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Knowledge of Hepatitis C Virus Screening in Long-Term Pediatric Cancer Survivors: A Report from the Childhood Cancer Survivor Study

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Abstract

Background—Pediatric cancer survivors who were treated before routine hepatitis C virus (HCV) screening of blood donors in 1992 have an elevated risk of transfusion-acquired HCV.

Methods—To assess long-term pediatric cancer survivors' knowledge of HCV testing and blood transfusion history, a questionnaire was administered to 9,242 participants in the Childhood Cancer Survivor Study (CCSS) who are at risk for transfusion-acquired HCV following cancer therapy from 1970–1986.

Results—More than 70% of survivors reported either no prior HCV testing (41%) or uncertainty about testing (31%), with only 29% reporting prior testing. One-half recalled having a treatment-related blood transfusion; those who recalled a transfusion were more likely to report HCV testing (39%) than those who did not (18%) or were unsure (20%). In multivariate models, survivors who reported no prior HCV testing were more likely to be older (odds ratio [OR] per five-year increase, 1.1; 95% confidence interval [95% CI], 1.0–1.1) and to report no care at a cancer center within the past two years (OR, 1.2; 95% CI, 1.0–1.4), no cancer treatment summary (OR, 1.3; 95% CI, 1.2–1.5), and no transfusions (OR, 2.6; 95% CI, 2.3–3.0) or uncertainty about transfusions (OR, 2.2; 95% CI, 1.9–2.6), and less likely to be racial/ethnic minorities (OR, 0.9; 95% CI, 0.8–1.0) or survivors of acute myeloid leukemia (OR, 0.7; 95% CI, 0.5–1.0).

Conclusions—Many pediatric cancer survivors at risk for transfusion-acquired HCV are unaware of their transfusion history and prior testing for HCV and would benefit from programs to increase HCV knowledge and screening.

Keywords

cancer screening; late effects; survivorship; adverse treatment effects; chronic disease

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INTRODUCTION

Hepatitis C virus (HCV) is the primary cause of chronic liver disease and liver transplantation in the United States.1 Based upon the 1999–2002 National Health and Nutrition Examination Survey (NHANES), at least 4.1 million Americans have been infected with HCV, of whom 3.2 million are chronically infected.2 Though many patients with chronic HCV are initially asymptomatic, the infection progressively impairs liver function and causes 10,000–12,000 deaths annually.1, 3 Two to three decades after first infection, 15–35% of patients develop cirrhosis, which increases the risk of hepatocellular carcinoma to 1–4% per year.3, 4 As the population ages, the burden of HCV-related morbidity and mortality is projected to grow substantially.5–7

Before the first blood donor screening regulations were adopted in the mid-1980s, an estimated 40% of HCV transmission resulted from blood transfusions.8 Pediatric cancer patients frequently require blood and blood products during therapy; thus, those who were treated before the current HCV blood donor screening methods were initiated in 1992 have an elevated risk of transfusion-acquired HCV. As in the general population, chronic HCV infection in pediatric cancer survivors is associated with liver fibrosis, cirrhosis, hepatocellular carcinoma, extra-hepatic manifestations, and impaired quality of life.9–15 In cancer survivors, these effects may be compounded by exposure to immunosuppressive and hepatotoxic chemotherapy.9, 12, 13, 15

Since the natural history of HCV infection may be modified by lifestyle choices (i.e. avoidance of alcohol) and clinical care (i.e. availability of antiviral therapy, liver function monitoring), patient knowledge of HCV status is of critical importance. Recognizing that some survivors are unsure of whether or not they received a transfusion or blood product during therapy, the Children's Oncology Group recommends that all survivors who were treated prior to 1993 be screened for HCV.16 Importantly, survivors' awareness of screening and their HCV status is largely unknown. This study aimed to assess survivors' knowledge of blood transfusion history and prior testing for HCV in a large and diverse population of childhood cancer survivors at risk for transfusion-acquired HCV.

METHODS

Study Population

The Childhood Cancer Survivor Study (CCSS) is a multi-institutional longitudinal cohort study tracking the health outcomes of long-term (≥5-year) cancer survivors who were diagnosed with leukemia, Hodgkin lymphoma, non-Hodgkin lymphoma, neuroblastoma, CNS tumor, kidney (Wilms) tumor, bone tumor, or soft tissue sarcoma before 21 years of age. All participants were diagnosed between 1970 and 1986 and treated at one of 26 participating institutions in the United States and Canada. The CCSS recruitment methodology and cohort characteristics have been described in detail previously.17–19 All participants provided written informed consent prior to study initiation.

This analysis is limited to participants who completed the CCSS 2003 Follow-up Survey. At the time of the CCSS 2003 Follow-up Survey, there were 11,465 survivors who were alive and eligible for medical records abstraction. Of the 11,465 survivors, 1751 (15%) were passive or active non-respondents, 406 (3.5%) could not be located, and 66 (0.06%) did not respond to the HCV questions. Participants did not differ from non-participants by diagnosis, original cancer treatment, or age at diagnosis. However, participants were slightly more likely to be female (49% female in the participants vs. 43% in the nonparticipants, $p < 0.001$) and slightly younger at the first contact (mean age at baseline contact 23.7 years vs. 24.3 years, $p < 0.001$).

Cancer Treatment Information

Information regarding original cancer diagnoses was obtained for eligible cases from treating institutions. For all CCSS participants returning signed medical releases, information regarding primary cancer therapies was collected, including initial treatment, treatment for relapse, and (where applicable) preparatory regimens for bone marrow transplantation. Qualitative information was abstracted from medical records for 42 specific chemotherapeutic agents, for which quantitative dose information was abstracted on 22. Copies of radiation therapy records were obtained and centrally reviewed, including doses of cranial and craniospinal radiotherapy and total body irradiation. Importantly, during the era in which these patients were diagnosed and treated, blood transfusions were often administered in hospitals or settings outside of the treating institution. Thus, transfusion history was not included in the abstraction process. The treatment abstraction forms employed in data collection are available at www.stjude.org/ccss.

Main Outcome Measures

The primary outcomes of interest were survivors' knowledge of prior testing for HCV and treatment-related blood transfusion history. The following three questions were asked: "Has a doctor or health care professional ever tested you for hepatitis C?"; "Did you receive a blood transfusion (red cells, platelets, fresh/frozen plasma) during your treatment for cancer?"; and "Have you received a blood transfusion for another reason either before your cancer was diagnosed or since you finished treatment?" Participants responded to all questions with "yes", "no", or "not sure" and provided their age at time of interest (test or transfusion). A small number of participants (N=74) who reported no treatment-related transfusions but recalled having a transfusion for another reason after 1993 (based on reported age) were excluded from some analyses since their recall of testing and transfusions may differ systematically from those at highest risk for transfusion-acquired HCV (treated/transfused before 1993). For exploratory purposes, though it was not a main outcome of the analysis, participants who reported a prior test for HCV were also asked to report the result of that test: "positive for hepatitis C (means that you are or have been infected)", "negative for hepatitis C", or "not sure".

Independent Variables

Demographic and cancer-related information (age, gender, race/ethnicity, diagnosis, age at diagnosis) was collected previously through the CCSS. The CCSS 2003 Follow-up survey assessed socioeconomic status (health insurance, household income, and education) and health care practices during the previous two years. Participants were asked whether, during that two-year time period, they received care at a cancer center or clinic (yes vs no) or discussed HCV with a physician (yes vs no), and whether they currently had a written summary of their previous cancer treatment (yes vs no/not sure). The 2003 Follow-up questionnaire is available for download at www.stjude.org/ccss.

Statistical Analysis

The proportion of participants who self-reported prior testing for HCV (yes, no, not sure) or recalled having a treatment-related blood transfusion (yes, no, not sure) was described according to demographic characteristics, socioeconomic status, cancer-related factors, and health care practices. Within each blood transfusion response category, participants were further characterized by the proportion who reported a prior test for HCV. Associations between participant characteristics and reporting no prior HCV testing or uncertainty about testing (vs. prior testing) were assessed by univariate and multivariate logistic regression. All factors that were significant at the univariate level were included in the multivariate model and sequentially removed according to the Likelihood Ratio Test and a two-sided

significance level of 0.05. All analyses were conducted with SAS version 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

The most common cancer diagnosis in the study cohort was leukemia and the median age of participants was 6 years (range, 0–20) at diagnosis and 31 years (range, 17–54) at time of study. Most were non-Hispanic white (86%), were educated beyond high school (79%), had health insurance or were Canadian (88%), and had an annual household income greater than $20,000 (68%). Complete participant characteristics are provided in Table 1.

Of the 9,242 survivors in this analysis, 29% reported prior HCV testing, while 41% reported no testing and 31% were unsure (Table 1). Notably, even among those who received care at a cancer center within the previous two years, the proportion reporting prior HCV testing was little more than one-third (36%). Participants who reported having a recent discussion with their physician about HCV were much more likely to report testing (86%) than those who had no such discussion (26%).

Table 2 presents the proportion of survivors reporting prior testing for HCV according to self-reported history of treatment-related blood transfusions. One-half of survivors recalled having a treatment-related transfusion, and of those who recalled a transfusion, 39% reported prior testing for HCV, compared to 18% of those who recalled no transfusion and 20% of those who were unsure of their transfusion history. As expected given diagnosis-specific treatment protocols, there was wide variation in the proportion recalling a treatment-related transfusion among survivors of different cancer types, ranging from 31% of CNS tumor survivors to 84% of acute myeloid leukemia (AML) survivors. Although the proportion reporting HCV testing varied by diagnosis even among those who recalled a transfusion, it was never more than one-half (range, 31% to 46%), indicating substantial gaps in survivors' knowledge of HCV. Of those who reported prior testing, 89% were unsure of the test result and 10% reported HCV positivity (data not shown).

Univariate and multivariate comparisons of survivors who reported no prior HCV testing (or uncertainty about testing) versus a prior test for HCV are shown in Table 3. Nearly all participants who reported no prior HCV testing also reported not having a recent discussion with their physician about HCV (99%); thus, this variable was excluded from the multivariate analysis to identify other associations with the outcome of interest. In multivariate models, survivors who recalled not having a treatment-related blood transfusion or uncertainty about their transfusion history were two times more likely to report no prior testing for HCV (no transfusion: OR, 2.6; 95% CI, 2.3–3.0; uncertain: OR, 2.2; 95% CI, 1.9–2.6). Additional factors that were associated with reporting no prior HCV testing included: older age at study (per five-year increase, OR, 1.1; 95% CI, 1.0–1.1), no recent care at a cancer center (OR, 1.2; 95% CI, 1.0–1.4), and no cancer treatment summary (OR, 1.3; 95% CI, 1.2–1.5). Compared to Hodgkin lymphoma survivors, CNS tumor survivors were more likely to report no prior testing (OR, 1.5; 95% CI, 1.2–1.8) and AML survivors were less likely to report no prior testing (OR, 0.7; 95% CI, 0.5–1.0). Racial/ethnic minorities were also slightly less likely than non-Hispanic whites to report no prior testing (OR, 0.9; 95% CI, 0.8–1.0).

DISCUSSION

In this large cohort of pediatric cancer survivors at risk for transfusion-acquired HCV, less than 30% reported prior HCV testing. Fifty percent of survivors recalled having a blood transfusion during cancer therapy. For perspective, at St. Jude Children's Research Hospital,

which maintained a record of blood transfusions administered during this time period, the following percent of survivors had a record of a blood transfusion: all patients, 58%; AML, 95%; ALL, 83%; Wilms tumor, 63%; osteosarcoma, 53%; neuroblastoma, 51%; Non-Hodgkin lymphoma, 48%; soft tissue sarcoma, 39%; Ewing's sarcoma, 34%; CNS tumor, 32%; Hodgkin lymphoma, 12%. Even among the 50% of CCSS survivors in our study who reported having a blood transfusion, only 39% reported a prior test for HCV. Awareness of HCV testing is essential for obtaining appropriate follow-up care and minimizing the effects of infection; thus, these gaps in knowledge constitute a serious public health problem that warrants attention.

Survivors who did not recall a therapy-related transfusion or were uncertain about transfusions were twice as likely as those who recalled having a transfusion to report no prior HCV testing. This suggests that health care providers may be more likely to test patients who know they were transfused, as recommended by the Centers for Disease Control and Prevention (CDC) and National Institutes of Health (NIH), rather than test all pediatric cancer survivors who were treated before 1993, as recommended by the COG.1, 3, 16 The 1993 cutoff date may vary for survivors treated outside North America, based on the timing of donor screening for HCV with the second generation ELISA in other regions. Since standard therapy for AML requires transfusion of blood or blood products, it is appropriate to assume that all AML survivors in this cohort had a transfusion. Notably, 84% of AML survivors recalled having a blood transfusion, but only 44% reported prior HCV testing (46% of those who recalled a transfusion). While awareness of transfusion history is certainly important, it does not seem to be sufficient to ensure HCV testing.

Knowledge of HCV testing and infection status is necessary for optimal patient care, particularly because the severity of disease may be minimized by careful clinical follow-up and pharmacological and lifestyle interventions. Evidence suggests that combination therapy with interferon-α and ribavirin is effective against chronic HCV in pediatric cancer survivors, with 44–67% achieving a sustained virological response.9, 20, 21 Changes in diet and physical activity may also modify the disease course, as obesity has been linked with more severe liver steatosis among pediatric cancer survivors with transfusion-acquired chronic HCV.9 Although alcohol is a well-known risk factor for more severe HCV-associated liver disease, recent data indicates that individuals with HCV report greater alcohol consumption than those without the disease, highlighting the importance of behavioral counseling in caring for patients with chronic HCV.2

Despite the availability of these strategies to minimize the burden of disease, several lines of research from the CCSS suggest that long-term survivors of pediatric cancer may be at particular risk of morbidity from transfusion-acquired chronic HCV, especially as they age. By 25 years after therapy, two-thirds of survivors in the CCSS reported at least one chronic condition and 38.5% reported two or more.22 In the same cohort, older age has been associated with greater risk of moderate to extreme adverse general health, functional impairment, activity limitations, and pain.23 The effect of these comorbidities on the clinical course of HCV is unknown, but may contribute to liver damage and declining health status and quality of life. In light of this, it is concerning that only 18% of more than 8,500 CCSS participants reported recent survivor-focused medical care with risk-based counseling or tests to screen for late effects.24 Older participants were less likely to report risk-based counseling and screening, just as older participants in this analysis were less likely to report prior testing for HCV. Together, these findings suggest that long-term pediatric cancer survivors at risk of transfusion-acquired HCV may be less likely to obtain appropriate clinical follow-up and HCV screening as they age, despite the increased risk of comorbidities and clinical manifestations of HCV attributable to a longer interval of time since cancer therapy and possible HCV exposure.

It is important to acknowledge that the risk of transfusion-acquired HCV has declined markedly over the past two to three decades, following the implementation of more stringent blood donor screening regulations.25 The second-generation HCV antibody screening test that has been used in North America since 1992 has lowered the estimated risk of infection to 0.001% per unit of blood, compared to 0.03% per unit with the first-generation antibody (1990–1991), 0.19% per unit with surrogate markers (1986–1990), and 0.45% per unit with HIV, syphilis, and HBV screening only (1985–1986).3, 25, 26 Most survivors in this study cohort were treated for cancer and exposed to blood or blood products prior to these regulations (1970–1980), when 10–12% of patients who received blood transfusions were infected with HCV.27, 28 Therefore, for many long-term pediatric cancer survivors alive today, the risk of transfusion-acquired HCV is not trivial.

Although we did not have access to blood samples to objectively measure the prevalence of HCV infection in this study cohort, we did ask participants who recalled prior HCV testing if they were or had ever been infected with HCV. Comparable to other U.S. cohorts that reported transfusion-acquired HCV infection rates of 6–12% in pediatric cancer survivors, approximately 10% of survivors in this study who recalled HCV testing also reported HCV infection.9, 13, 15 Of concern, 89% were unsure of their HCV status, indicating a widespread breakdown in knowledge and awareness.

In interpreting these study findings, several limitations warrant consideration. The primary outcomes, HCV testing and therapy-related transfusion history, were obtained by participant self-report and not verified by medical records or other sources. Of note, participants who were younger at the time of their cancer diagnosis (ie, less than 10 years of age), may have needed to rely upon the recall of their parents for whether or not they had a blood transfusion. Self-reported methods cannot provide objective measures of fact, but are well suited for characterizing subjective outcomes like knowledge and awareness, which was the primary focus of this analysis. Similarly, although the cohort was not biochemically tested for HCV, participant self-report of HCV status still provides important information about knowledge, which may influence health behaviors. Since this study was cross-sectional in nature, temporality of associations cannot be inferred, so that we cannot know, for example, whether HCV testing preceded or followed a recent physician's discussion about HCV or a survivor's recall of blood transfusion history.

The relatively low level of awareness about HCV testing and transfusion history that is documented in this study constitutes a serious public health problem. As survivors age, the impact of undetected chronic HCV on health and quality of life is likely to worsen, given the progressive nature of the infection. The importance of knowing one's HCV status is underscored by the availability of clinical and behavioral strategies that can alter the disease course and minimize morbidity and mortality. Given the lack of understanding even among this relatively health conscious cohort of CCSS participants, there is an urgent need for interventions to educate and screen pediatric cancer survivors who may have undetected HCV following previous therapy-related blood transfusions. In conclusion, many pediatric cancer survivors at risk for transfusion-acquired HCV lack knowledge of their transfusion history and prior testing for HCV, and would benefit from public health programs to educate survivors and screen for this disease.

Acknowledgments

The **Childhood Cancer Survivor Study (CCSS)** is a collaborative, multi-institutional project, funded as a resource by the National Cancer Institute, of individuals who survived five or more years after diagnosis of childhood cancer. **CCSS** is a retrospectively ascertained cohort of 20,346 childhood cancer survivors diagnosed before age 21 between 1970 and 1986 and approximately 4,000 siblings of survivors, who serve as a control group. The cohort was assembled through the efforts of 26 participating clinical research centers in the United States and Canada. The

study is currently funded by a U24 resource grant (NCI grant # U24 CA55727) awarded to St. Jude Children's Research Hospital. Currently, we are in the process of expanding the cohort to include an additional 14,000 childhood cancer survivors diagnosed before age 21 between 1987 and 1999. For information on how to access and utilize the CCSS resource, visit www.stjude.org/ccss

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Table 1

Characteristics of survivors according to self-reported history of prior test for Hepatitis C virus (HCV)

Characteristics	Total	Self-Report of Prior Test for HCV					
		Yes		No		Not sure	
	N	N	%	N	%	N	%
All Survivors	9242	2652	29	3758	41	2832	31
Diagnosis							
Acute lymphoblastic leukemia	2717	920	34	995	37	802	30
Acute myeloid leukemia	233	103	44	58	25	72	31
Other leukemias	184	61	33	58	32	65	35
CNS tumor	1168	224	19	624	53	320	27
Kidney (Wilms)	862	240	28	364	42	258	30
Neuroblastoma	626	160	26	269	43	197	31
Soft tissue sarcoma	815	231	28	344	42	240	29
Bone cancer	759	225	30	298	39	236	31
Non-Hodgkin lymphoma	699	193	28	268	38	238	34
Hodgkin lymphoma	1177	295	25	479	41	403	34
Gender							
Female	4559	1339	29	1791	39	1429	31
Male	4682	1313	28	1966	42	1403	30
Race/Ethnicity							
White, non-Hispanic	7917	2238	28	3204	40	2475	31
Other	1325	414	31	554	42	357	27
Health Insurance							
No	1104	309	28	462	42	333	30
Yes or Canadian	8064	2330	29	3256	40	2478	31
Household Income							
< $20,000	2914	843	29	1191	41	880	30
≥ $20,000	6066	1742	29	2456	40	1868	31
Education							
High school or less	1920	512	27	850	44	558	29

Characteristics	Total	Self-Report of Prior Test for HCV					
		Yes		No		Not sure	
	N	N	%	N	%	N	%
Post-high school education	7202	2112	29	2858	40	2232	31
Age at Diagnosis (years)							
0–4	3756	1079	29	1566	42	1111	30
5–9	2060	628	30	801	39	631	31
10–14	1855	548	30	751	40	556	30
15–20	1570	397	25	639	41	534	34
Age at Interview (years)							
15–24	2063	613	30	832	40	618	30
25–34	4082	1234	30	1625	40	1223	30
≥ 35	3096	805	26	1300	42	991	32
Care at Cancer Center ≤ 2 y ago							
No	7943	2191	28	3359	42	2393	30
Yes	1298	461	36	399	31	438	34
Physician Discussed HCV ≤ 2 y ago							
No	7830	1998	26	3285	42	2547	33
Yes	519	444	86	44	8.5	31	6.0
Cancer Treatment Summary							
No	5758	1582	27	2471	43	1705	30
Yes	2286	820	36	815	36	651	28

Note: Total sample size for each variable may be less than 9242 due to missing values.

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Table 2

Percent reporting prior testing for HCV, by self-reported history of blood transfusion or other blood product [†]

Characteristics	Total (N=9168)	Self-Report of Blood Transfusion History					
		Transfusion[†] (N=4573)		No Transfusion (N=3081)		Unsure (N=1514)	
	N	% of total	% tested	% of total	% tested	% of total	% tested
All Survivors[*]	9168	50	39	34	18	17	20
Diagnosis							
Acute lymphoblastic leukemia	2691	69	41	19	18	12	21
Acute myeloid leukemia	231	84	46	8.2	47	7.4	18
Other leukemias	184	68	42	18	12	14	19
CNS tumor	1154	31	31	47	13	21	15
Kidney (Wilms)	858	42	39	32	19	26	21
Neuroblastoma	620	38	37	36	16	25	21
Soft tissue sarcoma	812	40	39	41	20	19	22
Bone cancer	756	56	38	31	20	13	19
Non-Hodgkin lymphoma	691	47	36	38	19	15	22
Hodgkin lymphoma	1170	31	40	56	19	13	16
Gender							
Female	4522	54	39	33	19	14	19
Male	4645	46	39	35	17	19	20
Race/Ethnicity							
White, non-Hispanic	7857	50	39	34	17	17	19
Other	1311	52	40	33	21	16	23
Health Insurance							
No	1093	49	35	29	18	22	25
Yes or Canadian	8002	50	40	34	18	16	19
Household Income							
< $20,000	2889	50	38	32	19	18	20
≥ $20,000	6020	50	39	34	18	16	19
Education							

Characteristics	Total (N=9168)	Self-Report of Blood Transfusion History					
		Transfusion† (N=4573)		No Transfusion (N=3081)		Unsure (N=1514)	
	N	% of total	% tested	% of total	% tested	% of total	% tested
High school or less	1906	49	37	33	16	19	20
Post-high school education	7142	50	40	34	18	16	20
Age at Diagnosis (years)							
0–4	3722	50	39	29	18	21	21
5–9	2033	52	40	30	19	17	20
10–14	1849	51	39	38	18	11	21
15–20	1563	46	37	43	17	11	12
Age at Interview (years)							
15–24	2041	54	40	28	17	18	20
25–34	4045	51	41	32	19	17	21
≥ 35	3081	46	36	39	18	15	17
Care at Cancer Center ≤ 2 y ago							
No	7875	48	37	34	18	18	20
Yes	1292	60	48	31	18	8.9	12
Physician Discussed HCV ≤ 2 y ago							
No	7770	48	34	35	17	16	18
Yes	515	81	90	11	66	7.8	72
Cancer Treatment Summary							
No	5713	48	37	36	18	16	20
Yes	2269	57	46	30	19	13	27

† Includes only blood transfusions due to cancer treatment

* Total (N=9168) excludes survivors who had a transfusion after 1993 for a non-cancer cause (n=74); subtotals within each category may be less than 9168 due to missing values

Table 3

Comparison of 9168 survivors reporting no prior HCV testing versus those reporting a prior test for HCV [†]

	Univariate Model[*]			Multivariate Model[*]		
Characteristics	**OR**	**95% CI**	**P-value**	**OR**	**95% CI**	**P-value**
Diagnosis						
Acute lymphoblastic leukemia	0.7	0.6 – 0.8	<0.001	1.0	0.8 – 1.2	0.715
Acute myeloid leukemia	0.4	0.3 – 0.6	<0.001	0.7	0.5 – 1.0	0.041
Other leukemias	0.7	0.5 – 1.0	0.021	1.0	0.7 – 1.4	0.808
CNS tumor	1.4	1.2 – 1.7	0.001	1.5	1.2 – 1.8	<0.001
Kidney (Wilms)	0.9	0.7 – 1.1	0.159	1.0	0.8 – 1.3	0.884
Neuroblastoma	1.0	0.8 – 1.2	0.818	1.1	0.9 – 1.5	0.372
Soft tissue sarcoma	0.9	0.7 – 1.0	0.103	0.9	0.7 – 1.1	0.378
Bone cancer	0.8	0.7 – 1.0	0.027	1.0	0.8 – 1.2	0.656
Non-Hodgkin lymphoma	0.9	0.7 – 1.1	0.224	1.0	0.8 – 1.3	0.830
Hodgkin lymphoma (referent)	1.0			1.0		
Gender						
Female (referent)	1.0					
Male	1.1	1.0 – 1.2	0.159			
Race/Ethnicity						
White, non-Hispanic (referent)	1.0			1.0		
Other	0.9	0.8 – 1.0	0.027	0.9	0.8 – 1.0	0.041
Health Insurance						
No	1.1	0.9 – 1.2	0.534			
Yes or Canadian (referent)	1.0					
Household Income						
< $20,000	1.0	0.9 – 1.1	0.836			
≥ $20,000 (referent)	1.0					
Education						
High school or less	1.1	1.0 – 1.3	0.022			
Post-high school education (referent)	1.0					
Age at Diagnosis (years)						

Characteristics	Univariate Model* OR	95% CI	P-value	Multivariate Model* OR	95% CI	P-value
0–4	0.8	0.7 – 1.0	0.011			
5–9	0.8	0.7 – 0.9	0.001			
10–14	0.8	0.7 – 0.9	0.006			
15–20 (referent)	1.0					
Age at Interview (years)						
Per 5-year increase	1.1	1.0 – 1.1	<0.001	1.1	1.0 – 1.1	0.006
Care at Cancer Center ≤ 2 y ago						
No	1.5	1.3 – 1.6	<0.001	1.2	1.0 – 1.4	0.012
Yes (referent)	1.0					
Cancer Treatment Summary						
No	1.5	1.3 – 1.6	<0.001	1.3	1.2 – 1.5	<0.001
Yes (referent)	1.0			1.0		
Transfusion History						
No transfusion	2.9	2.6 – 3.3	<0.001	2.6	2.3 – 3.0	<0.001
Responded unsure	2.6	2.3 – 3.0	<0.001	2.2	1.9 – 2.6	<0.001
Transfusion for cancer (referent)	1.0			1.0		

† Total (N=9168) excludes survivors who had a transfusion after 1993 for a non-cancer cause (n=74); “No prior testing” includes survivors who were uncertain about prior testing

* Models do not include “physician discussed HCV ≤ 2 y ago” because the strong association with “no prior testing” outcome may mask other associations

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