

Supplementary Online Content

Delavar A, Barnes JM, Wang X, Johnson KJ. Association between race/ethnicity and US childhood and adolescent cancer survival by treatment amenability. *JAMA Pediatr*. Published online February 24, 2020. doi:10.1001/jamapediatrics.2019.6074

eFigure 1. Directed Acyclic Graph

eFigure 2. Flow Chart of Subject Exclusions

eTable 1. SEER Variables Used in the Analysis

eTable 2. Cancer Types Represented in the Analysis

eTable 3. Risk of Cancer Death for Children and Adolescents Diagnosed With Cancer From 2007-2016 by Race/Ethnicity and Cancer Amenability Category (Low: <70% RSR, Medium: 70-85% RSR, High: >85% RSR) With Non-Hispanic Whites as the Reference Group and Adjusting for Insurance Status

eTable 4. Risk of Cancer Death for Children and Adolescents Diagnosed With Cancer From 2000-2016 by Race/Ethnicity and Cancer Amenability Category ($\leq 50\%$ and $>50\%$ RSR) With Non-Hispanic White as the Reference Group and Adjusting for Insurance Status

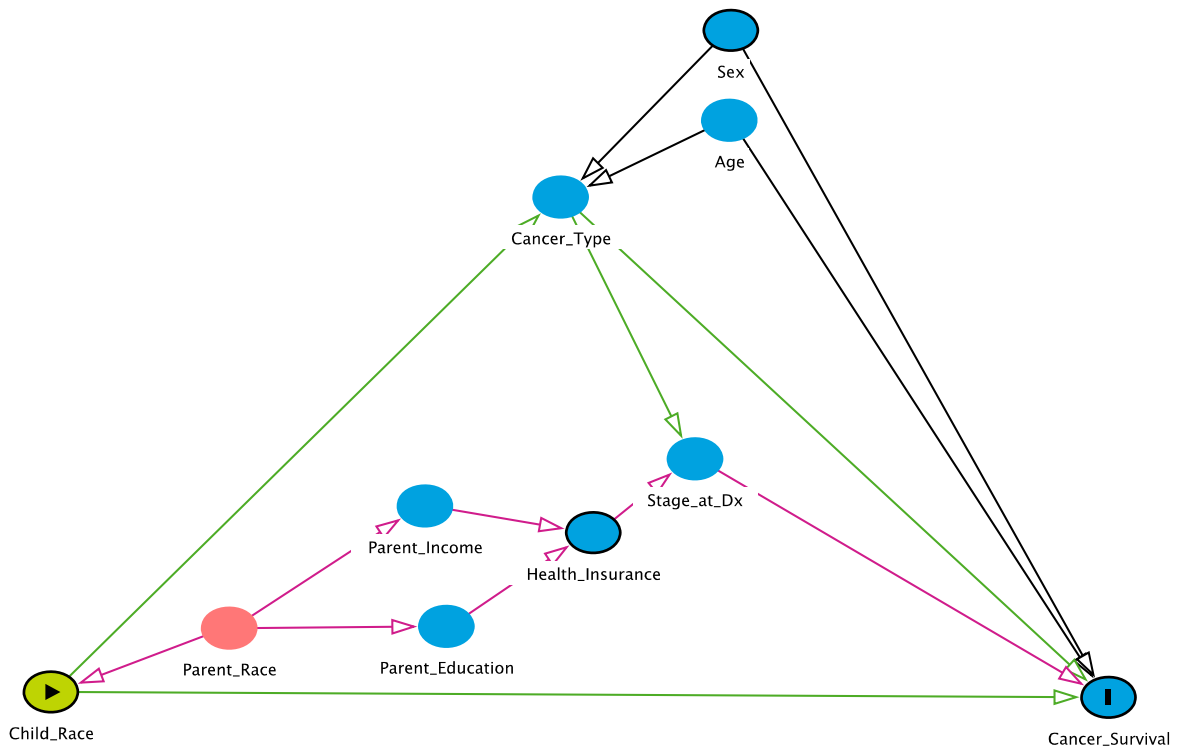
eTable 5. Risk of Cancer Death for Children and Adolescents Diagnosed With Cancer From 2000-2016 by Race/Ethnicity for Common Cancer Types

eReferences

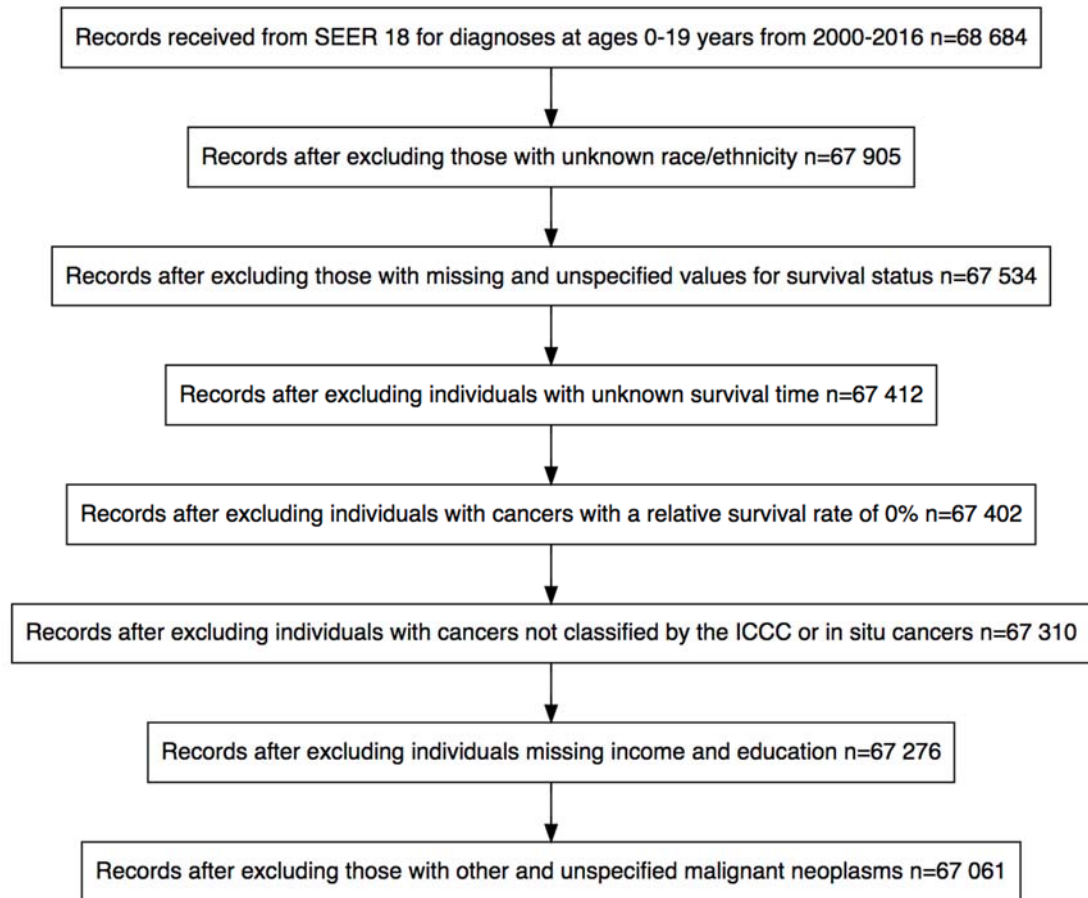
This supplementary material has been provided by the authors to give readers additional information about their work.

eFigure 1. Directed acyclic graph.

Directed acyclic graph of known and suspected confounders for the relationship between race/ethnicity and cancer survival among children and adolescents. Age, sex, parent race/ethnicity, parent income, parent education, insurance status, cancer type, and stage at diagnosis were considered. Parent income and education provides a minimal set of covariates necessary for mitigating confounding bias for this relationship.



eFigure 2. Flow Chart of Subject Exclusions



eTable 1. SEER variables used in the analysis.

SEER variable	Variable description
Patient ID	Patient identification
Age at diagnosis	Age at cancer diagnosis
Year of diagnosis	Year of cancer diagnosis
SEER cause-specific death classification	Death by cancer or alive/dead by other cause
Survival months	Survival months
Sex	Sex
Race and origin recode (NHW, NHB, NHAIAN, NHAPI, Hispanic) Race and Hispanic ethnicity	Race and Hispanic ethnicity
ICCC site rec extended ICD-O-3/WHO 2008	International classification of childhood cancer
Median family income (in tens) 2000	Median family income in county
% High school education 2000	Percent with less than high school education
Insurance Recode (2007+)	Health insurance status

eTable 2. Cancer types represented in the analysis.

Cancer type ^a	Count	RSR ^b	RSR 3-category ^c	RSR 2-category ^c
I(a.1) Precursor cell leukemias	13478	0.871	high	>50
I(a.2) Mature B-cell leukemias	261	0.864	high	>50
I(a.3) Mature T-cell and NK cell leukemias	28	0.637	low	>50
I(a.4) Lymphoid leukemia, NOS	23	0.818	medium	>50
I(b) Acute myeloid leukemias	3089	0.628	low	>50
I(c) Chronic myeloproliferative diseases	471	0.869	high	>50
I(d) Myelodysplastic syndrome and other myeloproliferative	139	0.608	low	>50
I(e) Unspecified and other specified leukemias	497	0.698	low	>50
II(a) Hodgkin lymphomas	4706	0.964	high	>50
II(b.1) Precursor cell lymphomas	1106	0.832	medium	>50
II(b.2) Mature B-cell lymphomas except Burkitt lymphoma	1396	0.882	high	>50
II(b.3) Mature T-cell and NK-cell lymphomas	888	0.851	high	>50
II(b.4) Non-Hodgkin lymphomas, NOS	187	0.856	high	>50
II(c) Burkitt lymphoma	978	0.902	high	>50
II(d) Miscellaneous lymphoreticular neoplasms	227	0.878	high	>50
II(e) Unspecified lymphomas	120	0.854	high	>50
III(a.1) Ependymomas	927	0.776	medium	>50
III(a.2) Choroid plexus tumor	105	0.639	low	>50
III(b) Astrocytomas	5781	0.824	medium	>50
III(c.1) Medulloblastomas	1526	0.715	medium	>50
III(c.2) PNET	564	0.567	low	>50
III(c.3) Medulloepithelioma	27	0.681	low	>50
III(c.4) Atypical teratoid/rhabdoid tumor	301	0.328	low	≤50
III(d.1) Oligodendrogliomas	276	0.86	high	>50
III(d.2) Mixed and unspecified gliomas	1642	0.548	low	>50
III(d.3) Neuroepithelial glial tumors of uncertain orig	35	0.571	low	>50
III(e.1) Pituitary adenomas and carcinomas	3	1	high	>50
III(e.3) Pineal parenchymal tumors	144	0.618	low	>50
III(e.4) Neuronal and mixed neuronal-glia tumors	46	0.884	high	>50
III(e.5) Meningiomas	18	0.722	medium	>50
III(f) Unspecified intracranial and intraspinal neoplasms	108	0.482	low	≤50
IV(a) Neuroblastoma and ganglioneuroblastoma	3036	0.772	medium	>50

IV(b) Other peripheral nervous cell tumors	87	0.81	medium	>50
IX(a) Rhabdomyosarcomas	1843	0.649	low	>50
IX(b.1) Fibroblastic and myofibroblastic tumors	269	0.912	high	>50
IX(b.2) Nerve sheath tumors	216	0.609	low	>50
IX(c) Kaposi sarcoma	14	0.787	medium	>50
IX(d.1) Ewing tumor and Askin tumor of soft tissue	263	0.718	medium	>50
IX(d.10) Alveolar soft parts sarcoma	63	0.823	medium	>50
IX(d.11) Miscellaneous soft tissue sarcomas	151	0.354	low	≤50
IX(d.2) pPNET of soft tissue	146	0.729	medium	>50
IX(d.3) Extrarenal rhabdoid tumor	99	0.323	low	≤50
IX(d.4) Liposarcomas	132	0.881	high	>50
IX(d.5) Fibrohistiocytic tumors	476	0.995	high	>50
IX(d.6) Leiomyosarcomas	82	0.867	high	>50
IX(d.7) Synovial sarcomas	411	0.83	medium	>50
IX(d.8) Blood vessel tumors	60	0.568	low	>50
IX(d.9) Osseous & chondromatous neoplasms of soft tissue	38	0.624	low	>50
IX(e) Unspecified soft tissue sarcomas	454	0.725	medium	>50
V Retinoblastoma	1301	0.969	high	>50
VI(a.1) Nephroblastoma	2204	0.92	high	>50
VI(a.2) Rhabdoid renal tumor	57	0.462	low	≤50
VI(a.3) Kidney sarcomas	80	0.908	high	>50
VI(b) Renal carcinomas	209	0.76	medium	>50
VI(c) Unspecified malignant renal tumors	6	0.751	medium	>50
VII(a) Hepatoblastoma	712	0.787	medium	>50
VII(b) Hepatic carcinomas	226	0.446	low	≤50
VII(c) Unspecified malignant hepatic tumors	2	1	high	>50
VIII(a) Osteosarcomas	1981	0.67	low	>50
VIII(b) Chondrosarcomas	139	0.946	high	>50
VIII(c.1) Ewing tumor and Askin tumor of bone	1064	0.688	low	>50
VIII(c.2) pPNET of bone	59	0.773	medium	>50
VIII(d.1) Malignant fibrous neoplasms of bone	21	0.897	high	>50
VIII(d.2) Malignant chordomas	88	0.711	medium	>50
VIII(d.3) Odontogenic malignant tumors	16	1	high	>50
VIII(d.4) Miscellaneous malignant bone tumors	52	0.98	high	>50
VIII(e) Unspecified malignant bone tumors	64	0.804	medium	>50
X(a.1) Intracranial & intraspinal germinomas	554	0.93	high	>50
X(a.2) Intracranial & intraspinal teratomas	60	0.662	low	>50

X(a.3) Intracranial & intraspinal embryonal carcinomas	9	0.198	low	≤50
X(a.4) Intracranial & intraspinal yolk sac tumor	9	0.648	low	>50
X(a.5) Intracranial & intraspinal choriocarcinoma	13	0.495	low	≤50
X(a.6) Intracranial & intraspinal tumors of mixed forms	94	0.815	medium	>50
X(b.1) Germinomas: extracranial/extragonadal	65	0.771	medium	>50
X(b.2) Malignant teratomas: extracranial/extragonadal	232	0.83	medium	>50
X(b.3) Embryonal carcinomas: extracranial/extragonadal	9	0.535	low	>50
X(b.4) Yolk sac tumor: extracranial/extragonadal	127	0.8	medium	>50
X(b.5) Choriocarcinomas: extracranial/extragonadal	76	0.919	high	>50
X(b.6) Other mixed germ cell: extracranial/extragonadal	94	0.726	medium	>50
X(c.1) Malignant gonadal germinomas	587	0.971	high	>50
X(c.2) Malignant gonadal teratomas	591	0.977	high	>50
X(c.3) Gonadal embryonal carcinomas	301	0.988	high	>50
X(c.4) Gonadal yolk sac tumor	316	0.953	high	>50
X(c.5) Gonadal choriocarcinoma	34	0.663	low	>50
X(c.6) Malignant gonadal tumors of mixed forms	1260	0.944	high	>50
X(d) Gonadal carcinomas	167	0.765	medium	>50
X(e) Other and unspecified malignant gonadal tumors	92	0.927	high	>50
XI(a) Adrenocortical carcinomas	89	0.552	low	>50
XI(b) Thyroid carcinomas	3141	0.993	high	>50
XI(c) Nasopharyngeal carcinomas	210	0.869	high	>50
XI(d) Malignant melanomas	1865	0.95	high	>50
XI(e) Skin carcinomas	31	1	high	>50
XI(f.1) Carcinomas of salivary glands	308	0.963	high	>50
XI(f.10) Carcinomas of other specified sites	416	0.757	medium	>50
XI(f.11) Carcinomas of unspecified site	53	0.346	low	≤50
XI(f.2) Carcinomas of colon and rectum	225	0.539	low	>50
XI(f.3) Carcinomas of appendix	416	0.981	high	>50
XI(f.4) Carcinomas of lung	162	0.82	medium	>50
XI(f.5) Carcinomas of thymus	22	0.621	low	>50
XI(f.6) Carcinomas of breast	66	0.837	medium	>50
XI(f.7) Carcinomas of cervix uteri	48	0.835	medium	>50
XI(f.8) Carcinomas of bladder	93	0.957	high	>50
XI(f.9) Carcinomas of eye	8	1	high	>50

Abbreviations: NK, natural killer; NOS, not otherwise specified; PNET, primitive neuroectodermal tumor; pPNET, peripheral primitive neuroectodermal tumor; RSR, relative survival rate.

^aCancer types based on International Classification of Childhood Cancer extended classification definitions.¹ Cancer types with zero cases were removed.

^bFive-year relative survival rates were calculated for each cancer type among cases aged 0-19 years with a first primary malignant cancer diagnosed from 2000-2016 using SEER 18 data and SEER*Stat software.²

^cThe RSR 3-category variable was based on RSR cut points of >85% (high amenability), 70-85% (medium amenability), and <70% (low amenability). The RSR 2-category variable was based on relative survival rate cut points of >50% and ≤50%

eTable 3. Risk of cancer death for children and adolescents diagnosed with cancer from 2007-2016 by race/ethnicity and cancer amenability category (Low: <70% RSR, Medium: 70-85% RSR, High: >85% RSR) with non-Hispanic Whites as the reference group and adjusting for insurance status.

Race/Ethnicity	Total No.	Dead No.	HR (95% CI) ^a	HR (95% CI) ^b
NH White	19 727	2180 (11.1)	Ref	Ref
NH Black	4167	708 (17.0)	1.58 (1.45-1.72)	1.37 (1.26-1.50)
NH American Indian/Alaskan Native	327	55 (16.8)	1.62 (1.24-2.11)	1.46 (1.11-1.91)
NH Asian or Pacific Islander	3134	432 (13.8)	1.36 (1.22-1.50)	1.39 (1.25-1.54)
Hispanic (any race)	12 006	1610 (13.4)	1.31 (1.23-1.40)	1.28 (1.19-1.37)
Race/Ethnicity by Amenability				
NH White				
Low	3560	971 (27.3)	Ref	Ref
Medium	5253	747 (14.2)	Ref	Ref
High	10 914	462 (4.2)	Ref	Ref
NH Black				
Low	964	311 (32.3)	1.24 (1.10-1.41)	1.16 (1.02-1.32)
Medium	1145	244 (21.3)	1.62 (1.41-1.88)	1.53 (1.32-1.77)
High	2058	153 (7.4)	1.76 (1.46-2.11)	1.65 (1.37-1.98)
P for interaction			0.003	0.002
NH American Indian/Alaskan Native				
Low	70	26 (37.1)	1.34 (0.91-1.97)	1.25 (0.85-1.86)
Medium	80	19 (23.8)	2.04 (1.30-3.22)	1.96 (1.24-3.10)
High	177	10 (5.6)	1.39 (0.74-2.59)	1.33 (0.71-2.48)
P for interaction			0.35	0.32
NH Asian or Pacific Islander				
Low	622	197 (31.7)	1.35 (1.16-1.57)	1.35 (1.15-1.57)
Medium	748	142 (19.0)	1.49 (1.24-1.78)	1.49 (1.24-1.78)
High	1764	93 (5.3)	1.33 (1.06-1.66)	1.33 (1.07-1.67)
P for interaction			0.65	0.65
Hispanic (any race)				
Low	2195	690 (31.4)	1.28 (1.16-1.41)	1.17 (1.06-1.30)
Medium	2489	419 (16.8)	1.30 (1.16-1.47)	1.19 (1.06-1.35)
High	7322	501 (6.8)	1.74 (1.53-1.97)	1.58 (1.39-1.80)
P for interaction			<0.001	<0.001

Abbreviations: NH, non-Hispanic; N, number; HR, hazard ratio; CI, confidence interval.

^aUnadjusted model using age as the time scale. The race/ethnicity by amenability models also include amenability category and an interaction term between race and amenability category.

^bAdjusted model using age as the time scale. Model includes insurance category, percent below high school education in county quintile, and median family income in county quintile. The race/ethnicity by amenability models also include amenability category and an interaction term between race and amenability category.

eTable 4. Risk of cancer death for children and adolescents diagnosed with cancer from 2000-2016 by race/ethnicity and cancer amenability category ($\leq 50\%$ and $>50\%$ RSR) with non-Hispanic White as the reference group and adjusting for insurance status.

Race/Ethnicity	Total No.	Dead No. (%)	HR (95% CI) ^a	HR (95% CI) ^b
NH White				
$\leq 50\%$	293	139 (47.4)	Ref	Ref
$>50\%$	19 434	2041 (10.5)	Ref	Ref
NH Black				
$\leq 50\%$	88	43 (48.9)	1.09 (0.77-1.53)	1.08 (0.76-1.52)
$>50\%$	4079	665 (16.3)	1.60 (1.46-1.74)	1.49 (1.36-1.63)
P for interaction			0.03	0.07
NH American Indian/Alaskan Native				
$\leq 50\%$	4	1 (25.0)	0.30 (0.04-2.15)	0.29 (0.04-2.04)
$>50\%$	323	54 (16.7)	1.71 (1.31-2.24)	1.62 (1.23-2.12)
P for interaction			0.09	0.09
NH Asian or Pacific Islander				
$\leq 50\%$	58	32 (55.2)	1.19 (0.81-1.74)	1.24 (0.85-1.83)
$>50\%$	3076	400 (13.0)	1.35 (1.21-1.50)	1.36 (1.22-1.51)
P for interaction			0.52	0.67
Hispanic (any race)				
$\leq 50\%$	183	94 (51.4)	1.32 (1.01-1.71)	1.23 (0.94-1.60)
$>50\%$	11 823	1516 (12.8)	1.32 (1.23-1.41)	1.20 (1.12-1.29)
P for interaction			0.99	0.87

Abbreviations: NH, non-Hispanic; No., number; HR, hazard ratio; CI, confidence interval; Ref, reference.

^aUnadjusted model using age as the time scale. The race/ethnicity by amenability models also include amenability category and an interaction term between race and amenability category.

^bAdjusted model using age as the time scale. Model included percent below high school education in county quintile and median family income in county quintile, amenability category and an interaction term between race and amenability category.

eTable 5. Risk of cancer death for children and adolescents diagnosed with cancer from 2000-2016 by race/ethnicity for common cancer types.

Cancer type/Race	Total No. (%)	Dead No. (%)	HR ^a	95% CI	HR ^b	95% CI
Rhabdomyosarcoma (5-year RSR=65%)						
NH White	911	265	1.0	Ref	1.0	Ref
NH Black	291	95	1.2	0.95-1.52	1.22	0.96-1.55
NH American Indian/Alaskan Native	18	9	2.4	1.23-4.67	2.38	1.21-4.68
NH Asian or Pacific Islander	124	43	1.54	1.12-2.13	1.57	1.13-2.18
Hispanic	499	160	1.24	1.02-1.51	1.21	0.98-1.49
Precursor cell leukemia (5-year RSR=87%)						
NH White	6148	547	1.0	Ref	1.0	Ref
NH Black	914	136	1.73	1.43-2.09	1.69	1.40-2.05
NH American Indian/Alaskan Native	130	19	1.7	1.08-2.69	1.71	1.08-2.71
NH Asian or Pacific Islander	1041	118	1.41	1.16-1.72	1.44	1.18-1.76
Hispanic	5245	758	1.88	1.69-2.10	1.74	1.55-1.96
Hodgkin Lymphoma (5-year RSR=96%)						
NH White	2726	97	1.0	Ref	1.0	Ref
NH Black	576	34	1.85	1.25-2.73	1.74	1.17-2.60
NH American Indian/Alaskan Native	18	1	1.47	0.21-10.57	1.44	0.20-10.48
NH Asian	288	16	1.8	1.06-3.06	1.93	1.13-3.29
Hispanic	1098	41	1.18	0.81-1.70	1.14	0.78-1.68
Astrocytoma (5-year RSR=82%)						
NH White	3516	494	1.0	Ref	1.0	Ref
NH Black	621	138	1.81	1.50-2.19	1.78	1.47-2.16
NH American Indian/Alaskan Native	42	6	1.17	0.52-2.61	1.18	0.52-2.64
NH Asian or Pacific Islander	331	73	1.81	1.41-2.31	1.91	1.49-2.45
Hispanic	1271	233	1.42	1.21-1.65	1.39	1.18-1.64
Acute Myeloid Leukemia (5-year RSR=63%)						
NH White	1406	407	1.0	Ref	1.0	Ref
NH Black	391	160	1.7	1.41-2.04	1.68	1.40-2.03
NH American Indian/Alaskan Native	43	13	0.91	0.52-1.58	0.87	0.50-1.52
NH Asian or Pacific Islander	299	93	1.24	0.99-1.55	1.31	1.04-1.65
Hispanic	950	301	1.25	1.07-1.45	1.19	1.01-1.40
Neuroblastoma and Ganglioneuroblastoma (5-year RSR=77%)						
NH White	1769	318	1.0	Ref	1.0	Ref
NH Black	382	93	1.52	1.21-1.92	1.50	1.19-1.89

NH American Indian/Alaskan Native	17	5	1.75	0.72-4.24	1.86	0.76-4.55
NH Asian or Pacific Islander	222	56	1.92	1.44-2.55	1.97	1.47-2.63
Hispanic	646	134	1.32	1.08-1.61	1.23	1.00-1.53
Nephroblastoma (5-year RSR=92%)						
NH White	1108	69	1.0	Ref	1.0	Ref
NH Black	379	25	1.13	0.71-1.79	1.10	0.69-1.74
NH American Indian/Alaskan Native	24	1	0.69	0.10-4.97	0.74	0.10-5.36
NH Asian or Pacific Islander	101	9	1.57	0.78-3.14	1.46	0.72-2.94
Hispanic	592	51	1.55	1.08-2.23	1.35	0.91-1.99
Osteosarcoma (5-year RSR=67%)						
NH White	895	267	1.0	Ref	1.0	Ref
NH Black	318	96	1.03	0.82-1.31	1.03	0.81-1.30
NH American Indian/Alaskan Native	14	8	2.55	1.26-5.15	2.77	1.36-5.67
NH Asian or Pacific Islander	152	37	0.85	0.60-1.20	0.84	0.59-1.19
Hispanic	602	185	1.09	0.91-1.32	1.06	0.87-1.29
Medulloblastoma (5-year RSR=72%)						
NH White	877	231	1.0	Ref	1.0	Ref
NH Black	119	39	1.46	1.04-2.05	1.43	1.01-2.01
NH American Indian/Alaskan Native	13	3	1.33	0.42-4.15	1.33	0.42-4.20
NH Asian or Pacific Islander	115	33	1.17	0.81-1.68	1.10	0.76-1.60
Hispanic	402	117	1.06	0.85-1.32	1.01	0.80-1.28

Abbreviations: NH, non-Hispanic; No., number; HR, hazard ratio; CI, confidence interval; Ref, reference.

^aUnadjusted model using age as the time scale.

^bAdjusted model using age as the time scale. Model adjusted for percent below high school education in county quintile and median family income in county quintile.

eReferences

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