

Health Insurance Coverage and Racial/Ethnic Disparities in US Childhood and Adolescent Cancer Survival

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Objective To evaluate potential effect modification by health insurance coverage on racial and ethnic disparities in cancer survival among US children and adolescents.

Study design Data from 54 558 individuals diagnosed with cancer at ≤ 19 years between 2004 and 2010 were obtained from the National Cancer Database. Cox proportional hazards regression was used for analyses. An interaction term between race/ethnicity and health insurance type was included to examine racial/ethnic disparities in survival by each insurance status category.

Results Racial/ethnic minorities experienced a 14%-42% higher hazard of death compared with non-Hispanic Whites (NHWs) with magnitudes varying by health insurance type ($P_{\text{interaction}} < .001$). Specifically, among those reported as privately insured, the hazard of death was higher for non-Hispanic Blacks (NHBs) (hazard ratio [HR] = 1.48, 95% CI: 1.36-1.62), non-Hispanic American Indian/Alaskan Natives (HR = 1.99, 95% CI: 1.36-2.90), non-Hispanic Asians or Pacific Islanders (HR = 1.30, 95% CI: 1.13-1.50), and Hispanics (HR = 1.28, 95% CI: 1.17-1.40) vs NHWs. Racial/ethnic disparities in survival among those reported as covered by Medicaid were present for NHBs (HR = 1.30, 95% CI: 1.19-1.43) but no other racial/ethnic minorities (HR ranges: 0.98~1.00) vs NHWs. In the uninsured group, the hazard of death for NHBs (HR = 1.68, 95% CI: 1.26-2.23) and Hispanics (HR = 1.27, 95% CI: 1.01-1.61) was higher vs NHWs.

Conclusions Disparities in survival exist across insurance types, particularly for NHB childhood and adolescent cancer patients vs NHWs with private insurance. These findings provide insights for research and policy, and point to the need for more efforts on promoting health equity while improving health insurance coverage. (*J Pediatr* 2023; ■:1-7).

Medical advances and new treatment regimens have dramatically improved the prognosis of children and adolescents with cancer. However, racial and ethnic disparities in health care delivery and outcomes that disproportionately affect the non-White population are well-documented. For example, the estimated 5-year relative survival rates for White and Black children and adolescents were 86.5% and 80.9%, respectively, between 2010 and 2016.¹ This difference in cancer survival may indicate a disproportionate benefit from treatment advances for racial/ethnic minority populations, which may manifest through factors related to race/ethnicity, such as socioeconomic status,² health insurance coverage,³ or ancestry attributes.⁴

Health insurance coverage, a policy-relevant and modifiable social factor, is associated with access to health care resources and timely health care. In our prior study, we reported that US children and adolescents with Medicaid or no insurance have a higher risk of death and shorter survival during 5 years of follow-up after diagnosis than those with private insurance.⁵ Despite the survival benefits associated with private insurance, another study which focused on solid malignancies among adults found that the degree of benefits varied by race, with a larger cancer-specific mortality disparity between Blacks and Whites in the private insurance group compared with those with Medicaid or uninsured.⁶ However, the interplay between health insurance type and racial/ethnic disparity in cancer survival has yet to be determined among children and adolescents with cancer.

ACS	American Community Survey	NHAIAN	Non-Hispanic American Indian/ Alaska Native
HR	Hazard ratio		
ICCC-3	The International Classification of Childhood Cancer, Third Edition	NHAPI	Non-Hispanic Asian/Pacific Islander
ICD-O-3	The International Classification of Diseases for Oncology, Third Edition	NHB	Non-Hispanic Black
		NHW	Non-Hispanic White
NCDB	National Cancer Database	NPCR	National Program of Cancer Registries
		PH	Proportional hazards
		SES	Socioeconomic status

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Using data from the National Cancer Database (NCDB), we sought to evaluate potential effect modification by health insurance coverage on the association between race/ethnicity and cancer survival among children and adolescents to further explore how insurance status affects observed racial/ethnic disparities.

Methods

Sample

Data from individuals aged ≤ 19 years with any cancer diagnoses were obtained from the NCDB. The NCDB is a joint project of the Commission on Cancer of the American College of Surgeons and the American Cancer Society. It is a national hospital-based oncology outcomes database compiling data from > 1500 Commission on Cancer accredited programs in the US and Puerto Rico. NCDB captures $\sim 70\%$ of all newly diagnosed cancer cases in the U.S.⁷ We included patients diagnosed between 2004 and 2010 with follow-up through December 31, 2015, to allow at least 5 years of follow-up for all individuals. We excluded cases with 0 survival months and missing values on covariates. This study has been determined as nonhuman subjects research by the Washington University Institutional Review Board.

Variables

Race/ethnicity was defined using the 'race' and 'Spanish Hispanic origin' variables and categorized as non-Hispanic White (NHW), non-Hispanic Black (NHB), non-Hispanic Asian/Pacific Islander (NHAPI), non-Hispanic American Indian/Alaska Native (NHAIAN), and Hispanic. Health insurance coverage status was defined using the 'primary payer' variable recorded at initial diagnosis or treatment and includes 3 categories: private insurance (private insurance/managed care), Medicaid, and no insurance. Individuals recorded as having Medicare or other government insurance were excluded due to the small sample size for these groups. Our primary outcome variable, death, was defined by the 'vital status' variable and was captured through December 2015. Survival time was defined using the 'last contact or death months from diagnosis' variable. Potential confounders that were common or proxy causes of both variables of interest and the outcome, including age, sex, and socioeconomic status (SES) indicators, were included for the interplay between race/ethnicity and health insurance status on childhood and adolescent cancer survival. Age and sex were defined using 'age at diagnosis' and 'sex' variables. Age was categorized into the groups: <1 year, 1-4, 5-9, 10-14, and 15-19 years and further grouped as children (0-14 years) and adolescents (15-19 years) for subgroup analyses. Selected SES indicators were collected based on ZIP code level attributes ascertained from the 2008-2012 American Community Survey. These variables include median household income, percentage no high school degree, and rural/urban residence area, and were

used as surrogates for individual-level SES. Cancer stage at diagnosis was further defined using the 'collaborative stage metastasis at diagnosis' variable that identifies metastatic involvement of distant sites at diagnosis for all cancers except leukemias, that are not staged, and lymphoma. We dichotomized this variable into no distant metastasis (code 0) and any distant metastasis (codes 5-60) for subgroup analyses. Cancer subtypes were defined according to the *International Classification of Childhood Cancer, Third Edition* (ICCC-3) definitions based on site and histology coded according to the *International Classification of Diseases for Oncology, Third Edition* (ICD-O-3, **Table 1**; available at www.jpeds.com)⁸ and used for subgroup analyses.

Statistical Analyses

Hazard ratios (HRs) and 95% CIs for the association between race/ethnicity and overall death were estimated using Cox proportional hazards (PH) regression for all childhood and adolescent cancer cases and by age group (children and adolescents) and stage metastasis status at diagnosis, setting NHW as the reference group. An interaction term between race/ethnicity and health insurance status was included in the Cox PH model to examine statistical evidence for racial/ethnic disparities in survival by each insurance status category. The *P* value for the interaction term from Cox PH model was estimated using likelihood ratio and Wald tests. The PH assumption was examined using the `cox.zph` function. Results indicated that the PH assumption was violated for age and health insurance coverage status (for the overall model). Stratified Cox PH regressions by age group and health insurance coverage status using the `strata` function were performed to correct for the PH assumption violation. Subgroup-specific HRs and 95% CIs for racial/ethnic minorities vs NHWs within each insurance status were derived from the Cox PH model using linear contrasts. Due to the small sample size in the NHAPI and NHAIAN groups, stratum-specific HRs and 95% CIs were only calculated for NHBs and Hispanics in cancer type stratified analyses. R (version 4.2.2) was used for all data analyses and visualization.

Results

A total of 56 981 cases diagnosed at 0-19 years with private health insurance, Medicaid, or no insurance were identified between 2004 and 2010. Among these, 2423 cases (4.3%) were missing data on covariates, survival time, or had zero survival months, leaving 54 558 cases included in the analyses. The study sample was 67.9% NHW, 12.4% NHB, 3.5% NHAPI, 0.5% NHAIAN, and 15.7% Hispanic. In general, NHWs and NHAPIs were more likely to have private insurance and live in a residential area with higher household income and a lower percentage with no high school degree. NHWs were also less likely to have distant cancer metastasis. Approximately half of NHB and Hispanic children and adolescents had Medicaid at diagnosis or initial treatment, while

Table II. Demographic characteristics of children and adolescents with cancer according to race and ethnicity, NCDB 2004-2010

Variable	Total N (%)	NHW N (%)	NHB N (%)	NHAPI N (%)	NHAIAN N (%)	Hispanic N (%)
Total	54 558 (100)	37 045 (67.9)	6 752 (12.4)	1 906 (3.5)	290 (0.5)	8 565 (15.7)
Age						
<1 y	3 015 (5.5)	1 985 (5.4)	384 (5.7)	116 (6.1)	19 (6.6)	511 (6.0)
1-4 y	11 297 (20.7)	7 509 (20.3)	1 257 (18.6)	437 (22.9)	71 (24.5)	2 023 (23.6)
5-9 y	8 711 (16.0)	5 667 (15.3)	1 138 (16.9)	324 (17.0)	47 (16.2)	1 535 (17.9)
10-14 y	10 625 (19.5)	7 016 (18.9)	1 517 (22.5)	357 (18.7)	62 (21.4)	1 673 (19.5)
15-19 y	20 910 (38.3)	14 868 (40.1)	2 456 (36.4)	672 (35.3)	91 (31.4)	2 823 (33.0)
Sex						
Male	28 990 (53.1)	19 700 (53.2)	3 472 (51.4)	1 016 (53.3)	139 (47.9)	4 663 (54.4)
Female	25 568 (46.9)	17 345 (46.8)	3 280 (48.6)	890 (46.7)	151 (52.1)	3 902 (45.6)
Insurance coverage						
Private insurance	36 526 (66.9)	28 356 (76.5)	3 168 (46.9)	1 322 (69.4)	109 (37.6)	3 571 (41.7)
Medicaid	15 965 (29.3)	7 754 (20.9)	3 288 (48.7)	528 (27.7)	175 (60.3)	4 220 (49.3)
Uninsured	2 067 (3.8)	935 (2.5)	296 (4.4)	56 (2.9)	6 (2.1)	774 (9.0)
Median household income						
<\$38 000	9 916 (18.2)	4 705 (12.7)	2 746 (40.7)	113 (5.9)	121 (41.7)	2 231 (26.0)
\$38 000-\$47 999	12 929 (23.7)	8 433 (22.8)	1 608 (23.8)	308 (16.2)	73 (25.2)	2 507 (29.3)
\$48 000-\$62 999	14 554 (26.7)	10 408 (28.1)	1 372 (20.3)	488 (25.6)	60 (20.7)	2 226 (26.0)
\$63 000 +	17 159 (31.5)	13 499 (36.4)	1 026 (15.2)	997 (52.3)	36 (12.4)	1 601 (18.7)
% no high school degree						
≥21%	11 496 (21.1)	4 458 (12.0)	2 292 (33.9)	373 (19.6)	84 (29.0)	4 289 (50.1)
13%-20.9%	13 823 (25.3)	8 855 (23.9)	2 419 (35.8)	385 (20.2)	99 (34.1)	2 065 (24.1)
7%-12.9%	16 646 (30.5)	13 040 (35.2)	1 441 (21.3)	584 (30.6)	76 (26.2)	1 505 (17.6)
<7%	12 593 (23.1)	10 692 (28.9)	600 (8.9)	564 (29.6)	31 (10.7)	706 (8.2)
Residence area						
Metro	45 848 (84.0)	29 896 (80.7)	6 070 (89.9)	1 832 (96.1)	134 (46.2)	7 916 (92.4)
Urban	7 796 (14.3)	6 374 (17.2)	616 (9.1)	70 (3.7)	122 (42.1)	614 (7.2)
Rural	914 (1.7)	775 (2.1)	66 (1.0)	4 (0.2)	34 (11.7)	35 (0.4)
Collaborative stage metastasis at diagnosis*						
No distant metastasis	28 930 (87.7)	20 231 (88.4)	3 658 (86.9)	909 (85.4)	148 (84.1)	3 984 (85.9)
Distant metastasis	4 053 (12.3)	2 663 (11.6)	552 (13.1)	155 (14.6)	28 (15.9)	655 (14.1)
Cancer type†						
Leukemias, myeloproliferative diseases, and myelodysplastic diseases	10 546 (19.3)	6 770 (18.3)	1 027 (15.2)	454 (23.8)	67 (23.1)	2 228 (26.0)
Lymphomas and reticuloendothelial neoplasms	7 316 (13.4)	4 958 (13.4)	1 066 (15.8)	255 (13.4)	28 (9.7)	1 009 (11.8)
CNS and miscellaneous intracranial and intraspinal neoplasms	12 288 (22.5)	8 496 (22.9)	1 635 (24.2)	362 (19.0)	69 (23.8)	1 726 (20.2)
Neuroblastoma and other peripheral nervous cell tumors	2 300 (4.2)	1 647 (4.4)	286 (4.2)	78 (4.1)	12 (4.1)	277 (3.2)
Retinoblastoma	722 (1.3)	399 (1.1)	133 (2.0)	37 (1.9)	4 (1.4)	149 (1.7)
Renal tumors	1 970 (3.6)	1 252 (3.4)	387 (5.7)	49 (2.6)	14 (4.8)	268 (3.1)
Hepatic tumors	572 (1.0)	358 (1.0)	72 (1.1)	29 (1.5)	7 (2.4)	106 (1.2)
Malignant bone tumors	2 845 (5.2)	1 925 (5.2)	361 (5.3)	100 (5.2)	22 (7.6)	437 (5.1)
Soft tissue and other extraosseous sarcomas	5 003 (9.2)	3 342 (9.0)	769 (11.4)	155 (8.1)	19 (6.6)	718 (8.4)
Germ cell tumors, trophoblastic tumors, and neoplasms of gonads	4 953 (9.1)	3 274 (8.8)	584 (8.6)	199 (10.4)	23 (7.9)	873 (10.2)
Other malignant epithelial neoplasms and malignant melanomas	4 489 (8.2)	3 630 (9.8)	283 (4.2)	123 (6.5)	16 (5.5)	437 (5.1)
Other and unspecified malignant neoplasms	143 (0.3)	88 (0.2)	24 (0.4)	5 (0.3)	1 (0.3)	25 (0.3)
Other unclassified	1 411 (2.6)	906 (2.4)	125 (1.9)	60 (3.1)	8 (2.8)	312 (3.6)

CNS, central nervous system; NCDB, National Cancer Database; NHAIAN, Non-Hispanic American Indian/Alaska Native; NHAPI, Non-Hispanic Asian/Pacific Islander; NHB, Non-Hispanic Black; NHW, non-Hispanic White.

*Included all cancers except leukemias, myeloproliferative diseases, and myelodysplastic diseases; lymphomas and reticuloendothelial neoplasms, and other unclassified.

†Categorized based on the International Classification of Childhood Cancer, Third edition.

most NHWs and NHAPIs were recorded as privately insured. NHAIANs had the largest proportion of having Medicaid and Hispanic children and adolescents had a notably higher proportion of being uninsured. The age at diagnosis and sex distributions across various race/ethnicity groups were similar (Table II).

Racial and ethnic minorities experienced inferior survival compared with NHWs despite adjustment for other demographics and SES. However, the magnitude of racial and ethnic differences in cancer overall survival varied by their health insurance coverage at diagnosis or initial treatment ($P_{\text{interaction}} < .001$) as depicted in the Figure. Among children and adolescents with private insurance, all

racial and ethnic minority groups had worse survival than NHWs, with a 48% (HR = 1.48, 95% CI: 1.36-1.62), 30% (HR = 1.30, 95% CI: 1.13-1.50), and 28% (HR = 1.28, 95% CI: 1.17-1.40) higher hazard of death for NHBs, NHAPIs, and Hispanics, respectively. The hazard of death for NHAIAN was almost 2 times (HR = 1.99, 95% CI: 1.36-2.90) the hazard for NHWs. However, a statistically significant relative survival difference was only found in NHB vs NHW among those enrolled in Medicaid (HR = 1.30, 95% CI: 1.19-1.43). NHAPI (HR = 1.00, 95% CI: 0.81-1.24), NHAIAN (HR = 0.98, 95% CI: 0.69-1.40), and Hispanic (HR = 0.99, 95% CI: 0.90-1.08) children and adolescents had similar hazards of death in 5 years vs

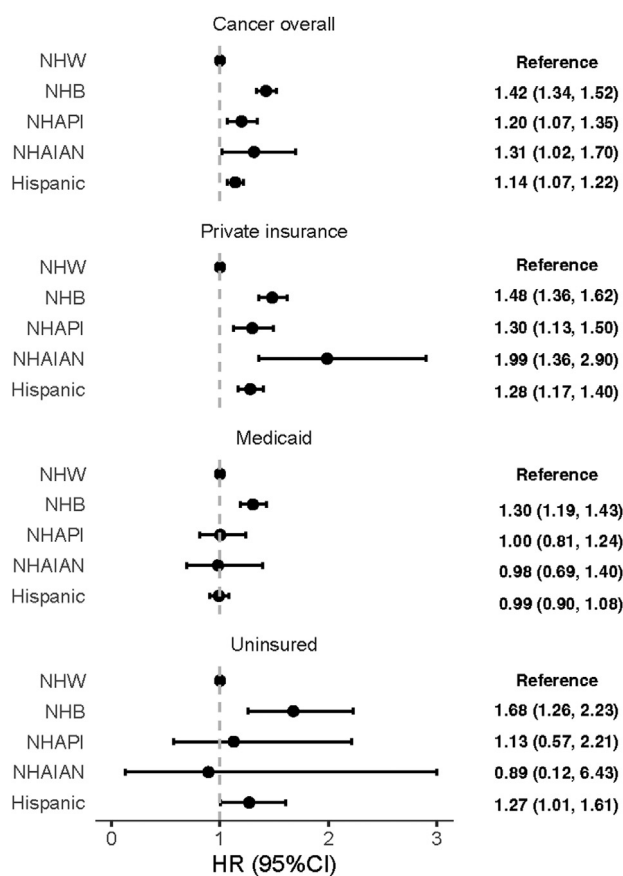


Figure. Hazard ratios (HRs) and 95% CIs for the association between overall survival and race/ethnicity by health insurance coverage. All HRs were adjusted for age, sex, median household income quartile, percentage no high school degree quartile, and residence area, with non-Hispanic White as reference group. The *P* value for interaction between race/ethnicity and health insurance coverage at diagnosis or initial treatment was $<.001$. HR, hazard ratio; NHAIAN, Non-Hispanic American Indian/Alaska Native; NHAPI, Non-Hispanic Asian/Pacific Islander; NHB, Non-Hispanic Black; NHW, Non-Hispanic White.

NHWs. Moreover, the magnitude of racial and ethnic survival differences was decreased for the Medicaid group compared with those privately insured, as indicated by the leftward shift of all hazard ratios for those enrolled on Medicaid vs those with private insurance (Figure). The leftward shift pattern was also observed among uninsured NHAPI (HR = 1.13, 95% CI: 0.57-2.21) and NHAIAN (HR = 0.89, 95% CI: 0.12-6.34) children and adolescents vs those with private insurance. Additionally, the most prominent relative survival difference between NHBs vs NHWs was observed among those who were uninsured at diagnosis or initial treatment (HR = 1.68, 95% CI: 1.26-2.23). The higher hazard of death of uninsured Hispanic children and adolescents (HR = 1.27, 95% CI: 1.01-1.61) vs NHWs was similar to those who were privately insured (HR = 1.28, 95% CI: 1.17-1.40).

The magnitude of the HRs by racial and ethnic groups varied across cancer types but was generally elevated for NHBs vs NHWs among those who were privately insured and those with Medicaid. For soft tissue and other extrasosseous sarcomas, NHBs had a similar hazard of death vs NHWs for both private and Medicaid insurance enrollees. Compared with NHWs, Hispanics had a higher hazard of death among those with private insurance for most cancer types, except lymphomas and reticuloendothelial neoplasms and other malignant epithelial neoplasms and malignant melanomas. Among Medicaid enrollees, Hispanics with lymphomas and reticuloendothelial neoplasms, central nervous system (CNS) and miscellaneous intracranial and intraspinal neoplasms, neuroblastoma and other peripheral nervous cell tumors, soft tissue and other extrasosseous sarcomas, and other malignant epithelial neoplasms and malignant melanomas had equal or better survival than NHWs. Moreover, the pattern of larger disparities between racial/ethnic minorities and NHWs among those with private insurance vs among Medicaid enrollees was consistently observed across cancer types. We also found the largest disparities between uninsured NHBs and NHWs in 6 cancer types (leukemias, myeloproliferative and myelodysplastic diseases, CNS and miscellaneous intracranial and intraspinal neoplasms, hepatic tumors, soft tissue and other extrasosseous sarcomas, germ cell tumors, trophoblastic tumors, and neoplasms of gonads, and other malignant epithelial neoplasms and malignant melanomas). However, these estimates are imprecise due to small sample size in uninsured groups (Table III; available at www.jpeds.com).

We further stratified the analyses by age group. Lower magnitude racial/ethnic disparities in survival in those with Medicaid compared with those with private insurance were consistently observed across various age groups, with the only exception being between NHAPI and NHW adolescents (Table IV). Further stratification analyses demonstrated that the reduced NHB and Hispanic vs NHW survival disparities between those with private insurance and Medicaid varied by both cancer type and age group (Table V; available at www.jpeds.com), possibly due to the small sample size or age differences in tumor biology.

In stratified analyses by stage metastasis status at diagnosis, we observed lower magnitude racial/ethnic disparities in survival between those with private insurance and Medicaid across various metastasis groups, particularly among those without distant metastasis (Table VI). In addition, minority children and adolescents without distant metastasis in general had larger racial and ethnic disparities in overall survival vs those with metastasis (Table VI).

Discussion

Using data obtained from the NCDB, we observed that although the racial/ethnic disparities in cancer overall survival were present among children and adolescents with private insurance, the disparities in survival were narrower among those enrolled in Medicaid than in private insurance

Table IV. Hazard ratios and 95% CIs for the association between overall survival and race/ethnicity by health insurance coverage and age group*

Insurance status	N	NHB vs NHW	NHAPI vs NHW	NHAIAN vs NHW	Hispanic vs NHW	<i>P</i> _{interaction} [†]
Children						
Total	33 648	1.37 (1.26, 1.48)	1.22 (1.06, 1.40)	1.26 (0.92, 1.73)	1.11 (1.03, 1.20)	.001
Private insurance	21 267	1.37 (1.22, 1.54)	1.36 (1.15, 1.61)	2.04 (1.30, 3.21)	1.28 (1.14, 1.43)	
Medicaid	11 446	1.29 (1.16, 1.44)	0.93 (0.72, 1.22)	0.94 (0.61, 1.45)	0.98 (0.88, 1.09)	
Uninsured	935	1.66 (1.11, 2.49)	1.67 (0.77, 3.63)	-	1.01 (0.71, 1.44)	
Adolescents						
Total	20 910	1.56 (1.40, 1.73)	1.14 (0.93, 1.40)	1.45 (0.93, 2.26)	1.18 (1.06, 1.32)	.046
Private insurance	15 259	1.67 (1.45, 1.92)	1.16 (0.90, 1.50)	1.88 (0.94, 3.78)	1.28 (1.10, 1.51)	
Medicaid	4519	1.37 (1.17, 1.61)	1.16 (0.81, 1.65)	1.08 (0.59, 1.98)	0.98 (0.83, 1.17)	
Uninsured	1132	1.75 (1.17, 2.61)	0.50 (0.12, 2.02)	-	1.49 (1.08, 2.06)	

NHAIAN, Non-Hispanic American Indian/Alaska Native; NHAPI, Non-Hispanic Asian/Pacific Islander; NHB, Non-Hispanic Black; NHW, non-Hispanic White.

*Adjusted for sex, median household income quartile, % no high school degree quartile, and residence area, with non-Hispanic White as reference group.

†Computed using the likelihood ratio test, similar to results computed from the Wald test.

for all cancers combined and across the majority of cancer types. This finding suggests that although private insurance may benefit patients of all races in absolute terms compared with Medicaid, racial/ethnic disparities are paradoxically wider.

Despite advances in cancer treatment and advocacy for addressing health care disparities,⁹ racial and ethnic differences in childhood and adolescent cancer survival are still well documented by previous studies.^{3,10-12} These disparities may arise from differences in disease biology and social and economic factors that may be related to differences in access, delivery, and quality of health services. Private insurance has long been reported to reduce cancer mortality compared with public insurance and no insurance coverage.⁵ However, racial and ethnic variation in cancer survival remained present in the private insurance group. Indeed, Pan et al analyzed patients with 10 solid tumors in adults and found a comparable cancer-specific survival between Blacks and Whites among uninsured and Medicaid patients and larger disparities among privately insured patients,⁶ suggesting that Whites incurred greater benefits from private insurance than Blacks. They also found that Native Americans had similar odds of death vs Whites between the Medicaid and uninsured groups, but a higher odds of death in the private insurance group. However, conclusions from this finding

are limited by the small number of cases. Hispanics had superior survival compared with Whites between uninsured and Medicaid patients but not those with private insurance; Asians had lower cancer mortality than Whites across all insurance groups.⁶ Another study in a colorectal cancer population who were all insured and enrolled in an integrated health care system also reported substantial disparities of NHBs vs NHWs, similar risk of death in NHAPI, and lower risk in Hispanics compared with NHWs.¹³

In the population of children and adolescents with cancer, in addition to the larger racial/ethnic disparities in cancer overall survival between NHBs and NHWs with private insurance vs those with Medicaid, our study also found a similar pattern across other racial and ethnic minorities. This evidence suggests that NHW children and adolescents may derive greater benefits from private insurance than Medicaid vs other races and ethnicities. This enlarged disparity might be related to many factors including the type of private insurance that allows access to different providers/health systems and differences in noninsurance-related factors that may exist among higher-income families with private insurance. In general, Medicaid-eligible children and adolescents are from lower-income families who face more financial difficulties in coping with cancer from both medical and nonmedical

Table VI. Hazard ratios and 95% CIs for the association between overall survival and race/ethnicity by health insurance coverage and stage metastasis status at diagnosis*

Insurance status	N	NHB vs NHW	Hispanic vs NHW	<i>P</i> _{interaction} [†]
No distant metastasis				
Total	27 873	1.47 (1.34, 1.62)	1.19 (1.08, 1.32)	.002
Private insurance	19 162	1.50 (1.31, 1.72)	1.42 (1.24, 1.63)	
Medicaid	7672	1.35 (1.17, 1.55)	0.96 (0.83, 1.12)	
Uninsured	1039	2.01 (1.31, 3.07)	1.40 (0.96, 2.05)	
Distant metastasis				
Total	3870	1.25 (1.08, 1.44)	1.08 (0.93, 1.24)	.599
Private insurance	2429	1.29 (1.06, 1.56)	1.12 (0.91, 1.38)	
Medicaid	1274	1.14 (0.93, 1.42)	1.02 (0.83, 1.25)	
Uninsured	167	1.99 (1.02, 3.90)	1.26 (0.71, 2.22)	

NHB, Non-Hispanic Black; NHW, non-Hispanic White.

*Adjusted for age, sex, median household income quartile, % no high school degree quartile, and residence area with non-Hispanic White as reference group.

†Computed using the likelihood ratio test, similar as results computed from Wald test.

expenses.^{14,15} These Medicaid beneficiaries had relatively small variation in SES. While for the private insurance group, health care systems offer a variety of health insurance plans with different out-of-pocket expenses that may vary by race/ethnicity and impact the receipt of health care services.¹³ The disparity becomes more evident where family SES is more variable as would be expected in the privately insured group. Additionally, even when insurance coverage is similar, there might also be racial/ethnic differences in patient-physician communication, trust as well as racism that might affect utilization of health care. For instance, racial/ethnic minorities had an increased odds of reporting racism associated with cancer-related health behaviors vs Whites.¹⁶ Another study found that Black patients with prostate cancer who delayed seeking health care were reported with lower physician trust levels than Whites.¹⁷ When stratified by cancer type, the reduced racial/ethnic disparities in overall survival in Medicaid vs private insurance were generally found across most cancer types, despite nonsignificant interactions between race/ethnicity and health insurance coverage, possibly attributable to small sample size or differences in tumor biology. Using neuroblastoma as an example, Black patients were more likely to present with advanced stage disease and unfavorable histology tumors, leading to worse event-free survival vs Whites.¹⁸ Evidence from clinical sites and genetic analyses suggests that delay in diagnosis or nonadherence to therapy was less likely to account for this worse outcome in Black patients.¹⁹⁻²¹ In this way, it is not surprising that our study observed consistently higher HRs in both private insurance and Medicaid cohorts in NHB vs NHW population.

The finding of similar overall survival between NHWs and Hispanics among those with Medicaid is an example of the Hispanic paradox in the population of childhood and adolescents with cancer. The Hispanic paradox refers to the fact that despite the disadvantages of low income, poor educational and occupational opportunities, and inadequate access to health care, Hispanics have long been noted to have superior or equal survival compared with NHWs, particularly in the population with lower level of SES.^{22,23} A few mechanisms related to immigration, assimilation, and possibly data errors have been proposed.²² However, the current study only observed this survival advantage in lymphomas and reticuloendothelial neoplasms, CNS and miscellaneous intracranial and intraspinal neoplasms, neuroblastoma and other peripheral nervous cell tumors, soft tissue and other extraosseous sarcomas and other malignant epithelial neoplasms, and malignant melanomas, suggesting that tumor characteristics (eg, biology, presentation, or treatment regimen) might also at play. For example, Hispanics were found to be more commonly diagnosed with grade 3 follicular lymphoma and to receive rituximab plus chemotherapy as initial therapy, and have higher progression-free survival but equal overall survival at a median follow-up of 52 months compared with White patients.²⁴

We also observed stronger disparities for NHBs and Hispanics vs NHWs in patients with no distant metastasis than those with cancer metastasis. This finding agrees with the results from another study on childhood and adolescent cancer treatment amenability where patients with more survivable cancer types are generally more likely to experience larger disparities.¹⁰ Cancers with no distant metastasis oftentimes are more amenable to medical intervention, which consequently underscores the importance of other socioeconomic resources that may impact outcomes.

The interpretation of the findings from this study is subject to a few limitations. First, NCDB does not include individual-level socioeconomic variables; education and income used in the analyses are measured at the ZIP code level. In addition, NCDB only records patient's insurance status at initial diagnosis or treatment, while children and adolescents without insurance could be enrolled in Medicaid after cancer diagnosis and recorded as having Medicaid at initial treatment.²⁵ NCDB also does not account for patients who might have switched insurance status after diagnosis or treatment. The results of the analyses may also be sensitive to selection bias due to the exclusion of individuals with missing data. Furthermore, the generalizability of the findings is limited by the sampling strategy of NCDB, which recruits hospital-based samples from Commission on Cancer accredited hospitals.²⁶ Patient characteristics in NCDB might differ to some extent from the general US cancer population. For example, relative to the National Program of Cancer Registries (NPCR), which covers 93% of the US population, the current study population had a higher proportion of NHW children and adolescents (67.9% vs 56.8% in NPCR) and lower proportion of Hispanics (15.7% vs 22.2% in NPCR).²⁷ However, NCDB is one of the largest public databases available for this analysis and captured 68% of new childhood and adolescent cancer diagnoses in the US between 2012 and 2014 based on personal communication with NCDB Participant Use Data File team. Finally, the lack of tumor characteristics (eg, treatment regimen and responses) and small sample size in specific tumor biological subtypes limits our exploration of the interplay between tumor biology and health insurance status on race/ethnicity disparity in cancer survival.

In conclusion, we found larger racial/ethnic disparities in childhood and adolescent cancer survival among the privately insured group compared with Medicaid, indicating further research within the privately insured group in addition to those with Medicaid is needed to identify underlying reasons for these disparities. These findings provide insights for research and policy and point to the need for more efforts on promoting health equity while improving health insurance coverage. ■

Per the NCDB data use agreement, we acknowledge that The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed, or the conclusions drawn from these data.

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Data Statement

Data sharing statement available at www.jpeds.com.

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Table I. Cancer types defined based on the ICCC-3

Cancer type	ICD-O-3 histology	ICD-O-3 site
Leukemias, myeloproliferative diseases, and myelodysplastic diseases	9820, 9823, 9826, 9827, 9831-9837, 9940, 9948, 9840, 9861, 9866, 9867, 9870-9874, 9891, 9895-9897, 9910, 9920, 9931, 9863, 9875, 9876, 9950, 9960-9964, 9945, 9946, 9975, 9980, 9982-9987, 9989, 9800, 9801, 9805, 9860, 9930	C000-C809
Lymphomas and reticuloendothelial neoplasms	9650-9655, 9659, 9661-9665, 9667, 9591, 9670, 9671, 9673, 9675, 9678-9680, 9684, 9689-9691, 9695, 9698-9702, 9705, 9708, 9709, 9714, 9716-9719, 9727-9729, 9731-9734, 9760-9762, 9764-9769, 9970, 9687, 9740-9742, 9750, 9754-9758, 9590, 9596	C000-C809
CNS and miscellaneous intracranial and intraspinal neoplasms	9383, 9390-9394, 9384, 9400-9411, 9420, 9421-9424, 9440-9442, 9470-9474, 9480, 9508, 9381, 9382, 9430, 9444, 9450, 9451, 9460, 8270-8281, 8300, 9350-9352, 9360-9362, 9412, 9413, 9492, 9493, 9505-9507, 9530-9539, 9582	C000-C809
Neuroblastoma and other peripheral nervous cell tumors	9380 9501-9504 8000-8005 9490, 9500, 8680-8683, 8690-8693, 8700, 9520-9523 9501-9504	C723, C700-C722, C724-C729, C751, C753 C700-C729 C700-C729, C751-C753 C000-C809 C000-C699, C739-C768, C809
Retinoblastoma	9510-9514	C000-C809
Renal tumors	8959, 8960, 8964-8967, 8311, 8312, 8316-8319, 8361 8963, 9364, 8010-8041, 8050-8075, 8082, 8120-8122, 8130-8141, 8143, 8155, 8190-8201, 8210, 8211, 8221-8231, 8240, 8241, 8244-8246, 8260-8263, 8290, 8310, 8320, 8323, 8401, 8430, 8440, 8480-8490, 8504, 8510, 8550, 8560-8576, 8000-8005	C000-C809 C649
Hepatic tumors	8970, 8160-8180 8010-8041, 8050-8075, 8082, 8120-8122, 8140, 8141, 8143, 8155, 8190-8201, 8210, 8211, 8230, 8231, 8240, 8241, 8244-8246, 8260-8264, 8310, 8320, 8323, 8401, 8430, 8440, 8480-8490, 8504, 8510, 8550, 8560-8576, 8000-8005	C000-C809 C220, C221
Malignant bone tumors	9180-9187, 9191-9195, 9200, 9210, 9220, 9240, 9260 9221, 9230, 9241-9243, 8812, 9250, 9261, 9262, 9270-9275, 9280-9282, 9290, 9300-9302, 9310-9312, 9320-9322, 9330, 9340-9342, 9370-9372 9363-9365, 8810, 8811, 8823, 8830, 8000-8005, 8800, 8801, 8803-8805	C400-C419, C760-C768, C809 C000-C809 C400-C419
Soft tissue and other extraosseous sarcomas	8900-8905, 8910, 8912, 8920, 8991, 8820, 8822, 8824-8827, 9150, 9160, 9491, 9540-9571, 9580, 9140, 8587, 8710-8713, 8806, 8831-8833, 8836, 8840-8842, 8850-8858, 8860-8862, 8870, 8880, 8881, 8890-8898, 8921, 8982, 8990, 9040-9044, 9120-9125, 9130-9133, 9135, 9136, 9141, 9142, 9161, 9170-9175, 9231, 9251, 9252, 9373, 9581 8810, 8811, 8813-8815, 8821, 8823, 8834-8835, 8830, 8800-8805 8963 9180, 9210, 9220, 9240 9260 9364 9365	C000-C809 C000-C399, C440-C768, C809 C000-C639, C659-C699, C739-C768, C809 C490-C499 C000-C399, C470-C759 C000-C399, C470-C639, C659-C699, C739-C768, C809 C000-C399, C470-C639, C659-C768, C809 C700-C729, C751-C753
Germ cell tumors, trophoblastic tumors, and neoplasms of gonads	9060-9065, 9070-9072, 9080-9085, 9100, 9101 9060-9065, 9070-9072, 9080-9085, 9100-9105 9060-9065, 9070-9073, 9080-9085, 9090, 9091, 9100, 9101, 8010-8041, 8050-8075, 8082, 8120-8122, 8130-8141, 8143, 8190-8201, 8210, 8211, 8221-8241, 8244-8246, 8260-8263, 8290, 8310, 8313, 8320, 8323, 8380-8384, 8430, 8440, 8480-8490, 8504, 8510, 8550, 8560-8573, 9000, 9014, 9015, 8000-8005 8441-8444, 8450, 8451, 8460-8473, 8590-8671	C000-C809 C000-C559, C570-C619, C630-C699, C739-C750, C754-C768, C809 C569, C620-C629 C000-C809

(continued)

Table I. Continued

Cancer type	ICD-O-3 histology	ICD-O-3 site
Other malignant epithelial neoplasms and malignant melanomas	8370-8375, 8330-8337, 8340-8347, 8350, 8720-8780, 8790	C000-C809
	8010-8041, 8050-8075, 8082, 8120-8122, 8130-8141, 8190, 8200, 8201, 8211, 8230, 8231, 8244-8246, 8260-8263, 8290, 8310, 8320, 8323, 8430, 8440, 8480, 8481, 8510, 8560-8573	C739
	8010-8041, 8050-8075, 8082, 8083, 8120-8122, 8130-8141, 8190, 8200, 8201, 8211, 8230, 8231, 8244-8246, 8260-8263, 8290, 8310, 8320, 8323, 8430, 8440, 8480, 8481, 8500-8576	C110-C119
	8010-8041, 8050-8075, 8078, 8082, 8090-8110, 8140, 8143, 8147, 8190, 8200, 8240, 8246, 8247, 8260, 8310, 8320, 8323, 8390-8420, 8430, 8480, 8542, 8560, 8570-8573, 8940, 8941	C440-C449
	8010-8084, 8120-8157, 8190-8264, 8290, 8310, 8313-8315, 8320-8325, 8360, 8380-8384, 8430-8440, 8452-8454, 8480-8586, 8588-8589, 8940, 8941, 8983, 9000, 9010-9016, 9020, 9030	C000-C109, C129-C218, C239-C399, C480-C488, C500-C559, C570-C619, C630-C639, C659-C729, C750-C768, C809
	8930-8936, 8950, 8951, 8971-8981, 9050-9055, 9110	C000-C809
	9363	C000-C399, C470-C759
	8000-8005	C000-C218, C239-C399, C420-C559, C570-C619, C630-C639, C659-C699, C739-C750, C754-C809
	Other and unspecified malignant neoplasms	

CNS, central nervous system; ICC-3, the International Classification of Childhood Cancer, Third Edition; ICD-O-3, International Classification of Diseases for Oncology, Third Edition.

Table III. Hazard ratios and 95% CIs for the association between overall survival and race/ethnicity by health insurance coverage and cancer type*

Cancer type [†]	Insurance status	N	NHB vs NHW	Hispanic vs NHW	P _{interaction} [‡]
Leukemias, myeloproliferative diseases, and myelodysplastic diseases	Total	10 025	1.49 (1.29, 1.72)	1.18 (1.04, 1.35)	.274
	Private insurance	6247	1.47 (1.19, 1.82)	1.37 (1.15, 1.64)	
	Medicaid	3402	1.45 (1.19, 1.77)	1.05 (0.88, 1.26)	
	Uninsured	376	1.58 (0.83, 2.98)	1.11 (0.68, 1.82)	
Lymphomas and reticuloendothelial neoplasms	Total	7033	1.40 (1.13, 1.74)	0.77 (0.58, 1.02)	.230
	Private insurance	4997	1.52 (1.13, 2.04)	0.53 (0.32, 0.88)	
	Medicaid	1742	1.41 (1.03, 1.93)	0.95 (0.66, 1.37)	
	Uninsured	294	0.80 (0.27, 2.42)	0.69 (0.28, 1.71)	
CNS and miscellaneous intracranial and intraspinal neoplasms	Total	11 857	1.35 (1.20, 1.53)	1.17 (1.03, 1.32)	.028
	Private insurance	7786	1.34 (1.13, 1.60)	1.44 (1.21, 1.71)	
	Medicaid	3636	1.30 (1.10, 1.54)	0.98 (0.82, 1.17)	
	Uninsured	435	1.41 (0.84, 2.35)	0.99 (0.61, 1.61)	
Neuroblastoma and other peripheral nervous cell tumors	Total	2210	1.30 (1.00, 1.68)	1.03 (0.76, 1.40)	.755
	Private insurance	1388	1.32 (0.91, 1.91)	1.25 (0.81, 1.92)	
	Medicaid	780	1.26 (0.88, 1.79)	0.86 (0.56, 1.30)	
	Uninsured	42	0.98 (0.11, 9.10)	1.55 (0.26, 9.20)	
Renal tumors	Total	1907	2.26 (1.58, 3.24)	1.97 (1.25, 3.11)	.555
	Private insurance	1174	2.84 (1.84, 4.39)	1.91 (1.03, 3.56)	
	Medicaid	685	1.59 (0.89, 2.83)	1.87 (0.99, 3.54)	
	Uninsured	48	2.06 (0.34, 12.7)	1.31 (0.12, 14.9)	
Hepatic tumors	Total	536	1.59 (1.03, 2.46)	1.11 (0.70, 1.76)	.627
	Private insurance	298	1.63 (0.87, 3.04)	1.19 (0.61, 2.32)	
	Medicaid	208	1.34 (0.71, 2.52)	1.07 (0.57, 2.03)	
	Uninsured	30	5.26 (0.86, 32.2)	1.16 (0.17, 8.11)	
Malignant bone tumors	Total	2723	1.28 (1.03, 1.59)	1.16 (0.93, 1.44)	.922
	Private insurance	1866	1.39 (1.05, 1.85)	1.16 (0.87, 1.55)	
	Medicaid	735	1.15 (0.82, 1.60)	1.15 (0.83, 1.59)	
	Uninsured	122	1.20 (0.49, 2.92)	1.02 (0.45, 2.31)	
Soft tissue and other extrasosseous sarcomas	Total	4829	1.05 (0.88, 1.26)	1.18 (0.98, 1.41)	.049
	Private insurance	3264	0.99 (0.78, 1.27)	1.28 (0.99, 1.65)	
	Medicaid	1405	1.05 (0.80, 1.37)	0.95 (0.72, 1.26)	
	Uninsured	160	2.02 (0.78, 5.24)	2.89 (1.34, 6.23)	
Germ cell tumors, trophoblastic tumors, and neoplasms of gonads	Total	4731	1.82 (1.37, 2.41)	1.21 (0.92, 1.60)	.517
	Private insurance	3289	1.91 (1.32, 2.76)	1.15 (0.76, 1.75)	
	Medicaid	1143	1.59 (1.03, 2.45)	1.03 (0.67, 1.58)	
	Uninsured	299	2.71 (0.98, 7.54)	2.15 (1.01, 4.59)	
Other malignant epithelial neoplasms and malignant melanomas	Total	4350	1.44 (0.82, 2.54)	0.88 (0.48, 1.60)	.153
	Private insurance	3537	2.24 (1.13, 4.43)	0.99 (0.45, 2.22)	
	Medicaid	685	0.75 (0.30, 1.91)	0.82 (0.34, 1.94)	
	Uninsured	128	2.35 (0.21, 26.3)	–	

CNS, central nervous system; NHB, Non-Hispanic Black; NHW, non-Hispanic White.

*Adjusted for age, sex, median household income quartile, % no high school degree quartile, and residence area, with non-Hispanic White as reference group.

†Neuroblastoma and other and unspecified malignant neoplasms were not included due to small sample size.

‡Computed using the likelihood ratio test, similar as results obtained from Wald test.

Table V. Hazard ratios and 95% CIs for the association between overall survival and race/ethnicity by health insurance coverage, age group and cancer type*

Cancer type [†]	Insurance status	N	NHB vs NHW	Hispanic vs NHW	P _{interaction} [‡]
Leukemias, myeloproliferative diseases, and myelodysplastic diseases	Children				
	Total	7954	1.72 (1.44, 2.05)	1.17 (1.00, 1.37)	.134
	Private insurance	4917	1.87 (1.44, 2.41)	1.44 (1.16, 1.79)	
	Medicaid	2792	1.53 (1.20, 1.95)	0.99 (0.81, 1.23)	
	Uninsured	245	1.75 (0.74, 4.14)	0.88 (0.45, 1.74)	
	Adolescents				
	Total	2071	1.38 (1.08, 1.77)	1.17 (0.94, 1.46)	.666
	Private insurance	1330	1.21 (0.84, 1.75)	1.28 (0.95, 1.74)	
	Medicaid	610	1.49 (1.06, 2.11)	1.06 (0.77, 1.46)	
	Uninsured	131	1.58 (0.61, 4.11)	1.42 (0.66, 3.09)	
Lymphomas and reticuloendothelial eoplasms	Children				
	Total	2925	1.35 (0.95, 1.90)	0.80 (0.53, 1.21)	.088
	Private insurance	1964	1.54 (0.96, 2.48)	0.54 (0.26, 1.13)	
	Medicaid	879	1.38 (0.85, 2.24)	1.05 (0.62, 1.77)	
	Uninsured	82	-	0.22 (0.02, 1.98)	
	Adolescents				
	Total	4108	1.41 (1.06, 1.86)	0.73 (0.50, 1.07)	.768
	Private insurance	3033	1.49 (1.02, 2.19)	0.53 (0.27, 1.06)	
	Medicaid	863	1.39 (0.92, 2.10)	0.84 (0.51, 1.40)	
	Uninsured	212	1.17 (0.38, 3.65)	0.88 (0.33, 2.36)	
CNS and miscellaneous intracranial and intraspinal neoplasms	Children				
	Total	8297	1.38 (1.20, 1.58)	1.22 (1.07, 1.40)	.026
	Private insurance	5218	1.29 (1.06, 1.58)	1.50 (1.25, 1.81)	
	Medicaid	2845	1.36 (1.13, 1.63)	1.03 (0.85, 1.25)	
	Uninsured	234	1.83 (1.00, 3.33)	1.06 (0.59, 1.90)	
	Adolescents				
	Total	3560	1.23 (0.94, 1.61)	0.87 (0.63, 1.20)	.309
	Private insurance	2568	1.50 (1.05, 2.15)	1.10 (0.71, 1.71)	
	Medicaid	791	1.01 (0.67, 1.52)	0.69 (0.42, 1.16)	
	Uninsured	201	0.74 (0.28, 2.03)	0.61 (0.26, 1.41)	
Hepatic tumors	Children				
	Total	419	2.24 (1.32, 3.81)	1.33 (0.78, 2.28)	.888
	Private insurance	229	2.88 (1.28, 6.50)	1.26 (0.60, 2.66)	
	Medicaid	175	1.93 (0.97, 3.85)	1.41 (0.67, 2.98)	
	Uninsured	15	3.70 (0.31, 44.6)	0.86 (0.08, 9.78)	
	Adolescents				
	Total	117	1.36 (0.67, 2.77)	1.03 (0.43, 2.45)	.656
	Private insurance	69	1.28 (0.50, 3.29)	0.85 (0.18, 4.10)	
	Medicaid	33	0.96 (0.26, 3.58)	0.97 (0.27, 3.47)	
	Uninsured	15	6.37 (0.59, 68.6)	3.26 (0.24, 43.8)	
Malignant bone tumors	Children				
	Total	1462	1.59 (1.17, 2.18)	1.30 (0.95, 1.77)	.066
	Private insurance	974	1.71 (1.15, 2.55)	1.34 (0.88, 2.02)	
	Medicaid	444	1.30 (0.80, 2.11)	1.35 (0.87, 2.10)	
	Uninsured	44	7.05 (1.52, 32.7)	0.39 (0.04, 3.82)	
	Adolescents				
	Total	1261	1.10 (0.82, 1.48)	1.04 (0.77, 1.41)	.946
	Private insurance	892	1.20 (0.80, 1.78)	1.03 (0.68, 1.56)	
	Medicaid	291	1.05 (0.67, 1.65)	0.99 (0.61, 1.61)	
	Uninsured	78	0.84 (0.28, 2.52)	1.15 (0.47, 2.82)	
Soft tissue and other extraosseous sarcomas	Children				
	Total	2899	0.83 (0.64, 1.08)	1.20 (0.95, 1.52)	.068
	Private insurance	1844	0.79 (0.54, 1.16)	1.28 (0.92, 1.78)	
	Medicaid	978	0.81 (0.56, 1.15)	0.99 (0.71, 1.38)	
	Uninsured	77	2.54 (0.51, 12.6)	5.19 (1.50, 18.0)	
	Adolescents				
	Total	1930	1.34 (1.04, 1.73)	1.13 (0.84, 1.52)	.337
	Private insurance	1420	1.22 (0.88, 1.69)	1.32 (0.91, 1.93)	
	Medicaid	427	1.49 (0.99, 2.22)	0.82 (0.49, 1.37)	
	Uninsured	83	1.67 (0.51, 5.49)	1.72 (0.63, 4.68)	

(continued)

Table V. Continued

Cancer type [†]	Insurance status	N	NHB vs NHW	Hispanic vs NHW	P _{interaction} [‡]
Germ cell tumors, trophoblastic tumors, and neoplasms of gonads	Children				
	Total	1398	1.35 (0.80, 2.27)	0.67 (0.36, 1.26)	
	Private insurance	913	1.00 (0.46, 2.18)	0.79 (0.33, 1.89)	.528
	Medicaid	439	1.69 (0.82, 3.49)	0.69 (0.29, 1.65)	
	Uninsured	46	3.06 (0.18, 51.4)	-	
	Adolescents				
	Total	3333	2.02 (1.45, 2.82)	1.44 (1.05, 1.98)	
	Private insurance	2376	2.37 (1.56, 3.60)	1.35 (0.85, 2.17)	.380
Other malignant epithelial neoplasms and malignant melanomas	Children				
	Total	1110	0.42 (0.10, 1.85)	0.92 (0.34, 2.45)	
	Private insurance	833	0.72 (0.10, 5.41)	0.46 (0.06, 3.52)	.735
	Medicaid	246	0.34 (0.04, 2.79)	1.35 (0.40, 4.59)	
	Uninsured	31	-	-	
	Adolescents				
	Total	3240	1.85 (0.99, 3.44)	0.88 (0.41, 1.89)	
	Private insurance	2704	2.66 (1.27, 5.58)	1.32 (0.55, 3.18)	.241
Medicaid	439	0.93 (0.33, 2.63)	0.53 (0.14, 1.91)		
Uninsured	97	2.08 (0.18, 23.6)	-		

CNS, central nervous system; NHB, Non-Hispanic Black; NHW, non-Hispanic White.

*Adjusted for sex, median household income quartile, % no high school degree quartile, and residence area, with non-Hispanic White as reference group.

†Neuroblastoma and other peripheral nervous cell tumors, retinoblastoma, renal tumors and other and unspecified malignant neoplasms were not included due to small number of adolescent cancer cases.

‡Computed using the likelihood ratio test, similar as results obtained from Wald test.