002/cncr.21773 [PubMed: 16544312]

[21]. National Cancer Institute. Surveillance, Epidemiology, and End Results Program: Site Recode. ⟨https://seer.cancer.gov/siterecode/⟩. Accessed November 2022.

[22]. World Health Organization. International classification of diseases for oncology. 3rd ed. Geneva, Switzerland: World Health Organization Press; 2000.

[23]. Tiwari RC, Clegg LX, Zou Z. Efficient interval estimation for age-adjusted cancer rates. Stat Methods Med Res 2006;15(6):547–69. 10.1177/0962280206070621 [PubMed: 17260923]

[24]. Surveillance Research Program, National Cancer Institute. SEER*Stat Software, Latest Release: 8.3.2. 2016. Retrieved from ⟨http://seer.cancer.gov/seerstat⟩. Accessed January 2020.

[25]. Joinpoint Regression Program, Version 4.9.1.0. April 2022; Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute.

[26]. Miller KD, Fidler-Benaoudia M, Keegan TH, Hipp HS, Jemal A, Siegel RL. Cancer statistics for adolescents and young adults, 2020. CA Cancer J Clin 2020;70(6):443–59. 10.3322/caac.21637 [PubMed: 32940362]

[27]. Scott AR, Stoltzfus KC, Tchelebi LT, Trifiletti DM, Lehrer EJ, Rao P, et al. Trends in cancer incidence in US adolescents and young adults, 1973-2015. JAMA Netw Open 2020;3(12):e2027738. 10.1001/jamanetworkopen.2020.27738 [PubMed: 33258907]

[28]. Corsini C, Henouda S, Nejima DB, Bertet H, Toledano A, Boussen H, et al. Early onset breast cancer: differences in risk factors, tumor phenotype, and genotype between North African and South European women. Breast Cancer Res Treat 2017;166(2):631–9. 10.1007/s10549-017-4434-y [PubMed: 28779219]

[29]. Delort L, Kwiatkowski F, Chalabi N, Satih S, Bignon YJ, Bernard-Gallon DJ. Risk factors for early age at breast cancer onset-the "COSA program" population-based study. Anticancer Res 2007;27(2):1087–94. [PubMed: 17465248]

[30]. Sundquist M, Thorstenson S, Brudin L, Wingren S, Nordenskjold B. Incidence and prognosis in early onset breast cancer. Breast 2002;11(1):30–5. 10.1054/brst.2001.0358 [PubMed: 14965642]

[31]. Dirier A, Burhanedtin-Zincircioglu S, Karadayi B, Isikdogan A, Aksu R. Characteristics and prognosis of breast cancer in younger women. J BUON 2009;14(4):619–23. [PubMed: 20148452]

[32]. Assi HA, Khoury KE, Dbouk H, Khalil LE, Mouhieddine TH, El Saghir NS. Epidemiology and prognosis of breast cancer in young women. J Thorac Dis 2013;5(Suppl 1):S2–8. 10.3978/j.issn.2072-1439.2013.05.24 [PubMed: 23819024]

[33]. Eberth JM, Huber JC Jr., Rene A Breast cancer screening practices and correlates among American Indian and Alaska native women in California, 2003. Womens Health Issues 2010;20(2):139–45. 10.1016/j.whi.2009.12.004 [PubMed: 20211430]

[34]. Roubidoux MA. Breast cancer and screening in American Indian and Alaska Native women. J Cancer Educ 2012;27(1 Suppl):S66–72. 10.1007/s13187-012-0323-6 [PubMed: 22351427]

[35]. Znaor A, Skakkebaek NE, Rajpert-De Meyts E, Kulis T, Laversanne M, Gurney J, et al. Global patterns in testicular cancer incidence and mortality in 2020. Int J Cancer 2022;151(5):692–8. 10.1002/ijc.33999 [PubMed: 35277970]

[36]. Murphy CC, Lupo PJ, Roth ME, Winick NJ, Pruitt SL. Disparities in cancer survival among adolescents and young adults: a population-based study of 88 000 patients. J Natl Cancer Inst 2021;113(8):1074–83. 10.1093/jnci/djab006 [PubMed: 33484568]

[37]. Mix J, Saraiya M, Hallowell BD, Befano B, Cheung LC, Unger ER, et al. Cervical precancers and cancers attributed to HPV types by race and ethnicity: implications for vaccination, screening, and management. J Natl Cancer Inst 2022;114(6):845–53. 10.1093/jnci/djac034 [PubMed: 35176161]

[38]. Van Dyne EA, Henley SJ, Saraiya M, Thomas CC, Markowitz LE, Benard VB. Trends in Human Papillomavirus-Associated Cancers - United States, 1999-2015. MMWR Morb Mortal Wkly Rep 2018;67(33):918–24. 10.15585/mmwr.mm6733a2 [PubMed: 30138307]

[39]. Senkomago V, Henley SJ, Thomas CC, Mix JM, Markowitz LE, Saraiya M. Human Papillomavirus-Attributable Cancers - United States, 2012-2016. MMWR Morb Mortal Wkly Rep 2019;68(33):724–8. 10.15585/mmwr.mm6833a3 [PubMed: 31437140]

[40]. Indian Health Service First Quarter FY 2022 Immunization Report. Available at ⟨https://www.ihs.gov/sites/epi/themes/responsive2017/display_objects/documents/vaccine/reports/FY22_1stQuarter.pdf⟩. Accessed September 2022.

[41]. Pingali C, Yankey D, Elam-Evans LD, Markowitz LE, Valier MR, Fredua B, et al. National, regional, state, and selected local area vaccination coverage among adolescents aged 13–17 years – United States, 2020. MMWR Morb Mortal Wkly Rep 2021;70:1183–90. 10.15585/mmwr.mm7035a1externalicon. [PubMed: 34473682]

[42]. Henley SJ, Miller JW, Dowling NF, Benard VB, Richardson LC. Uterine cancer incidence and mortality - United States, 1999-2016. MMWR Morb Mortal Wkly Rep 2018;67(48):1333–8. 10.15585/mmwr.mm6748a1 [PubMed: 30521505]

[43]. Akimoto N, Ugai T, Zhong R, Hamada T, Fujiyoshi K, Giannakis M, et al. Rising incidence of early-onset colorectal cancer – a call to action. Nat Rev Clin Oncol 2021;18(4):230–43. 10.1038/s41571-020-00445-1 [PubMed: 33219329]

[44]. Haverkamp D, Melkonian SC, Jim MA. Growing disparity in the incidence of colorectal cancer among Non-Hispanic American Indian and Alaska Native Populations—United States, 2013–2017. Cancer Epidemiol Biomark Prev 2021;30(10):1799–806. 10.1158/1055-9965.EPI-21-0343

[45]. Siegel RL, Miller KD, Goding Sauer A, Fedewa SA, Butterly LF, Anderson JC, et al. Colorectal cancer statistics, 2020. CA: Cancer J Clin 2020;70(3):145–64. 10.3322/caac.21601 [PubMed: 32133645]

[46]. Kratzer TB, Jemal A, Miller KD, Nash S, Wiggins C, Redwood D, et al. Cancer statistics for American Indian and Alaska Native individuals, 2022: Including increasing disparities in early onset colorectal cancer. CA Cancer J Clin 2022;73:120–46. 10.3322/caac.21757 [PubMed: 36346402]

[47]. Gausman V, Dornblaser D, Anand S, Hayes RB, O'Connell K, Du M, et al. Risk factors associated with early-onset colorectal cancer. Clin Gastroenterol Hepatol 2020;18(12):2752–2759.e2. 10.1016/j.cgh.2019.10.009 [PubMed: 31622737]

[48]. Henderson P, Wilson DC. The rising incidence of paediatric-onset inflammatory bowel disease. Arch Dis Child 2012;97(7):585–6. 10.1136/archdischild-2012-302018 [PubMed: 22745290]

[49]. Burnett-Hartman AN, Lee JK, Demb J, Gupta S. An update on the epidemiology, molecular characterization, diagnosis, and screening strategies for early-onset colorectal cancer. Gastroenterology 2021;160(4):1041–9. 10.1053/j.gastro.2020.12.068 [PubMed: 33417940]

[50]. Barr RD, Ries LAG, Lewis DR, Harlan LC, Keegan THM, Pollock BH, et al. Incidence and incidence trends of the most frequent cancers in adolescent and young adult Americans, including "nonmalignant/noninvasive" tumors: Adolescent Young Adult Cancer Incidence. Cancer 2016;122(7):1000–8. 10.1002/cncr.29867 [PubMed: 26848808]

[51]. Burkhamer J, Kriebel D, Clapp R. The increasing toll of adolescent cancer incidence in the US. PLoS ONE 2017;12(2):e0172986. 10.1371/journal.pone.0172986 [PubMed: 28235028]

[52]. Massimino M, Evans DB, Podda M, Spinelli C, Collini P, Pizzi N, et al. Thyroid cancer in adolescents and young adults. Pediatr Blood Cancer 2018;65(8):e27025. 10.1002/pbc.27025 [PubMed: 29528191]

[53]. Nash SH, Lanier AP, Southworth MB. Occurrence of endocrine and thyroid cancers among Alaska Native People, 1969-2013. Thyroid 2018;28(4):481–7. 10.1089/thy.2017.0408 [PubMed: 29439613]

[54]. de Souza Reis R, Gatta G, de Camargo B. Thyroid carcinoma in children, adolescents, and young adults in Brazil: A report from 11 population-based cancer registries. PLoS ONE 2020;15(5):e0232416. 10.1371/journal.pone.0232416 [PubMed: 32357198]

[55]. Janssen SHM, van der Graaf WTA, van der Meer DJ, Manten-Horst E, Husson O. Adolescent and Young Adult (AYA) cancer survivorship practices: an overview. Cancers 2021;13(19):4847. 10.3390/cancers13194847 [PubMed: 34638332]

[56]. Patterson P, McDonald FEJ, Zebrack B, Medlow S. Emerging issues among adolescent and young adult cancer survivors. Semin Oncol Nurs 2015;31(1):53–9. 10.1016/j.soncn.2014.11.006 [PubMed: 25636395]
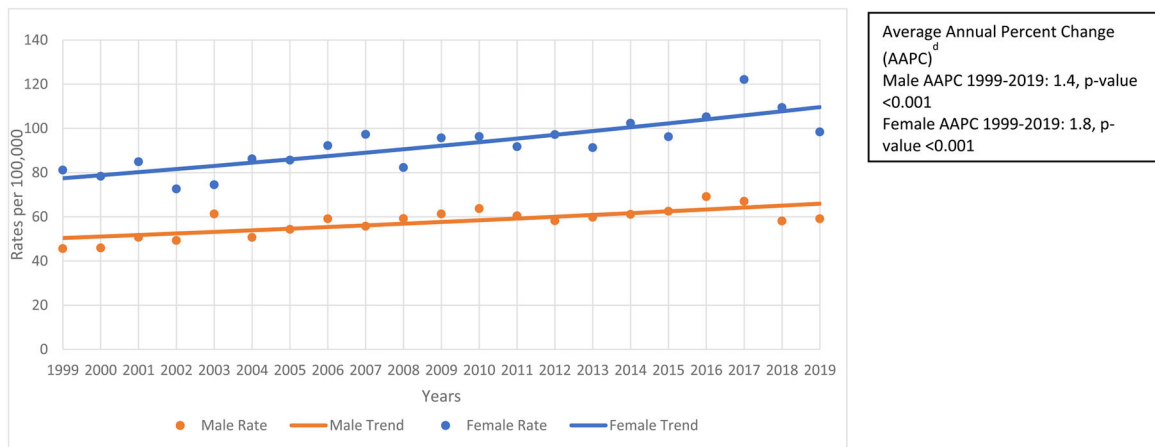
Fig. 1. Annual age-adjusted incidence rates[a] and trend lines for all AYA[b] cancer sites in NH-AI/AN[c] populations, by sex, PRCDA counties, U.S., 1999–2019.
Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission. [a]Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39). [b]AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only. [c]AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin. [d]AAPC refers annual average percentage change and is calculated using Joinpoint Regression. *P*-value < .05 indicates a significant trend.
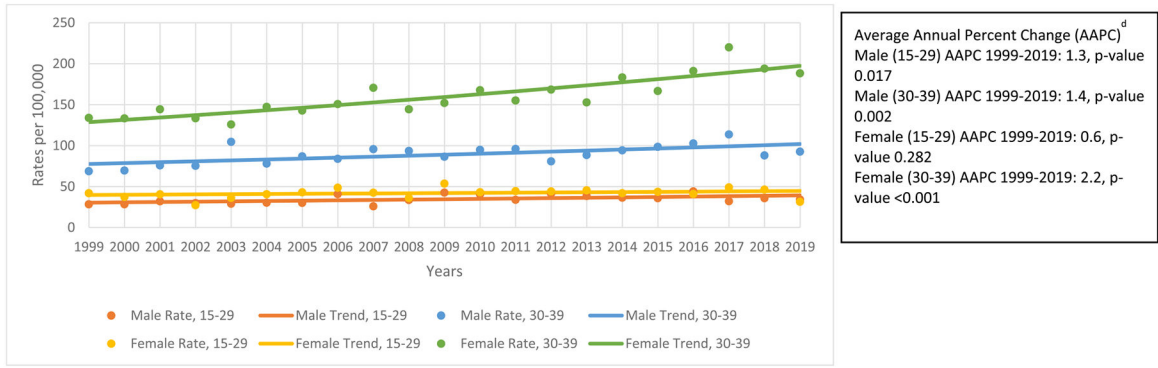
Average Annual Percent Change (AAPC)[d]
Male (15-29) AAPC 1999-2019: 1.3, p-value 0.017
Male (30-39) AAPC 1999-2019: 1.4, p-value 0.002
Female (15-29) AAPC 1999-2019: 0.6, p-value 0.282
Female (30-39) AAPC 1999-2019: 2.2, p-value <0.001

Fig. 2. Annual age-adjusted incidence rates[a] and trend lines for all AYA[b] cancer sites in NH-AI/AN[c,d] population, by sex and age group, PRCDA, U.S., 1999–2019.

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission. [a]Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39). [b]AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only. [c]AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin. [d]AAPC refers annual average percentage change and is calculated using Joinpoint Regression. *P*-value < .05 indicates a significant trend.
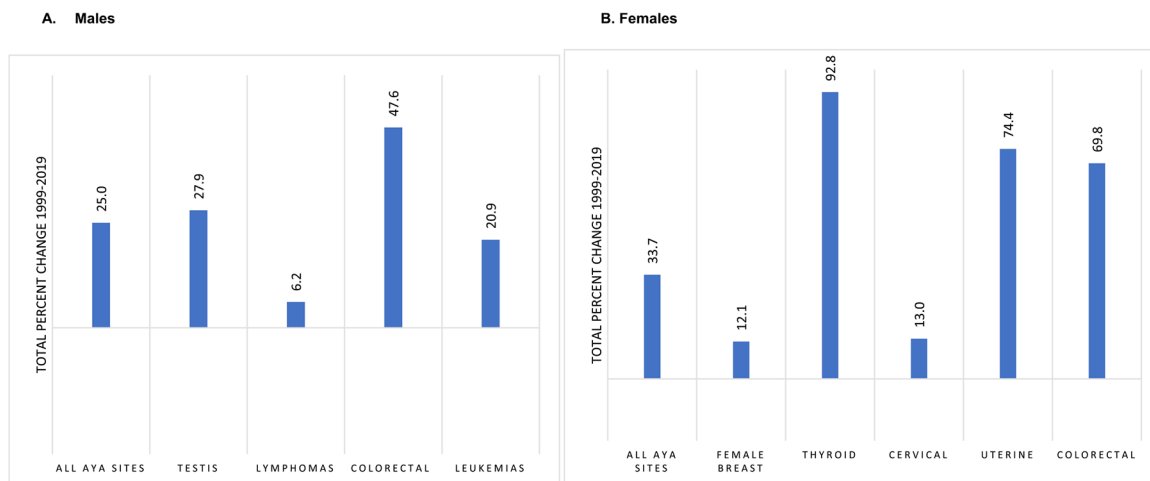
A.   Males

B. Females

Fig. 3. Change in rates[a] in selected AYA[b] cancers in NH-AI/AN[c] populations, by sex, PRCDA Counties, U.S., 1999–2019.

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission. [a]Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39). The change in rates was calculated as the total percent change from the 5-year rate for 1999–2004 to the 5-year rate for 2015–2019. [b]AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only. Cancers selected based on top five cancers in males (A) and females (B). Kidney is excluded due to small counts for males. [c]AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

Table 1

Percent distribution and rates[*] of all AYA[†] and leading AYA cancers in NH-AI/AN[‡] males and females, PRCDA counties, U.S. 1999–2019

Site (in order based on overall U.S. rank[§] in AI/AN)	Count	% of all AYA cancers	AI/ AN rate	95% CI	Range of rates in individual geographic regions
Males					
All AYA sites	3264	—	57.9	55.9–60.0	(34.3–72.4)
Testis	807	24.7	13.6	12.6–14.6	(8.3–14.7)
Lymphomas	393	12.0	6.9	6.2–7.6	(4.1–9.6)
Colorectal	282	8.6	5.4	4.8–6.0	(4.2–7.8)
Leukemias	285	8.7	4.7	4.2–5.3	(2.4–5.8)
Kidney	236	7.2	4.7	4.2–5.4	(3.9–6.3)
Sarcomas	218	6.7	3.6	3.1–4.1	(2.6–5.1)
CNS	204	6.3	3.4	3.0–3.9	(2.4–4.7)
Thyroid	158	4.8	2.9	2.4–3.3	(2.3–4.6)
Melanoma	149	4.6	2.8	2.4–3.3	(0.8–5.5)
Head and neck	105	3.2	2.0	1.6–2.4	(1.1–3.4)
Females					
All AYA sites	5126	—	92.7	90.1–95.3	(72.2–117.9)
Female breast	986	19.2	19.0	17.9–20.3	(11.9–30.8)
Thyroid	901	17.6	15.7	14.7–16.8	(12.7–18.5)
Cervical	538	10.5	9.8	9.0–10.7	(5.3–14.7)
Uterine	318	6.2	6.1	5.4–6.8	(2.8–9.7)
Colorectal	297	5.8	5.5	4.9–6.2	(3.7–7.9)
Lymphomas	308	6.0	5.2	4.6–5.8	(3.4–7.2)
Melanoma	254	5.0	4.5	3.9–5.1	(1.8–7.2)
Sarcomas	230	4.5	3.9	3.4–4.4	(2.4–4.7)
Leukemias	233	4.5	3.8	3.4–4.4	(3.1–5.1)
Kidney	177	3.5	3.4	2.9–3.9	(2.2–4.5)

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

Cl = confidence interval; CNS = central nervous system and other intracranial and intraspinal neoplasm.

[*] Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39).

[†] AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only.

[‡] AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

[§] Rank based on rates and counts.

Table 2

Ten leading cancer sites for AYAs[*] in NH-AI/AN[†] males, PRCDA counties, U.S. 1999–2019

Site (in order based on overall U.S. rank[†] in AI/AN)	Northern Plains			Alaska			Southern Plains			Pacific Coast			East			Southwest		
	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[‡] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)
All AYA sites	—	463	61.5 (55.9–67.5)	—	262	64.0‖ (56.4–72.4)	—	907	72.4‖ (67.6–77.3)	—	641	60.0 (55.4–64.9)	—	132	34.3¶ (28.7–40.7)	—	859	48.5¶ (45.3–52.0)
Testis	1	111	14.2 (11.6–17.1)	1	59	13.6 (10.3–17.6)	1	183	13.9 (11.9–16.1)	1	163	14.7 (12.5–17.2)	1	34	8.3¶ (5.7–11.6)	1	257	13.5 (11.9–15.3)
Lymphomas	2	62	7.8 (5.9–10.0)	3	23	5.6 (3.5–8.5)	2	123	9.6‖ (7.9–11.4)	2	92	8.5 (6.8–10.4)	2	24	6.3 (4.0–9.4)	4	69	4.1¶ (3.1–5.1)
Colorectal	3	41	5.7 (4.1–7.8)	2	29	7.8 (5.2–11.2)	3	82	7.0‖ (5.6–8.8)	5	42	4.2 (3.0–5.7)	7	~	~¶ (~)	2	83	5.1 (4.0–6.3)
Leukemias	4	39	5.1 (3.6–7.0)	5	23	5.0 (3.1–7.5)	5	77	5.8 (4.5–7.3)	3	56	4.9 (3.7–6.4)	5	9	2.4¶ (1.1–4.6)	5	81	4.0 (3.2–5.0)
Kidney	5	33	4.9 (3.4–6.9)	7	14	3.9 (2.2–6.5)	4	68	6.3 (4.9–7.9)	4	44	4.4 (3.2–5.9)	8	~	~¶ (~)	3	73	4.8 (3.8–6.0)
Sarcomas	8	23	2.6 (1.6–3.9)	4	23	5.1 (3.2–7.7)	8	63	4.6 (3.5–5.9)	7	36	3.2 (2.3–4.5)	3	13	3.3 (1.8–5.7)	6	60	3.3 (2.5–4.2)
CNS	7	28	3.4 (2.2–5.0)	10	13	2.9 (1.5–5.0)	7	65	4.7‖ (3.6–6.0)	6	43	3.9 (2.8–5.3)	4	10	2.7 (1.3–4.9)	8	45	2.4 (1.8–3.3)
Thyroid	6	34	4.6‖ (3.2–6.5)	6	17	4.1 (2.3–6.6)	9	38	3.1 (2.2–4.3)	10	24	2.3 (1.4–3.4)	9	~	~¶ (~)	7	43	2.5 (1.8–3.4)
Melanoma	10	17	2.4 (1.4–3.9)	9	12	3.4 (1.8–5.9)	6	66	5.5‖ (4.3–7.0)	8	32	3.1 (2.1–4.4)	6	9	2.3 (1.1–4.4)	10	13	0.8¶ (0.4–1.3)

Site (in order based on overall U.S. rank[†] in AI/AN)	Northern Plains			Alaska			Southern Plains			Pacific Coast			East			Southwest		
	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[‡] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)
Head and neck	9	18	2.5 (1.5–4.0)	8	13	3.4 (1.8–5.7)	10	27	2.2 (1.4–3.2)	9	26	2.6 (1.7–3.8)	10	~	~ (~)	9	18	1.1[¶] (0.6–1.7)

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

Counts less than six and associated rates and rate ratios are suppressed (~).

Percent regional coverage of AI/AN in PRCDA counties to AI/AN in all counties: Northern Plains = 54.0%; Alaska = 100%; Southern Plains = 56.6%; Pacific Coast = 60.7%; East = 16.8%; Southwest = 83.6%; Total United States = 53.2%.

CI = confidence interval: CNS = central nervous system and other intracranial and intraspinal neoplasms.

[*] AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seercancer.gov/ayarecode/. Present analysis includes malignant cancers only.

[†] AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

[‡] Rank based on rates and counts.

[§] Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39).

[∥] Rate is significantly higher than rate in U.S. overall.

[¶] Rate is significantly lower than rate in U.S. overall.

Table 3

10 Leading cancer sites for AYAs* in NH-AI/AN† females, PRCDA counties, U.S. 1999–2019

Site (in order based on overall U.S. rank‡ in AI/AN)	Northern Plains			Alaska			Southern Plains			Pacific Coast			East			Southwest		
	Rank‡	Count	AI/AN rate§ (95% CI)	Rank‡	Count	AI/AN rate§ (95% CI)	Rank‡	Count	AI/AN rate§ (95% CI)	Rank‡	Count	AI/AN rate§ (95% CI)	Rank‡	Count	AI/AN rate§ (95% CI)	Rank‡	Count	AI/AN rate§ (95% CI)
All AYA sites	—	729	96.9 (89.9–104.3)	—	437	113.0‖ (102.5–124.2)	—	1454	117.9‖ (111.8–124.2)	—	994	93.9 (88.1–99.9)	—	270	72.2‖ (63.8–81.3)	—	1242	72.3‖ (68.3–76.5)
Female breast	1	133	19.2 (16.1–22.8)	1	111	30.8‖ (25.3–37.1)	1	301	26.0‖ (23.1–29.1)	1	185	18.6 (16–21.5)	1	65	18.1 (14–23.1)	2	191	11.9‖ (10.2–13.7)
Thyroid	2	139	17.7 (14.9–21.0)	2	74	18.5 (14.4–23.2)	2	231	17.7 (15.4–20.1)	2	182	16.7 (14.3–19.3)	2	52	13.7 (10.2–18.0)	1	223	12.7‖ (11.1–14.5)
Cervical	3	79	10.6 (8.4–13.2)	3	53	13.2 (9.8–17.3)	3	175	14.7‖ (12.6–17.0)	3	112	10.6 (8.7–12.8)	3	29	7.8 (5.2–11.3)	4	90	5.3‖ (4.2–6.5)
Uterine	8	31	4.4 (3.0–6.2)	10	11	3.0¶ (1.5–5.3)	8	53	4.6 (3.4–6.0)	6	54	5.4 (4.0–7.0)	7	11	2.8‖ (1.4–5.1)	3	158	9.7 (8.2–11.3)
Colorectal	6	35	4.9 (3.4–6.8)	4	27	7.4 (4.8–10.7)	4	94	7.9‖ (6.4–9.7)	7	50	4.7 (3.5–6.2)	6	14	3.7 (2.0–6.3)	5	77	4.6 (3.6–5.7)
Lymphomas	4	48	5.9 (4.3–7.8)	5	22	5.3 (3.3–8.1)	5	97	7.2‖ (5.9–8.9)	5	60	5.4 (4.1–6.9)	4	19	4.9 (2.9–7.7)	7	62	3.4‖ (2.6–4.4)
Melanoma	10	29	3.6 (2.4–5.2)	6	19	5.2 (3.1–8.0)	6	90	7.2‖ (5.7–8.8)	4	69	6.3‖ (4.9–8.0)	5	15	4.0 (2.3–6.6)	10	32	1.8 (1.2–2.6)
Sarcomas	7	37	4.7 (3.3–6.4)	8	15	3.5 (1.9–5.8)	10	55	4.2 (3.1–5.5)	9	41	3.5 (2.5–4.8)	9	9	2.4 (1.1–4.6)‖	6	73	4.0 (3.1–5.1)
Leukemias	5	41	5.1 (3.6–6.9)	9	13	3.1 (1.6–5.4)	7	67	4.7 (3.6–6.0)	8	47	4.3 (3.2–5.7)	10	~	~‖(~)	8	60	3.1 (2.4–4.0)

Site (in order based on overall U.S. rank[‡] in AI/AN)	Northern Plains			Alaska			Southern Plains			Pacific Coast			East			Southwest		
	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)	Rank[‡]	Count	AI/AN rate[§] (95% CI)
Kidney	9	30	4.2 (2.8–6.0)	7	17	4.4 (2.6–7.1)	9	53	4.5 (3.4–5.9)	10	22	2.2 (1.4–3.4)	8	9	2.5 (1.1–4.7)	9	46	2.8 (2.0–3.7)

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

Counts less than six and associated rates and rate ratios are suppressed (~).

Percent regional coverage of AI/AN in PRCDA counties to AI/AN in all counties: Northern Plains = 54.0%; Alaska = 100%; Southern Plains = 54.0%; Pacific Coast = 60.7%; East = 16.8%; Southwest = 83.6%; Total United States = 53.2%.

CI = confidence interval; CNS = central nervous system.

[*]
AYA refers to adolescents and young adults (15–39 years of age). AYA cancers identified using classification scheme proposed by R.D. Barr and colleagues. Scheme described at https://seer.cancer.gov/ayarecode/. Present analysis includes malignant cancers only.

[†]
AI/AN race is reported by NPCR and SEER registries or through linkage with the IHS patient registration database. Includes only AI/AN of non-Hispanic origin.

[‡]
Rank based on rates and counts.

[§]
Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39).

[‖]
Rate is significantly higher than rate in U.S. overall.

[¶]
Rate is significantly lower than rate in U.S. overall.

Table 4

Leading AYA[*] cancers in NH-AI/AN[†] males and females by age group, PRCDA counties, U.S. 1999–2019

	15–29 Years old			30–39 Years old		
	Count	Rank[‡] in age group	Rate[§] (95% CI)	Count	Rank[‡] in age group	Rate[§] (95% CI)
Males						
All AYA sites	1395	—	34.7 (32.9–36.5)	1869	—	89.1 (85.1–93.3)
Testis	449	1	11.2 (10.2–12.3)	358	1	16.7 (15.0–18.5)
Lymphomas	177	2	4.4 (3.7–5.1)	216	2	10.3 (8.9–11.7)
Colorectal	70	6	1.8 (1.4–2.3)	212	3	10.2 (8.8–11.6)
Leukemias	172	3	4.2 (3.6–4.9)	113	5	5.4 (4.4–6.5)
Kidney	26	10	0.7 (0.4–1.0)	210	4	10.2 (8.9–11.7)
Sarcomas	127	4	3.1 (2.6–3.7)	91	9	4.3 (3.4–5.3)
CNS	112	5	2.8 (2.3–3.3)	92	8	4.3 (3.5–5.3)
Thyroid	59	7	1.5 (1.1–1.9)	99	7	4.7 (3.8–5.7)
Melanoma—malignant	40	8	1.0 (0.7–1.4)	109	6	5.2 (4.2–6.2)
Head and neck	33	9	0.8 (0.6–1.1)	72	10	3.5 (2.7–4.4)
Females						
All AYA sites	1643	—	41.9 (39.9–43.9)	3483	—	160.7 (155.4–166.2)
Female breast	123	5	3.2 (2.7–3.8)	863	1	40.2 (37.6–43.0)
Thyroid	383	1	9.7 (8.8–10.8)	518	2	23.7 (21.7–25.8)
Cervical	141	3	3.7 (3.1–4.3)	397	3	18.1 (16.3–19.9)
Uterine	48	9	1.3 (0.9–1.7)	270	4	12.5 (11.1–14.1)
Colorectal	74	8	1.9 (1.5–2.4)	223	5	10.4 (9.0–11.8)
Lymphomas	155	2	3.9 (3.3–4.5)	153	7	7.0 (5.9–8.2)
Melanoma—malignant	98	7	2.5 (2.0–3.1)	156	6	7.1 (6.1–8.3)
Sarcomas	120	6	3.0 (2.5–3.6)	110	9	5.1 (4.2–6.1)
Leukemias	133	4	3.3 (2.8–3.9)	100	10	4.5 (3.7–5.5)
Kidney	33	10	0.9 (0.6–1.2)	144	8	6.7 (5.6–7.9)

Source: National Program of Cancer Registries and Surveillance, Epidemiology, and End Results SEER*Stat Database: U.S. Cancer Statistics American Indian and Alaska Native Incidence Analytic Database—1999–2019. United States Department of Health and Human Services—Centers for Disease Control and Prevention. Released June 2022—based on the 2021 submission.

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Rank based on rates and counts.

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Rates are per 100,000 persons and are age-adjusted to the 2000 U.S. standard population by use of 5-year age groups (15–19, 20–24, 25–29, 30–34, 35–39).