



HHS Public Access

Author manuscript

Cancer Epidemiol Biomarkers Prev. Author manuscript; available in PMC 2023 April 04.

Published in final edited form as:

Cancer Epidemiol Biomarkers Prev. 2022 October 04; 31(10): 1896–1906.

doi:10.1158/1055-9965.EPI-22-0317.

Pediatric Cancer by Race, Ethnicity and Region in the United States

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Abstract

Background: In a 2018 descriptive study, cancer incidence in children (age 0–19) in diagnosis years 2003–2014 was reported as being highest in New Hampshire and in the Northeast region.

Methods: Using the Cancer in North America (CiNA) analytic file, we tested the hypotheses that incidence rates in the Northeast were higher than those in other regions of the United States either overall or by race/ethnicity group, and that rates in New Hampshire were higher than the Northeast region as a whole.

Results: In 2003–2014, pediatric cancer incidence was significantly higher in the Northeast than other regions of the United States overall and among non-Hispanic Whites and Blacks, but not among Hispanics and other racial minorities. However, there was no significant variability in incidence in the states within the Northeast overall or by race/ethnicity subgroup. Overall, statistically significantly higher incidence was seen in the Northeast for lymphomas (RR 1.15; 99% CI 1.10–1.19), central nervous system neoplasms (RR 1.12; 99% CI 1.07–1.16), and neuroblastoma (RR 1.13; 99% CI 1.05–1.21).

Conclusion: Pediatric cancer incidence is statistically significantly higher in the Northeast than in the rest of the United States, but within the Northeast, states have comparable incidence. Differences in cancer subtypes by ethnicity merit further investigation.

Impact: Our analyses clarify and extend previous reports by statistically confirming the hypothesis that the Northeast has the highest pediatric cancer rates in the country, by providing similar comparisons stratified by race/ethnicity, and by assessing variability within the Northeast.

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official positions of the New Hampshire Department of Environmental Services (DES), the New Hampshire Department of Health and Human Services (DHHS), or the Centers for Disease Control and Prevention (CDC).

Conflict of interest statement: The authors declare no potential conflicts of interest.

Keywords

childhood cancer; pediatric cancer; incidence; geographic; Northeast; race/ethnicity

Introduction

In 2018, Siegel et al. presented a report titled “Geographic Variation in Pediatric Cancer Incidence – United States, 2003–2014”, reporting that pediatric cancer incidence rates were highest in the Northeast and, by state, rates were “highest in New Hampshire (205.5 [per million per year]), DC (194.0), and New Jersey (192.3) and lowest in South Carolina (149.3) and Mississippi (145.2)”.¹ The publication drew attention in New Hampshire where a pediatric cancer cluster and concerns about environmental pollution had received considerable media coverage.^{2,3} However, in that descriptive study, because no comparisons were formally tested, the importance of these findings was unclear. The purpose of this paper is to assess whether the Northeast region and New Hampshire are outliers in pediatric cancer incidence in the United States by testing the hypotheses that rates in the Northeast were higher than those in each of other three regions of the United States either overall or by race/ethnic group, or that rates in New Hampshire were higher than the Northeast region as a whole.

Materials and Methods

The Cancer in North America (CiNA) analytic file for researchers⁴ certified by the North American Association of Central Cancer Registries (NAACCR),⁵ was used to evaluate pediatric (ages 0–19 years) cancer incidence in the United States (US) during 2003–2014, the period reported by Siegel et al.¹ Using age-standardized cancer incidence and rate ratios, we compared the individual states of the Northeast region (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania Rhode Island, and Vermont) with the Northeastern region as a whole to identify outlier states, and we compared the Northeast with other United States Census regions, both overall and by race/ethnicity. Due to substantial variation in population distributions by race/ethnicity, with minorities comprising from 7% (Vermont) to 47% (New York) of state populations in the Northeast region (Supplementary Figure 1), we conducted separate analyses for each racial/ethnic population to calculate rate ratios comparing the Northeast with its constituent states, and to compare the Northeast with other US regions and the US as a whole.

All analyses were conducted using the Surveillance, Epidemiology, and End Results Program (SEER) statistical software package SEER*Stat version 8.3.9.⁶ SEER*Stat automatically suppressed cell sizes of <6 following NAACCR’s guidelines for data quality assurance.⁷ Race/ethnicity was defined using a combination of race and ethnicity variables provided in the CiNA data set, 1) race recode (White, Black, American Indian/Alaska Native (AIAN), Asian/Pacific Islander (API), Unknown) and 2) Origin Recode NAACCR Hispanic Identification Algorithm⁸ (Hispanic, non-Hispanic) to create the race/ethnicity variable for analysis with defined values of non-Hispanic White, non-Hispanic Black, non-Hispanic

AIAN, non-Hispanic API and Hispanic (all races).⁹ Overall case counts included cases for which either race or ethnicity was unknown.

States can only contribute data to CiNA for years in which they meet criteria for high quality incidence data.¹⁰ Some data were excluded from the CiNA analytic file because of lack of permission from the state (Kansas) or failure to meet inclusion quality criteria during diagnosis years 2003 – 2014 (Nevada¹); 2003 data were excluded for data quality reasons for Mississippi and Tennessee. Because data from California and Washington states were included, data from the smaller regional registries within these states were excluded to avoid double counting (Figure 1).⁵ Pediatric cases were selected from the “age recode with < 1 years olds” variable including 0–19 years age groups for the diagnosis years 2003 – 2014 using the International Classification of Childhood Cancer (ICCC) definition.¹¹ Patients were included if tumor behavior was coded as “malignant”, “only malignant” in International Classification of Diseases for Oncology, 3rd edition (ICD-O-3)¹², malignant 2010+ cases”⁶ and with one primary only or the first of two or more primaries were included. Cases from death certificate or autopsy reporting sources were excluded (Figure 1). We assessed 12 categories and 47 subtypes of invasive cancer defined by the ICCC as well as pediatric non-malignant brain tumors. Pediatric brain tumors were selected from the CiNA data set using the primary ICD-O-3 site codes C70.0 – C72.9 and C75.1 – C75.3 with benign or borderline malignant behavior (ICD-O-3 behavior code of /0 and /1); the analysis timeframe for these tumors was 2004 – 2014 based on the start date for data collection relative to benign or borderline malignant behavior nationally in 2004. For validation, case counts were compared with those reported by Siegel,¹ taking into account an expectation of small differences in data selection criteria and the accrual of additional cases in the intervening years.

The study protocol was approved by the Institutional Review Board of the North American Association of Central Cancer Registries.

Statistical measures

Incidence rates in the four US regions (Northeast, Midwest, South, West) and states within regions, were directly standardized for age to the 2000 US population (19 age groups, Census P25–1130) and presented as rates per 1,000,000 with 95% confidence intervals. Overall incidence rates for United States (“All States”) are also reported. Where the number of cases was smaller than 10 no calculations were made, in accordance with the recommendations of Morris et al. relative to data stability.¹³ Incidence rates were broken down further by race/ethnicity within region and states as non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic American Indian/Alaska Native, and non-Hispanic Asian/Pacific Islander. Incidence rate ratios were calculated as the ratio of age-standardized rates to directly compare each region with the Northeastern Region, and compare each state within the Northeast Region with the Northeast as a whole. Standard errors and hence confidence intervals were calculated using Tiwari’s method that adjusts for the non-independence introduced by the overlap between the whole group (e.g., Northeast region) and subgroup (e.g., New Hampshire).¹⁴ The rate ratios were also calculated after stratification by race/ethnicity. To control the type 1 error rate, a Bonferroni correction was used within each

race/ethnic group with a modified p value of 0.05/number of tests used to test the composite hypothesis that there is no difference in incidence rates between the Northeast and any of its states or the other three Regions. Specific details of the corrections are shown as footnotes below each table. To make the interpretation of the confidence intervals consistent with the Bonferroni-adjusted p values, the confidence intervals were individually set at 99%. In this way 95% overall confidence level was preserved and therefore when rate ratios and their confidence intervals are presented by race/ethnicity using forest plots, statistical significance at the 5% level after adjustment for multiple testing is indicated by a confidence interval that does not cross the vertical null value line (1.0). Where there were fewer than 10 cases within a state/race/ethnicity group, the rate ratio was not calculated, and this is indicated by 'NA'. Invasive cancer subtypes and pediatric non-malignant brain tumors were analyzed in the same way. We used major cancer subtype categories and then presented more granular data for subtypes that showed significant differences within the Northeast region and compared to the rest of the United States as a post-hoc analysis.

Data Availability Statement:

The data are available by application to the North American Association of Central Cancer Registries.⁴

Results

The analytic file included 170,039 cases of first primary invasive cancers diagnosed in the United States from 2003 through 2014 in patients aged <20 years (Figure 1) and 21,419 non-malignant brain tumors diagnosed from 2004 through 2014. Overall, pediatric invasive cancer incidence was highest among non-Hispanic White children (185.8/million/year), followed by Hispanics (169.2), American Indians/Alaska Natives (149.6), Asian/Pacific Islanders (147.7), and Blacks (134.3) and incidence in the Northeast was significantly higher than the US for Whites and for Blacks (Table 1 and Supplementary Table 1). Incidence was significantly lower in the other three regions than the Northeast for all races combined and among non-Hispanic Whites; (Midwest: RR 0.91; 99% CI 0.89–0.94, South: RR 0.90; 99% CI 0.88–0.92, and West: RR 0.92; 99% CI 0.90–0.94). Similar results were seen for non-Hispanic Whites (Midwest: RR 0.89; 99% CI 0.87–0.92, South: RR 0.90; 99% CI 0.87–0.92, and West: RR 0.92; 99% CI 0.89–0.95). There were no significant differences in the comparison of each northeastern state with the Northeast as a whole (Figure 2). Similar but less precise estimates were seen among non-Hispanic Blacks by region (Midwest: RR 0.89; 99% CI 0.83–0.97, South: RR 0.92; 99% CI 0.86–0.98, and West: RR 0.92; 0.84–1.02), and among the larger northeastern states that had sufficient numbers to report. There were no significant regional differences in incidence among Hispanics (Midwest: RR 0.94; 99% CI 0.87–1.01, South: RR 1.03; 99% CI 0.98–1.09 and West: RR 0.98; 99% CI 0.93–1.04), but a significantly lower incidence was seen in Rhode Island than the Northeast as a whole (RR 0.58; 99% CI 0.36–0.87). Non-Hispanic Asians/Pacific Islanders in the South experienced significantly higher incidence than their counterparts in the Northeast (RR 0.87; 99% CI 0.77–0.98). In contrast, the incidence for non-Hispanic American Indians/Alaska Natives was higher in other regions than the Northeast (Midwest: RR 1.40; 99% CI 0.87–2.36, South: RR 1.50; 99% CI 0.95–2.49, and West: RR 1.63; 99% CI 1.05–2.68).

Incidence in the United States overall was highest for leukemias (45.9 per million), followed by central nervous system (CNS) (31.2) and lymphomas (26.4) (Table 2, Supplementary Tables 2a-f). Incidence rates in non-Hispanic White children in the Northeast were significantly higher than the US for leukemias (RR 1.07; 99% CI 1.03–1.12), lymphomas (RR 1.12; 99% CI 1.07–1.18), CNS neoplasms (RR 1.10; 99% CI 1.05–1.15), neuroblastoma (RR 1.11; 99% CI 1.01–1.20), and other malignancies (Figure 3). Within these categories, significantly elevated rates in the Northeast compared with the US were seen for lymphoid leukemias (RR 1.09; 99% CI 1.04–1.14), Hodgkin (RR 1.16; 99% CI 1.09–1.24) and non-Hodgkin (RR 1.14; 99% CI 1.05–1.25) lymphomas; astrocytomas (RR 1.12; 99% CI 1.05–1.19); other gliomas (1.19; 99% CI 1.07–1.32) (Supplementary Table 2b). In the United States and in the Northeast, there was a more than three-fold higher annual incidence of thyroid cancers among non-Hispanic Whites than non-Hispanic Blacks; among non-Hispanic Whites, thyroid cancer incidence in the Northeast was significantly higher than the US (RR 1.33; 99% CI 1.23–1.44) (Supplementary Table 2c).

The pattern for non-Hispanic Black children resembled that for Whites but with less precision in the estimates due to smaller numbers. However, Hispanic children in the Northeast had a different pattern than their counterparts in the US as a whole, with significantly lower incidence of leukemias (RR 0.90; 99% CI 0.83–0.96) (Figure 3), specifically lymphoid leukemias (RR 0.84; 99% CI 0.77–0.91) (Supplementary Table 2d) and germ cell tumors (RR 0.78; 99% CI 0.67–0.91) (Figure 3), specifically malignant gonadal germ cell tumors (RR 0.69; 99% CI 0.56–0.83) (Supplementary Table 2d). Hispanics had significantly higher incidence of lymphomas (RR 1.19; 99% CI 1.07–1.31) (Figure 3) as well as the renal tumor subcategory, renal carcinoma (RR 2.04; 99% CI 1.04–3.72) (Supplementary Table 2d). Asian/Pacific Islanders in the Northeast had incidence rates of the cancer subtypes that were comparable with the US as a whole (Figure 3 and Supplementary Table 2f).

The incidence of non-malignant brain tumors was significantly higher in the Northeast than the country overall, and for non-Hispanic Whites and for Hispanics; rates for non-Hispanic Blacks and non-Hispanic Asian/Pacific Islanders were higher in the Northeast but not significantly different than the US. Incidence by state within the Northeast varied widely from 17.4 to 33.0 per million per year (Table 3).

Discussion

Pediatric cancer incidence is significantly higher in the Northeast than other regions of the United States with incidence of 188.8 per million per year compared to 174.4 overall. However, there was no significant variability in incidence in the states within the Northeast region – i.e., none of the Northeastern states was identified as an outlier within the region. For example, the incidence in New Hampshire, cited previously as the state with the highest rate, is not statistically distinguishable from other states within the Northeast both overall and when stratified by race. The populations of the Northeast show substantial variation in race/ethnicity distribution: minorities comprise fewer than 10% of the populations of the three most northern states (Maine, New Hampshire, and Vermont) but nearly half of the populations of New York and New Jersey. Because the age-standardized incidence rates

vary by more than 38% across racial groups, with lowest rates in non-Hispanic Black children (144.8 per million per year) and highest in non-Hispanic Whites (201.8 per million per year), consideration of race in any regional comparisons is critical. The patterns we see indicate that there are differences in cancer types by race/ethnicity and region. In particular, the higher incidence of certain cancer types in the Northeast than the US were not mirrored in the Hispanic population, and Hispanic children in the Northeast have lower incidence of acute lymphoblastic leukemia (ALL) and germ cell tumors than elsewhere in the country. It has been reported previously that ALL is more common in Hispanics than non-Hispanics at most ages through the lifespan in the United States,¹⁵ although some studies in smaller populations within the US have found rates to be comparable,^{16,17} perhaps because the category “Hispanic” includes diverse ancestries and therefore diverse genetic and environmental risk factors. In our data, it is unclear why Hispanic children in Rhode Island have lower cancer incidence than their counterparts in the Northeast, and further study of the geographic differences in pediatric cancer incidence by ethnicity may provide clues to etiology and establish whether this is a real or chance observation.^{15,18} We could not study the incidence in children of mixed race because cancer registries do not capture these data, but a birth certificate-cancer registry linkage study in five states reported that patterns of risk tend to mirror those of the minority parent’s group.¹⁶

In addition to invasive cancers, non-malignant brain tumors also occur more commonly in the Northeast, but there is wide variation by state, as previously reported.¹⁹ Reporting of non-malignant brain tumors to cancer registries began in 2004, and these tumors make up 70% of all brain and CNS tumors.²⁰ It has been shown that case ascertainment for non-malignant brain tumors varies substantially between states and there is wide variation by state in the proportions of these cases that are microscopically confirmed; these proportions are strongly correlated with reported incidence by state, suggesting that flawed case ascertainment may account for these differences.¹⁹

What might underlie the high incidence of pediatric cancer in the Northeast, even after stratifying by race? We know that the incidence of adult cancer is also higher in the Northeast²¹ and the reasons for that are also unclear but – as for childhood cancer – likely to be multifactorial. Few strong risk factors for pediatric cancer have been identified. Increasing maternal age at delivery is associated with a higher risk of pediatric cancer in the offspring;^{22–24} it has been linked to the rising pediatric cancer incidence over time,²⁵ and average maternal age at delivery is higher in the Northeast.²⁶ Higher socioeconomic status (SES) is another risk factor for pediatric cancer^{1,27,28} that is more prevalent in the Northeast;^{29,30} high SES may be a proxy for maternal age and for access to medical care, including testing such as imaging. Increased use of medical imaging may lead to geographic differences in thyroid cancer incidence via enhanced detection of low risk lesions, often as incidental findings;^{31–34} use of pediatric CT scans is higher with white race, increasing household income, and private health insurance.^{35–39} However, relative to other regions, there is evidence of *less* frequent use of CT scans in children in the Northeast,^{40,41} even though others cite *more* frequent use in the Northeast for some adult indications.^{42,43} Several studies report excess cancer risk as a result of ionizing radiation exposure during childhood CT scans.^{32–34,44} In a large retrospective cohort study, CT scans conducted before age 20 were associated with a 24% excess cancer risk during an average of 9.5 years of follow-up,³³

and it has been estimated that the four million pediatric CT scans performed annually in the US will cause more than 4,000 future cancers during the lifespan.⁴⁴ A host of other possible explanations with varying degrees of evidence have been summarized by Lupo and Spector, including use of chemicals including pesticides and herbicides, pollution, parental smoking and use of recreational drugs and alcohol, maternal obesity and diabetes, preterm birth and birth weight, and possible preventive factors include breast feeding and use of prenatal vitamins.⁴⁵ High prevalence risk factors for adult cancers in northeastern states include arsenic in drinking water,⁴⁶ radon,⁴⁷ and woodsmoke due to use of wood-based fuels in the home,⁴⁸ but the evidence supporting causal associations between these factors and pediatric cancer is weak.^{49–52} Although the Northeast tends to rank well on various EPA pollution metrics,⁵³ the number of EPA National Priorities List (NPL) sites per capita is higher in some areas of the Northeast compared to other regions,⁵⁴ and examples of pollution in specific areas have raised concerns about possible cancer risks, although epidemiologic studies often have difficulty identifying specific causal associations.^{55–59} However, individual level data in a large population-based sample would be needed to elucidate the causes of excess pediatric cancer risk in the Northeast, to identify modifiable risk factors and exposure reduction strategies that could be targeted by public health and environmental health interventions.

Strengths of the study include the use of national, population-based cancer registry surveillance data that has undergone annual scrutiny for quality,^{5,60} the inclusion of all Northeastern states and their race/ethnicity data, and the use of rigorous statistical methods to compare the Northeast with its constituent states and with other regions or the country as a whole within race-specific strata. Restriction to first primary cancers avoids the potential problem that a first childhood cancer increases the risk of subsequent cancers, which in turn would tend to exaggerate any differences between states or regions with lower and higher incidence of first primaries. Limitations include the exclusion of data from Kansas, Nevada and from 2003 for Mississippi and Tennessee; uncertainty relating to data quality for non-malignant brain tumor reporting; and lack of information about mixed race/ethnicity.

In conclusion, the incidence of pediatric cancer in the Northeast is higher than the rest of the United States overall, and when race is taken into account. There is no evidence of any general trends towards higher rates in any states within the Northeast. Regional differences in incidence merit further exploration to identify potentially modifiable risk factors.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements

These analyses used NAACCR's Cancer in North America data referenced below.⁴ Support for cancer registries is provided by the state, province, or territory in which the registry is located. In the US, registries also participate in the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program or the Centers for Disease Control and Prevention's (CDC) National Program of Cancer Registries (NPCR) or both. In Canada, all registries submit data to the Canadian Cancer Registry maintained by Statistics Canada. We thank the New Hampshire Drinking Water and Ground Water Trust Fund for funding this study. The New Hampshire State Cancer Registry is supported in part by the Centers for Disease Control and Preventions (CDC) National Program of Cancer Registries (NPCR) through cooperative agreement NU58DP006298 awarded to the New Hampshire

Department of Health and Human Services, Division of Public Health Services, Bureau of Public Health Statistics & Informatics, Health Statistics and Data Management Section.

Financial Information:

This project was supported in part by the Centers for Disease Control and Preventions (CDC) National Program of Cancer Registries (NPCR) cooperative agreement NU58DP006298 awarded to the New Hampshire Department of Health and Human Services, Division of Public Health Services, Bureau of Disease Control and Health Statistics, Health Statistics and Data Management Section (A.B. Burke, PI). The New Hampshire State Registry is funded through a contract awarded to the Trustees of Dartmouth College (J.R. Rees, PI) and this project was funded by the New Hampshire Drinking Water and Ground Water Trust Fund through an amendment to the contract (J.R. Rees, PI).

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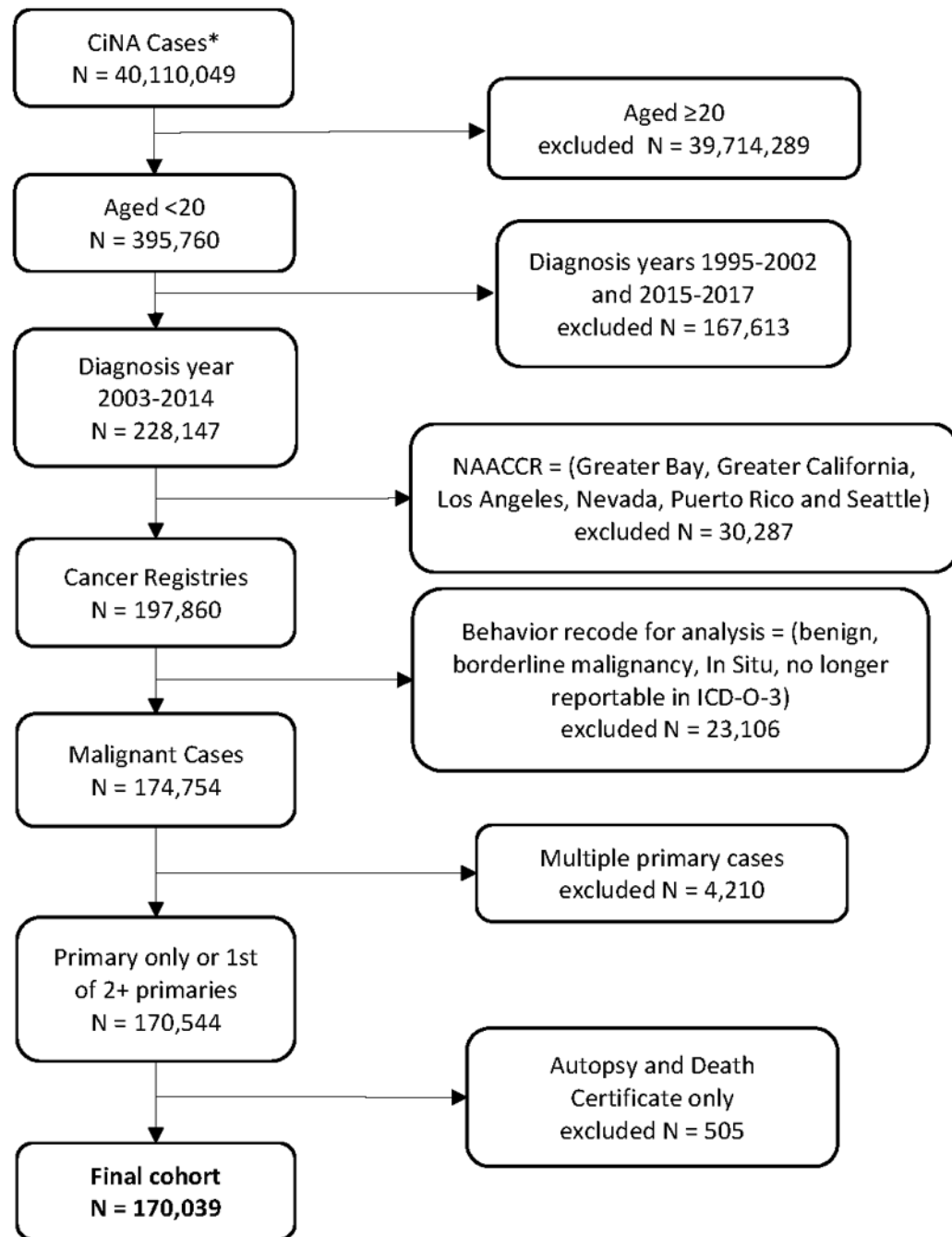


Figure 1.
Derivation of Pediatric (0–19 years) Cancer Cases.

*Cancer in North America (CiNA). Kansas and diagnosis year 2003 for Mississippi and Tennessee not included.⁵

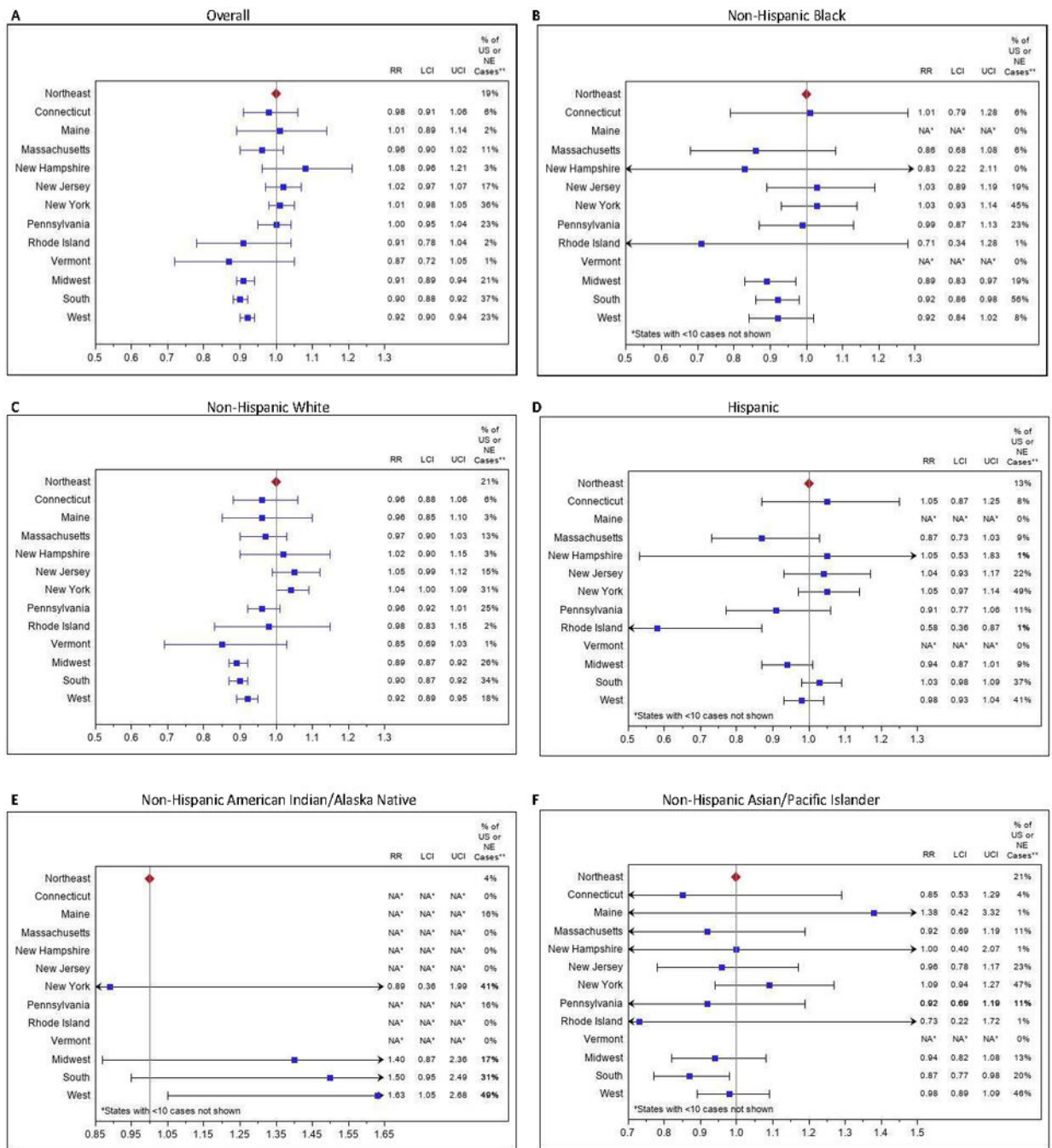


Figure 2. Rate Ratios (RR) and 99% confidence intervals (CI) [†] of age-standardized childhood cancer incidence rates for states and regions compared with Northeast (NE) among all races - overall§ (A); RR and 99% CIs for states and regions compared with NE among Non-Hispanic Black pediatric cancer cases (B); RR and 99% CIs for states and regions compared with NE among Non-Hispanic White pediatric cancer cases (C); RR and 99% CIs for states and regions compared with NE among Hispanic pediatric cases (D); RR and 99% CIs for states and regions compared with NE among Non-Hispanic American Indian/Alaska Native pediatric cases (E); RR and 99% CIs for states and regions compared with NE among Non-Hispanic Asian/Pacific Islander pediatric cases (F).

Indian/Alaska Native (**E**); RR and 99% CIs for states and regions compared with NE among Non-Hispanic Asian/Pacific Islander pediatric cases (**F**).

Abbreviations: RR: rate ratio; LCI: lower confidence interval; UCI: upper confidence interval; US: United States; ME: Northeast.

†Bonferroni correction method used to allow for multiple comparisons. Confidence intervals are set at 99% to preserve the 95% confidence level overall

*Age standardized rate not calculated for counts < 10. Counts < 10 are italicized.

§Overall case counts include 2,394 (1.4%) unknown race/ethnicity (Non-Hispanic unknown: N = 2,354; unknown all races: N = 40).

** % of US cases defined as (number of US region cases/number of US total cases)% and ME cases as (number of ME state cases/number of ME total cases)%.

Note: The scale minimum-maximum for Figures e) Non-Hispanic American Indian/Alaska Native, f) Non-Hispanic Asian/Pacific Islander has been made different to the other graphs to accommodate the point estimates while retaining the same range. Hence the width of the confidence intervals is comparable to the other figures.

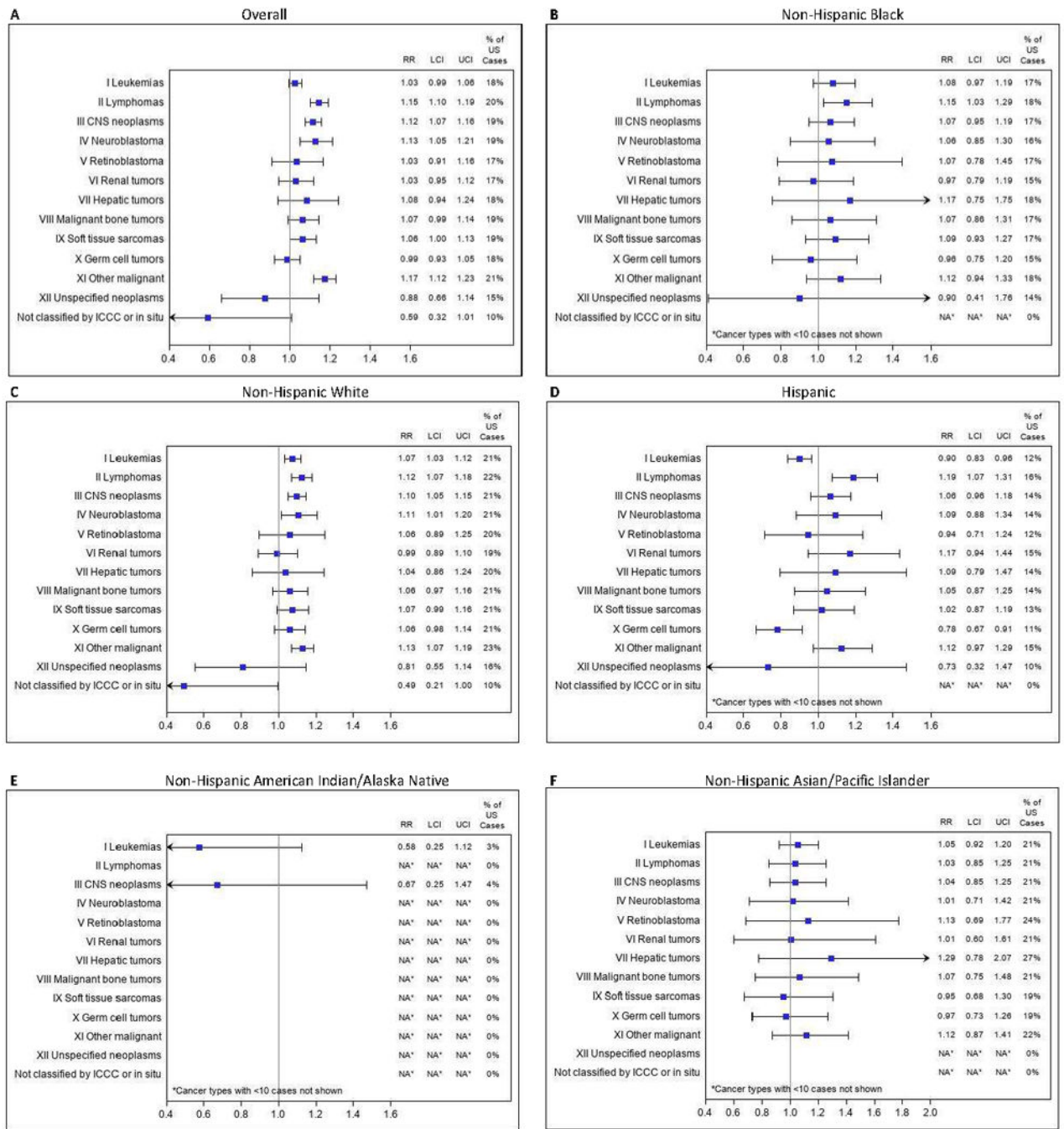


Figure 3. Pediatric cancer types I, * Rate Ratio (RR) and 99% confidence intervals (CI) β of age-standardized incidence rates for the Northeast (NE) compared with the United States (US) for all races - overall§ (A); RR and 99% CIs for NE pediatric cancer types compared with US among Non-Hispanic Black (B); RR and 99% CIs for NE pediatric cancer types compared with US among Non-Hispanic White (C); RR and 99% CIs for NE pediatric cancer types compared with US among Hispanic (D); RR and 99% CIs for NE pediatric cancer types compared with US among Non-Hispanic American Indian/Alaska Native (E);

RR and 99% CIs for NE pediatric cancer types compared with US among Non-Hispanic Asian/Pacific Islander (F).

†Complete Cancer Types Titles: I Leukemias, myeloproliferative & myelodysplastic diseases; II Lymphomas and reticuloendothelial neoplasms; III CNS and misc intracranial and intraspinal neoplasms; IV Neuroblastoma and other peripheral nervous cell tumors; V Retinoblastoma; VI Renal tumors; VII Hepatic tumors; VIII Malignant bone tumors; IX Soft tissue and other extraosseous sarcomas; X Germ cell & trophoblastic tumors & neoplasms of gonads; XI Other malignant epithelial neoplasms and melanomas; XII Other and unspecified malignant neoplasms; Not classified by ICCC or in situ (Note that in this study, we excluded in situs but have retained the ICCC site recode nomenclature)

*Age standardized rate not calculated for counts < 10. Counts < 10 are italicized (Morris, J.K. [2018]).

βBonferroni correction method used to allow for multiple comparisons. Confidence intervals are set at 99% to preserve the 95% confidence level overall

§Overall case counts include 2,394 (1.4%) unknown race/ethnicity (Non-Hispanic unknown: N=2,354; unknown all races: N = 40).

Abbreviations: LCI: lower confidence interval; UCI: upper confidence interval; US: United States;

Note: The scale maximum for Figure f) Non-Hispanic Asian/Pacific Islander has been made different to the other graphs to accommodate the point estimates for XII Unspecified neoplasms.

Table 1

Age-standardized Incidence* of Cancer among Persons Aged <20 Years, by United States (US) Total, US Census Regions, Northeast States, Overall** and by Race/Ethnicity, 2003–2014

	Overall		Non-Hispanic White		Non-Hispanic Black		Hispanic All Races		Non-Hispanic American Indian/Alaska Native		Non-Hispanic Asian/Pacific Islander	
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
All States	174.4# (173.6, 175.3)	170,039	185.8# (184.7, 186.9)	102,838	134.3# (132.4, 136.1)	20,119	169.2 (167.5, 171.0)	35,989	149.6 (142.1, 157.4)	1,510	147.7 (144.3, 151.2)	7,189
Northeast (Reference)	188.8 (186.7, 190.9)	32,016	201.8 (199.1, 204.5)	21,696	144.8 (139.9, 149.7)	3,428	169.8 (165, 174.7)	4,744	98.9 (74.6, 128.5)	56	154.7 (146.9, 162.7)	1,509
Connecticut	185.9 (177.9, 194.1)	2,060	194.7 (184.6, 205.3)	1,398	146.3 (126.7, 168)	201	177.6 (159.7, 196.9)	362	^ (^, ^)	^	131.8 (100.9, 169.1)	62
Maine	190.8 (177.1, 205.2)	726	194.6 (180.3, 209.9)	685	~ (~, ~)	9	^ (^, ^)	^	~ (~, ~)	9	213.9 (109.3, 377.8)	12
Massachusetts	181.2 (175.3, 187.2)	3,579	194.9 (187.6, 202.5)	2,721	124.8 (108.6, 142.8)	214	148.3 (134.3, 163.3)	413	^ (^, ^)	^	141.8 (121.2, 165)	169
New Hampshire	204.0 (190.1, 218.6)	812	205.9 (191.3, 221.4)	742	119.9 (57.3, 221.5)	10	177.9 (120.6, 252.7)	31	^ (^, ^)	^	155.2 (91.6, 246.7)	18
New Jersey	193.1 (187.9, 198.3)	5,322	212.8 (205.5, 220.3)	3,183	149.1 (137.7, 161.2)	635	177 (166.4, 188)	1,050	^ (^, ^)	^	148.5 (133.3, 165.1)	349
New York	191.2 (187.7, 194.8)	11,441	210.4 (205.4, 215.5)	6,714	148.5 (141.2, 156.1)	1,543	178.4 (171.2, 185.8)	2,319	87.5 (55.4, 131.6)	23	168.6 (156.5, 181.5)	714
Pennsylvania	187.8 (183.5, 192.2)	7,215	194.6 (189.5, 199.8)	5,521	143.9 (134, 154.3)	786	154.1 (140.9, 168.2)	505	~ (~, ~)	9	141.6 (121.1, 164.7)	170
Rhode Island	171.2 (157.1, 186.2)	551	197.6 (179.1, 217.4)	432	102.2 (67.3, 148.7)	27	98.3# (75, 126.6)	60	^ (^, ^)	^	112.8 (58.1, 196.6)	12
Vermont	165.1 (147.1, 184.8)	310	171.4 (152.3, 192.2)	300	^ (^, ^)	^	^ (^, ^)	^	^ (^, ^)	^	^ (^, ^)	^
Midwest	172.6# (170.9, 174.4)	35,995	180.5# (178.4, 182.7)	27,172	129.5# (125.4, 133.7)	3,794	158.8 (153.4, 164.4)	3,242	138.4 (121.8, 156.5)	253	145.3 (136, 155)	918

	Overall		Non-Hispanic White		Non-Hispanic Black		Hispanic All Races		Non-Hispanic American Indian/Alaska Native		Non-Hispanic Asian/Pacific Islander	
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
South	169.4 [#] (168.1, 170.7)	62,085	181.3 [#] (179.4, 183.2)	34,970	133.1 [#] (130.6, 135.5)	11,188	175.2 (172.2, 178.2)	13,221	148.3 (135, 162.4)	463	134.6 [#] (127.8, 141.6)	1,470
West	173.4 [#] (171.7, 175.1)	39,943	185.2 [#] (182.6, 187.9)	19,000	133.7 (127.4, 140.2)	1,709	166.3 (163.6, 169)	14,782	161.2 [#] (149.7, 173.2)	738	151.8 (146.7, 157.1)	3,292

* Rates are per 1,000,000 and age-adjusted to the 2000 US Std Population (19 age groups - Census P25-1130) standard; Confidence intervals (Tiwari, R.C. [2006] method) are 95% for rates.

** Overall case counts include 2,394 (1.4%) unknown race/ethnicity (non-Hispanic unknown: N=2,354; unknown all races: N=40).

~ Age standardized rate not calculated for counts < 10. Counts < 10 are italicized (Morris, J.K. [2018]).

^ Statistics not displayed due to fewer than 6 cases to preserve confidentiality.

The age-standardized rate is significantly different to the rate for Northeast after adjusting for multiple testing, (p<0.001, overall significance level).

Table 2

Comparison of Age-standardized Incidence ^{*/†} of Cancer, among Persons Aged <20 years[‡] for Northeast Region[§] with the United States by Race/Ethnicity, 2003–2014

Cancer Type	Overall			Non-Hispanic White			Non-Hispanic Black			
	All States (Population: 968,956,124; Reference)	Northeast (Population: 168,302,782)	All States (Population: 550,723,012; Reference)	Northeast (Population: 106,960,493)	All States (Population: 149,189,102; Reference)	Northeast (Population: 23,512,857)	Rate (95% CI)	Count	Rate (95% CI)	Count
I Leukemias, myeloproliferative & myelodysplastic diseases	45.9 (45.5, 46.4)	47.2 (46.1, 48.2)	45.6 (45.1, 46.2)	49.0 [#] (47.6, 50.4)	29.7 (28.8, 30.5)	32.0 (29.7, 34.4)	747	32.0 (29.7, 34.4)	4,407	32.0 (29.7, 34.4)
II Lymphomas and reticuloendothelial neoplasms	26.4 (26.0, 26.7)	30.2 [#] (29.4, 31.0)	28.1 (27.7, 28.6)	31.6 [#] (30.5, 32.6)	22.6 (21.8, 23.3)	26.0 [#] (24.0, 28.1)	634	26.0 [#] (24.0, 28.1)	3,440	26.0 [#] (24.0, 28.1)
III CNS and misc. intracranial and intraspinal neoplasms	31.2 (30.9, 31.6)	34.8 [#] (33.9, 35.7)	35.5 (35.0, 36.0)	38.9 [#] (37.8, 40.2)	24.8 (24.0, 25.6)	26.4 (24.4, 28.6)	614	26.4 (24.4, 28.6)	3,663	26.4 (24.4, 28.6)
IV Neuroblastoma and other peripheral nervous cell tumors	8.5 (8.3, 8.7)	9.6 [#] (9.1, 10.1)	10.1 (9.8, 10.4)	11.1 [#] (10.5, 11.8)	7.3 (6.9, 7.8)	7.8 (6.7, 9.0)	176	7.8 (6.7, 9.0)	1,078	7.8 (6.7, 9.0)
V Retinoblastoma	3.2 (3.1, 3.3)	3.3 (3.0, 3.6)	2.9 (2.7, 3.0)	3.0 (2.7, 3.4)	3.5 (3.2, 3.8)	3.8 (3.0, 4.6)	85	3.8 (3.0, 4.6)	514	3.8 (3.0, 4.6)
VI Renal tumors	6.9 (6.7, 7.0)	7.1 (6.7, 7.5)	7.2 (7.0, 7.4)	7.2 (6.6, 7.7)	8.6 (8.1, 9.1)	8.3 (7.2, 9.6)	189	8.3 (7.2, 9.6)	1,258	8.3 (7.2, 9.6)
VII Hepatic tumors	2.3 (2.2, 2.4)	2.5 (2.3, 2.8)	2.3 (2.2, 2.4)	2.4 (2.1, 2.7)	1.7 (1.5, 2.0)	2.0 (1.5, 2.7)	47	2.0 (1.5, 2.7)	257	2.0 (1.5, 2.7)
VIII Malignant bone tumors	8.6 (8.4, 8.7)	9.1 (8.7, 9.6)	9.0 (8.8, 9.3)	9.5 (9.0, 10.1)	7.1 (6.6, 7.5)	7.5 (6.5, 8.7)	182	7.5 (6.5, 8.7)	1,072	7.5 (6.5, 8.7)
IX Soft tissue and other extraosseous sarcomas	11.7 (11.5, 11.9)	12.5 [#] (11.9, 13.0)	11.8 (11.5, 12.1)	12.7 (12.0, 13.4)	12.6 (12.0, 13.2)	13.7 (12.3, 15.3)	327	13.7 (12.3, 15.3)	1,896	13.7 (12.3, 15.3)
X Germ cell & trophoblastic tumors & neoplasms of gonads	11.0 (10.8, 11.2)	10.8 (10.4, 11.3)	10.9 (10.7, 11.2)	11. (10.9, 12.2)	6.2 (5.8, 6.6)	5.9 (5.0, 6.9)	145	5.9 (5.0, 6.9)	942	5.9 (5.0, 6.9)
XI Other malignant epithelial neoplasms and melanomas	17.8 (17.6, 18.1)	20.9 [#] (20.3, 21.6)	21.4 (21.0, 21.8)	24.1 [#] (23.2, 25.0)	9.4 (8.9, 9.9)	10.5 (9.3, 11.9)	262	10.5 (9.3, 11.9)	1,448	10.5 (9.3, 11.9)

Cancer Type	Overall						Non-Hispanic White			Non-Hispanic Black		
	All States (Population: 968,956,124; Reference)	Northeast (Population: 168,302,782)	All States (Population: 550,723,012; Reference)	Northeast (Population: 106,960,493)	All States (Population: 149,189,102; Reference)	Northeast (Population: 23,512,857)	All States (Population: 550,723,012; Reference)	Northeast (Population: 106,960,493)	All States (Population: 149,189,102; Reference)	Northeast (Population: 23,512,857)	All States (Population: 48,250,501; Reference)	Northeast (Population: 9,640,856)
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
ICCC site recode ICD-O-3/WHO 2008												
XII Other and unspecified malignant neoplasms	0.7 (0.7, 0.8)	706	0.6 (0.5, 0.8)	107	0.7 (0.6, 0.8)	399	0.6 (0.4, 0.7)	62	0.8 (0.6, 0.9)	114	~ (~, ~)	~ (~, ~)
Not classified by ICCO or in situ [†]	0.2 (0.2, 0.3)	239	0.1 (0.1, 0.2)	25	0.3 (0.2, 0.3)	142	0.1# (0.1, 0.2)	14	0.2 (0.1, 0.3)	30	~ (~, ~)	^ (~, ~)
Hispanic												
Cancer Type	Hispanic			Non-Hispanic American Indian/Alaska Native			Non-Hispanic Asian/Pacific Islander					
	All States (Population: 210,772,149; Reference)	Northeast (Population: 27,626,954)	All States (Population: 10,021,360; Reference)	Northeast (Population: 56,162)	All States (Population: 48,250,501; Reference)	Northeast (Population: 9,640,856)	All States (Population: 210,772,149; Reference)	Northeast (Population: 27,626,954)	All States (Population: 10,021,360; Reference)	Northeast (Population: 56,162)	All States (Population: 48,250,501; Reference)	Northeast (Population: 9,640,856)
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
ICCC site recode ICD-O-3/WHO 2008												
I Leukemias, myeloproliferative & myelodysplastic diseases	56.2 (55.2, 57.2)	12,151	50.5# (47.9, 53.2)	1,421	43.8 (39.8, 48.1)	436	25.3 (13.8, 42.4)	14	45.6 (43.7, 47.5)	2,225	47.9 (43.7, 52.5)	469
II Lymphomas and reticuloendothelial neoplasms	23.6 (22.9, 24.2)	4,864	28.0# (26.1, 30.1)	766	18.2 (15.6, 21.0)	185	~ (~, ~)	8	22.0 (20.6, 23.3)	1,060	22.7 (19.8, 25.9)	218
III CNS and misc. intracranial and intraspinal neoplasms	24.9 (24.3, 25.6)	5,364	26.5 (24.6, 28.5)	738	26.4 (23.3, 29.8)	263	17.7 (8.5, 32.7)	10	22.2 (20.9, 23.5)	1,073	23.0 (20.0, 26.2)	223
IV Neuroblastoma and other peripheral nervous cell tumors	5.5 (5.2, 5.8)	1,290	6.0 (5.2, 7.0)	181	6.0 (4.6, 7.8)	60	~ (~, ~)	^	6.8 (6.1, 7.6)	341	6.9 (5.4, 8.7)	72
V Retinoblastoma	3.5 (3.3, 3.8)	839	3.3 (2.7, 4.0)	102	2.8 (1.9, 4.1)	28	~ (~, ~)	^	3.4 (2.9, 3.9)	169	3.8 (2.7, 5.2)	40
VI Renal tumors	5.3 (5.0, 5.6)	1,199	6.1 (5.3, 7.1)	180	6.5 (5.0, 8.3)	64	~ (~, ~)	^	3.5 (3.0, 4.1)	175	3.6 (2.5, 4.9)	36
VII Hepatic tumors	2.6 (2.4, 2.8)	594	2.8 (2.3, 3.5)	84	3.1 (2.1, 4.4)	31	~ (~, ~)	^	2.9 (2.4, 3.4)	143	3.7 (2.6, 5.1)	38

Cancer Type	Overall			Non-Hispanic White			Non-Hispanic Black			
	All States (Population: 968,956,124; Reference)	Northeast (Population: 168,302,782)	All States (Population: 550,723,012; Reference)	All States (Population: 106,960,493)	All States (Population: 149,189,102; Reference)	Northeast (Population: 23,512,857)	Rate (95% CI)	Count	Rate (95% CI)	Count
ICCC site recode ICD-O-3/WHO 2008	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
VIII Malignant bone tumors	8.4 (8.0, 8.8)	1,691	8.8 (7.7, 10.0)	236	7.1 (5.5, 8.9)	72	~ (∞, ∞)	7.2 (6.5, 8.0)	345	7.7 (6.0, 9.7)
IX Soft tissue and other extrasosseous sarcomas	10.8 (10.4, 11.3)	2,273	11.0 (9.8, 12.3)	305	11.0 (9.1, 13.3)	112	~ (∞, ∞)	8.4 (7.6, 9.3)	409	8.0 (6.3, 10.0)
X Germ cell & trophoblastic tumors & neoplasms of gonads	14.2 (13.7, 14.7)	2,875	11.1# (9.9, 12.4)	306	9.5 (7.8, 11.6)	100	~ (∞, ∞)	11.7 (10.7, 12.7)	566	11.3 (9.3, 13.6)
XI Other malignant epithelial neoplasms and melanomas	13.3 (12.8, 13.8)	2,659	14.9 (13.5, 16.5)	406	13.8 (11.7, 16.3)	145	~ (∞, ∞)	13.4 (12.4, 14.5)	649	15.0 (12.6, 17.7)
XII Other and unspecified malignant neoplasms	0.7 (0.6, 0.8)	141	0.5 (0.3, 0.8)	14	~ (∞, ∞)	8	~ (∞, ∞)	0.5 (0.3, 0.8)	25	~ (∞, ∞)
Not classified by ICCC or in situ [†]	0.2 (0.2, 0.3)	49	~ (∞, ∞)	^	~ (∞, ∞)	6	~ (∞, ∞)	~ (∞, ∞)	9	~ (∞, ∞)

Abbreviations: CI - Confidence Intervals.

* Rates are per 1,000,000 and age-adjusted to the 2000 US Std Population (19 age groups - Census P25-1130) standard; Confidence intervals (Tiwari, R.C. [2006] method) are 95% for rates.

§ Northeast: Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

¶ Incidence data are compiled from cancer registries that meet the data quality criteria for all years 2003-2014 (covering >99% of the U.S. population). Nevada is excluded; Kansas not included and diagnosis year 2003 not included for Mississippi and Tennessee. Registry-specific data quality information is available from NAACCR.⁵

~ Age standardized rate not calculated for counts < 10. Counts < 10 are italicized.

^ Statistics not displayed due to fewer than 6 cases to preserve confidentiality.

The age-standardized rate is significantly different to the rate for Northeast after adjusting for multiple testing, (p<0.01, overall significance level).

+ Note that in this study, we excluded in situ but have retained the ICCC site recode nomenclature

Table 3

Age-standardized Incidence* of Non-Malignant Brain Tumors among Persons Aged <20 Years, by United States (US), US Census Regions, Northeast States, Overall and by Race/Ethnicity, 2004[§]–2014

	Overall		Non-Hispanic White		Non-Hispanic Black		Hispanic All Races		Non-Hispanic American Indian/Alaska Native		Non-Hispanic Asian/Pacific Islander	
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
All States	23.8# (23.5, 24.1)	21,419	25.3# (24.8, 25.7)	12,970	19.4 (18.7, 20.2)	2,711	22.3# (21.7, 23.0)	4,284	25.4 (22.3, 28.8)	239	16.3 (15.2, 17.5)	732
Northeast (Reference)	26.9 (26.1, 27.8)	4,240	27.3 (26.3, 28.3)	2,741	21.4 (19.5, 23.4)	468	28.2 (26.2, 30.4)	717	~ (~)	8	20.1 (17.2, 23.2)	178
Connecticut	22.1# (19.3, 25.1)	228	23.1 (19.6, 27.0)	156	11.6 (6.5, 19.2)	15	22.4 (16.1, 30.3)	42	~ (~)	^	~ (~)	~
Maine	17.1# (13.1, 22.1)	61	17.4# (13.1, 22.6)	57	~ (~)	^	~ (~)	^	~ (~)	^	~ (~)	^
Massachusetts	21.1# (19.0, 23.3)	389	23.5 (21.0, 26.3)	309	18.4 (12.3, 26.5)	29	11.0# (7.3, 15.9)	28	~ (~)	^	~ (~)	~
New Hampshire	27.1 (22.1, 32.9)	104	26.4 (21.3, 32.5)	92	~ (~)	^	~ (~)	^	~ (~)	^	~ (~)	^
New Jersey	26.9 (24.9, 29.0)	682	27.0 (24.4, 29.9)	374	21.1 (16.8, 26.2)	83	30.6 (26.1, 35.6)	165	~ (~)	^	19.3 (13.8, 26.3)	40
New York	32.4# (30.9, 34.0)	1,786	33.0# (31.0, 35.2)	973	25.5 (22.4, 28.9)	244	35.3# (32.0, 38.8)	416	~ (~)	^	24.9 (20.2, 30.4)	97
Pennsylvania	24.4# (22.8, 26.0)	882	25.7 (23.8, 27.7)	690	17.8 (14.3, 21.8)	91	17.2# (12.8, 22.7)	51	~ (~)	^	~ (~)	~
Rhode Island	19.2 (14.5, 25.0)	57	20.3 (14.5, 27.7)	41	~ (~)	^	~ (~)	9	~ (~)	^	~ (~)	^
Vermont	28.2 (21.0, 37.3)	51	28.9 (21.3, 38.4)	49	~ (~)	^	~ (~)	^	~ (~)	^	~ (~)	^
Midwest	22.8# (22.1, 23.5)	4,377	23.9# (23.1, 24.7)	3,325	18.3 (16.8, 20.0)	496	19.2# (17.2, 21.4)	347	17.9 (12.0, 25.5)	30	14.5 (11.6, 18.0)	84

	Overall		Non-Hispanic White		Non-Hispanic Black		Hispanic All Races		Non-Hispanic American Indian/Alaska Native		Non-Hispanic Asian/Pacific Islander	
	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count	Rate (95% CI)	Count
South	23.1 [#] (22.6, 23.7)	7,844	24.7 [#] (23.9, 25.4)	4,427	19.0 (18.0, 20.0)	1,492	23.1 [#] (22.0, 24.3)	1,565	19.0 (14.3, 24.6)	56	15.5 (13.1, 18.1)	156
West	23.7 [#] (23.1, 24.4)	5,155	26.6 (25.6, 27.6)	2,626	21.7 (19.1, 24.5)	265	20.7 [#] (19.7, 21.7)	1,683	34.2 (28.9, 40.2)	148	15.6 [#] (13.9, 17.4)	316

Abbreviations: CI - Confidence Intervals.

* Rates are per 1,000,000 and age-adjusted to the 2000 US Std Population (19 age groups - Census P25-1130) standard; Confidence intervals (Tiwari, R.C. [2006] method) are 95% for rates.

[§]Nationally, identification of benign brain tumors began in United States cancer registries on 1/1/2004 mandated by Public Law 107, 260, the Benign Brain Tumor Cancer Registries Amendment Act (<https://training.seer.cancer.gov/brain/non-malignant/>).

[~] Age standardized rate not calculated for counts < 10. Counts < 10 are italicized.

[^] Statistics not displayed due to fewer than 6 cases to preserve confidentiality.

[#]The age-standardized rate is significantly different to the rate for Northeast after adjusting for multiple testing. (p<0.01, overall significance level).