Risky Health Behavior Among Adolescents in the Childhood Cancer Survivor Study Cohort

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Objective To report the prevalence and comparison of cancer-linked health behaviors and identify risk factors associated with unhealthy behavior among adolescent siblings and cancer survivors. **Methods** The Child Health and Illness Profile—Adolescent Edition (CHIP—AE) was completed by 307 survivors and 97 sibling controls 14–20 years of age. **Results** Risky behavior ranged from 0.7% to 35.8% for survivors and 1.0% to 41.2% for siblings. Comparisons of sexual behavior, tobacco, alcohol, or illicit drug use utilizing continuous data revealed no differences between groups. Categorically, survivors were less likely to report past smokeless tobacco use or current use of beer/wine or binge drinking (p-values range from .01 to .04). Survivors with better mental health were at lower risk for poor behavioral outcomes. **Conclusions** Adolescent survivors engage in risky health behaviors at rates generally equivalent to their siblings. Aggressive health education efforts should be directed toward this high-risk population.

Key words adolescents; childhood cancer; risky health behavior; survivors.

Adolescence is a developmental period traditionally marked by experimentation with risky health behavior including drug and alcohol use, cigarette smoking, and unprotected sex. Research conducted among U.S. youth has demonstrated that adolescent engagement in risky behavior predicts poorer outcomes in young and middle adulthood, including substance abuse and dependence, academic and vocational underachievement, and poorer physical and mental health (Nebbitt, Lombe, Sander-Phillips, & Stokes, 2010; Park, Weaver, & Romer, 2010; Staton et al., 1999; Vaughan, Corbin, & Fromme, 2009). Establishing the prevalence and risk factors for unhealthy behavior is particularly important among high-risk populations, such as adolescents surviving childhood cancer, as these survivors are at significantly increased risk of relapse, second malignancy, and organ toxicity/compromise secondary to cancer treatment and genetic predisposition (Bhatia et al., 2003; Hudson et al., 2003; Oeffinger et al., 2006). Engagement in unhealthy behavior exacerbates these vulnerabilities and places this group at even further risk of experiencing adverse health outcomes later in life (Emmons, 2008; Emmons et al., 2002; van Leeuwen et al., 1995).

Despite the importance of abstaining from unhealthy behavior, survivors of childhood cancers engage in tobacco, illicit drug, and alcohol use in addition to risky sexual behavior; however, it is unclear if these rates differ from those of healthy teens, and research examining this issue has resulted in mixed findings (Clarke & Eiser, 2007). While some studies have reported that survivors smoke, consume alcohol, and use illicit drugs at rates lower than siblings (Tao et al., 1998), community controls (Larcombe, Mott, & Hunt, 2002; Tyc, Klosky, Lensing, Throckmorton-Belzer & Rai, 2005), or the U.S. population (Carpentier, Mullins, Elkins, & Wolfe-Christensen, 2008; Emmons et al., 2005), others have found no differences or increased risky health

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behavior among adolescents and young adults surviving childhood cancer (Haupt et al., 1992; Hollen, Hobbie, Donnangelo, Shannon, & Erickson, 2007; Troyer & Holmes, 1988). For example, Verrill, Schafer, Vannatta, & Noll (2000) found that adolescent survivors were just as likely as age- and race-matched classmate controls to smoke tobacco and drink alcohol but were less likely to use illicit drugs. Bauld, Toumbourou, Anderson, Coffey, and Olsson (2005) found that compared to age-matched controls, adolescent survivors were more likely to report pain reliever use for nonmedical purposes, whereas young adult survivors were more likely to report alcohol use. Differences in the reported prevalence of risky behavior among childhood cancer survivors may be attributed to variations across studies in regard to control group selection, definitions of health behavior/use, method of assessment, source of report, setting of data collection, or participant age/developmental level (Rabin & Politi, 2010; Stolley, Restrepo & Sharp, 2010; Thompson, Gerhardt, Miller, Vannatta, & Noll, 2009; Tyc, Lensing, Vukadinovich, & Hovell, 2009). As diagnostic and treatment parameters also affect the uptake of risky behavior (Emmons et al., 2002; Frobisher et al., 2010; Kahalley et al., 2010; Krull et al., 2010; Sundberg et al., 2011), sampling differences in regard to medical history must also be considered. Given these complexities, it is particularly important to identify the determinants of risky behavior in this high-risk group as health attitudes and behaviors developed during adolescence predict future behavior into adulthood.

While the priority in this literature has been to study behaviors associated with second malignancies, the cancer experience may also disrupt normative developmental processes resulting in maladaptive social outcomes. Evidence of threats to achieving developmentally-appropriate social outcomes were reported by Krull and colleagues (2010) who found higher externalizing behavior and social withdrawal among adolescent cancer survivors as compared to sibling controls. In turn, social withdrawal was associated with poorer health outcomes in adulthood such as obesity and physical inactivity, which are both linked to cancer onset (Tercyak & Tyc, 2006). As with healthy teens, peers of adolescents surviving cancer also directly influence behavioral decision-making in regard to cancer-promoting behaviors. For example, adolescent survivors who perceive positive value associated with tobacco use, such as being more accepted by peers (Tyc et al., 2006) or having friends who smoke (Klosky et al., 2010; Tyc, Klosky, Lensing, Throckmorton-Belzer, & Rai, 2009), are more likely to use tobacco.

Psychologically speaking, it is well recognized that mental and behavioral health is linked in typically developing adolescents (Galaif, Sussman, Newcomb & Locke, 2007; Wickrama & Wickrama, 2010). As survivors of childhood cancer are at-risk for poor psychological outcomes (Hobbie et al., 2000), and engagement in unhealthy behavior increases risk of cancer and treatment-related morbidity and mortality, understanding these relationships is necessary for the promotion of optimal health outcomes in this high-risk group. Young adult survivors of childhood cancer with higher levels of anxiety, depression, and somatization, for example, have been found to engage in greater alcohol consumption (Lown et al., 2008) whereas increased anxiety and sadness has been associated with illicit substance use (Schultz et al., 2010). Despite the modifiable (and bidirectional) nature of mental and behavioral health, these relationships have not been well studied among adolescent survivors of childhood cancer.

The purpose of this study is to estimate the prevalence of risky health behaviors among adolescent survivors of childhood cancer, to make behavioral health comparisons between survivors and their siblings, and to identify factors associated with poor behavioral health outcomes. To date, the few studies that have examined risk behavior among survivors of childhood cancer have focused on alcohol, cigarette, and illicit drug use in adulthood. This study adds to the literature by considering a relatively large sample of adolescents surviving childhood cancer while addressing the previously unstudied area of sexual risk behavior. Furthermore, this work expands the scope of the survivorship literature by examining alternative behaviors which do not contribute to cancer risk, but rather, may result in injury, disruption of social development, or undesirable peer interaction, which are all important quality of life features.

Methods

Participants

Participants for this Institutional Review Board-approved study were selected from the adolescent subset of the Childhood Cancer Survivor Study (CCSS) cohort, a large cohort of survivors, representative of childhood cancer survivors in the U.S. (Robison et al., 2009). Details of the study and participant characteristics have been previously reported elsewhere (Robison et al., 2002; 2009). Briefly, the cohort includes individuals who were treated for leukemia, lymphoma, central nervous system (CNS) malignancy, kidney cancer, neuroblastoma, malignant bone tumor, or soft tissue sarcoma at 26 institutions in the U.S. and Canada. To be eligible for the larger cohort, participants were diagnosed between 1970 and 1986, were less than 21 years of age at diagnosis, and had survived

at least 5 years post diagnosis. A random sample of survivor siblings was also invited to participate.

At the time of study recruitment, 702 survivors and 303 siblings aged 14–19 years met preliminary eligibility for this study based on age. Since only the youngest in the original CCSS cohort were considered for participation in this study, all survivors were between 0 and 3 years of age at diagnosis. With respect to demographic, diagnostic and treatment characteristics, survivors who were White, older, female, and from households with income $\geq$ $60,000 were more likely to participate as compared to survivor nonparticipants (ps range from $<.01$ to .03). Reasons for refusing participation or failing to return questionnaires were not collected. See Figure 1 for enrollment details.

Instrumentation

Adolescent risk-taking behaviors were assessed using the Child Health and Illness Profile—Adolescent Edition (CHIP—AE) (Starfield et al., 1994). The CHIP—AE is a 214-item self-report measure that evaluates teen health status in six domains: (a) Satisfaction, (b) Discomfort, (c) Resilience, (d) Risks, (e) Achievement, and (f) Disorders. Specific health behaviors were measured as part of this instrument and analyzed separately. These behaviors included tobacco use (i.e., cigarette, smokeless tobacco), alcohol consumption (i.e., beer/wine, hard liquor/mixed drinks, binge drinking), illicit drug use (i.e., marijuana, crack/cocaine), and sexual behaviors (e.g., history of sexual intercourse, age at first sexual intercourse, number of partners, methods of preventing pregnancy, and/or sexually transmitted infection). Tobacco use, alcohol consumption, and illicit drug use questions were assessed on a Likert-type scale from 1 to 5. The five response options were then collapsed into three mutually exclusive categories with scores of 1 (past week) and 2 (past month) forming the ''current use'' category (i.e., use within the past month), scores of 3 (past year) and 4 (more than a year ago) forming the ''past use'' category (i.e., previous, but not current use), and a score of 5 (never) forming the ''never used'' category (i.e., participants denied ever having used the substance). Measurement of sexual behavior included four items: (a) history of sexual intercourse; (b) age (in years) at first intercourse; (c) number of sexual partners; and (d) utilization of protection at last sexual intercourse, or more specifically, teens were asked to indicate whether any type of protection had been used by the participant or his/her partner during his/her last sexual intercourse to aid in the prevention of pregnancy or sexually transmitted infection.

The CHIP—AE Risk domain, which consists of 38 items, was utilized in the current analyses as well. This domain consists of three subdomains: (a) Individual Risk (18 items), (b) Threats to Achievement (15 items), and (c) Peer Influences (five items). The Individual Risk subdomain examines activities such as the utilization of protective equipment (e.g., seatbelts, helmets), illegal behavior (e.g. stealing/shop lifting, truancy), or high-risk behavior (e.g., accepting a dare, impaired driving, car racing) that have high potential to threaten individual development. The Threats to Achievement subdomain includes negative behaviors that threaten or interrupt normal social development, including conduct disordered behavior such as harming others and destruction of property. The Peer Influences subdomain measures involvement with peers who engage in risky health behaviors ranging from smoking and drug/alcohol use to being

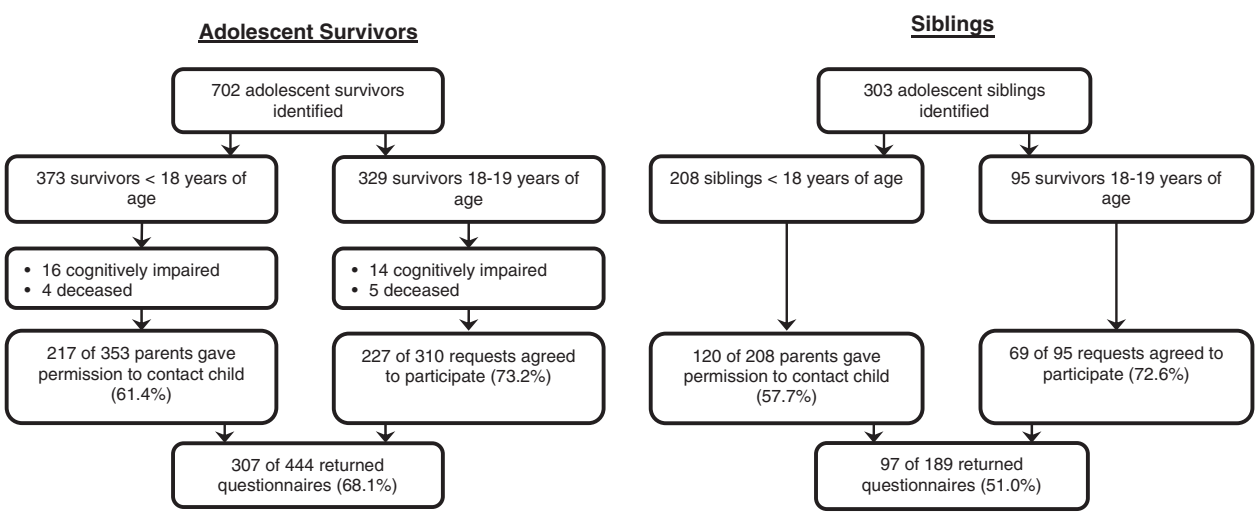

Figure 1. Flowchart depicting participant recruitment and questionnaire completion for adolescent survivors and siblings.

sexually active. Items in the Individual Risks and Threats to Achievement subdomains were scored on a Likert-type scale ranging from *1* to *5* with scores of 1 representing ''in the past week'' engagement in a behavior to scores of 5 representing ''never'' engaging in a behavior. Items on the Peer Influences subdomain are scored from *1* to *4* with scores of 1 indicating that ''all'' the participants' friends reportedly engaged in the stated risk behavior, and scores of 4 representing ''no'' friend participation. Higher scores indicate healthier or decreased risk behavior. Average health for both subdomain and domain scores was standardized at a score of 20 with a *SD* of 5. Those participants whose scores fell at or outside ±1.5 *SD* (e.g., scores falling at 27.5 or higher or 12.5 or lower) were dichotomized into a ''good'' outcomes group or a ''poor'' outcomes group. Internal reliabilities (Cronbach's α) for domain and subdomains ranged from .73 to .76 for Individual Risks, .80 to .81 for Threats to Achievement, .80 to .84 for Peer Influences, and .87 to .88 for the overall Risk domain across survivor and sibling groups. See Starfield et al. (1995 and 1996) for detailed information regarding the validity and other psychometric properties of the CHIP—AE.

To identify the characteristics which place survivors at increased risk for poor behavioral health outcomes, the influence of sociodemographic and treatment variables were also examined. Participant mental health was also included and measured via the Psychosocial Disorder subdomain score of the CHIP—AE. This subdomain queries emotional, mental or behavioral problems which may occur in adolescence. Respondents indicated whether they had (a) never had the problem, (b) previously had a problem but not within the past year, or (c) experienced the problem within the past year.

Analyses

Descriptive statistics were calculated for demographic, diagnostic, and treatment characteristics for survivors and siblings. Comparisons utilizing two sample *t*-tests and chi-square statistics (or Fisher's exact test) were initially conducted for demographic factors and later in regard to health behaviors. For each risk behavior outcome, univariate analyses of the independent variables were performed. Based on these findings, age and gender were included as covariates in subsequent analyses. The prevalence of risk behaviors was compared between survivors and siblings in age- and gender-adjusted generalized estimating equation (GEE) and generalized logit models (outcomes were treated as nominal variables in generalized logit models). To identify survivors most at-risk for a poor behavioral health outcome, sociodemographic, diagnostic, and treatment characteristics (including mental health) were then compared between survivors who did/did not fall in the overall ''poor behavioral health'' risk category in an age- and gender-adjusted logistic regression model. All the models in the analyses were converged. Akaike's Information Criterion (AIC) and Quasi-likelihood under the Independence Model Criterion (QIC) were used to evaluate relative goodness of fit for generalized logit models and GEE models, respectively. The Hosmer and Lemeshow test was used to test the goodness of fit for logistic regression models. The *C*-statistics were used as an indication of how well the logistic regression models discriminate between observations at different levels of the outcome (>0.7 indicate an acceptable discrimination). Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Results

Characteristics of the Study Population

Cancer survivor and sibling participants were similar with respect to gender, race, educational status, parental education, parental employment status, annual household income, health insurance status, and welfare, food stamp, and free lunch program status (Table I). However, survivors were, on average, 7 months older than their siblings at the time of participation (cancer survivor M age = 18.1 years, $SD = 1.0$, range: 15.4–20.4 years; sibling M age = 17.5 years, SD age = 1.4, range: 14.6–20.1 years; $p < .0001$). Based on this difference, age was considered as a covariate in further analyses.

Tobacco, Alcohol, Drug Use, and Sexual Behavior

The proportions of self-reported tobacco, illicit drug and alcohol use, and engagement in sexual behaviors for survivor and sibling groups are reported in Tables II and III. As can be seen in these tables, comparisons between groups identified few differences among survivors and siblings with respect to prevalence rates of risky health behaviors. Moreover, when continuous data were used to make age-adjusted comparisons between survivor and sibling groups in regard to tobacco, drug, alcohol, and sexual behavior variables (ranging from 1 ''never'' use to 5, use ''in the past week''), no significant differences were identified.

GEE regression and multinomial logistic regression models were also conducted to determine the OR for engaging in risky health behavior across groups (Tables III and IV). When analyzing these data in this fashion (controlling for age and gender), significant differences were observed in the areas of tobacco and alcohol use. Using ''never used'' as the reference, the likelihood for survivors

Table I. *Demographic, Diagnostic, and Treatment Characteristics of Adolescent Survivors of Childhood Cancer and Their Siblings*

	Survivors ($N = 307$) *n* (%)	Siblings ($N = 97$) *n* (%)	*p*-value
Gender			
Male	123 (40.07)	43 (44.33)	0.48
Female	184 (59.93)	54 (55.67)	
Age (years)			
14–17	129 (42.02)	58 (59.79)	<0.0001
18–20	178 (57.98)	39 (40.21)	
Race			
White	272 (88.60)	85 (87.63)	0.86
NonWhite	35 (11.40)	12 (12.37)	
Education status			
In school	178 (57.98)	60 (61.86)	0.34
Not in school	88 (28.66)	22 (22.68)	
Not indicated	41 (13.36)	15 (15.46)	
Parent education			
Did not complete high school	11 (3.58)	0 (0.0)	0.23
High school or some college	113 (36.81)	35 (36.08)	
College or higher	172 (56.03)	60 (61.86)	
Don't know	11 (3.58)	2 (2.06)	
Parent work status			
Employed	300 (97.72)	97 (100.0)	0.81
Unemployed	4 (1.30)	0 (0.0)	
Retired	2 (0.65)	0 (0.0)	
Student	1 (0.33)	0 (0.0)	
Household income			
<60,000/year	159 (51.79)	45 (46.39)	0.35
>60,000/year	145 (47.23)	52 (53.61)	
Unknown	3 (0.98)	0 (0.0)	
Insurance			
Yes	250 (81.43)	72 (74.22)	0.97
No	30 (9.77)	7 (7.22)	
Canadian resident	26 (8.47)	7 (7.22)	
Missing	1 (0.33)	11 (11.34)	
Receiving welfare			
No	291 (94.79)	96 (98.97)	0.24
Yes	5 (1.63)	0 (0.0)	
Don't know	11 (3.58)	1 (1.03)	
Receiving food stamps			
No	298 (97.07)	94 (96.91)	0.74
Yes	6 (1.95)	1 (1.03)	
Don't know	3 (0.98)	2 (2.16)	
Free lunch			
No	286 (93.16)	92 (94.85)	0.36
Yes	19 (6.19)	3 (3.09)	
Don't know	2 (0.65)	1 (1.03)	
Not indicated	0 (0.0)	1 (1.03)	
Age at diagnosis (years)			
0–1	198 (64.50)	–	–
2–3	109 (35.50)	–	
Time since diagnosis (years)			
<15	6 (1.95)	–	–
15–20	300 (97.72)	–	
>20	1 (0.33)	–	
Diagnosis			
CNS	40 (13.03)	–	–
Leukemia	95 (30.94)	–	
NonHodgkin's Lymphoma	4 (1.30)	–	
Wilms tumor	56 (18.24)	–	
Neuroblastoma	90 (29.32)	–	
Soft tissue sarcoma	19 (6.19)	–	
Bone cancer	3 (0.98)	–	
Treatment modalities			
Surgery only	41 (13.35)	–	–
Radiation therapy (no chemo)	11 (3.58)	–	
Chemotherapy + radiation	99 (32.25)	–	
Chemotherapy (no radiation)	144 (46.91)	–	
No chemo, surgery or radiation	2 (0.65)	–	
Unknown	10 (3.26)	–	
CNS treatment			
No CNS treatment	193 (62.87)	–	–
Any CNS treatment	114 (37.13)	–	

to have engaged in past smokeless tobacco use was .32 (95% CI: 0.11–0.92, $p = .03$) suggesting that adolescent survivors were less likely to have a history of smokeless tobacco use than siblings. Survivors were also less likely to be currently engaging in beer/wine consumption (OR = 0.50, CI: 0.29–0.86, $p = .01$) or binge drinking (OR = 0.53, CI: 0.29–0.97, $p = .04$) as compared to siblings. There were no differences across groups when assessing endorsement of ''past'' or ''current'' use compared to ''never'' use with respect to cigarette, marijuana, crack/cocaine use or risky sexual behaviors.

Individual Risks, Threats to Achievement, Peer Influences & Overall Behavioral Health

Differences in regard to individual risks, threats to achievement, peer influences, and overall risky health behaviors were also considered among adolescent survivor and sibling groups. After controlling for age and gender, no subdomain or overall Risk domain differences were observed (data not shown).

Multivariate logistic regression analyses were also conducted to explore demographic, diagnostic, treatment and mental health differences among adolescent cancer survivors categorized as having/not having a poor behavioral

Table II. *Tobacco, Drug and Alcohol Use Among Childhood Cancer Survivors and Their Siblings*

	Never *n* (%)		Past *n* (%)		Current *n* (%)		Unknown *n* (%)	
	Survivors	Siblings	Survivors	Siblings	Survivors	Siblings	Survivors	Siblings
Tobacco use								
Cigarette use	220 (71.66)	64 (65.98)	40 (13.03)	16 (16.49)	45 (14.66)	16 (16.49)	2 (0.65)	1 (1.03)
Smokeless tobacco	292 (95.11)	87 (89.69)	8 (2.61)	7 (7.22)	7 (2.28)	2 (2.06)	0 (0.00)	1 (1.03)
Alcohol consumption								
Beer/Wine	137 (44.63)	39 (40.21)	82 (26.71)	18 (18.56)	88 (28.66)	40 (41.24)	0 (0.00)	0 (0.00)
Hard liquor/Mixed drinks	167 (54.40)	45 (46.39)	65 (21.17)	25 (25.77)	73 (23.78)	27 (27.84)	2 (0.65)	0 (0.00)
Binge drinking	203 (66.12)	60 (61.86)	51 (16.61)	14 (14.43)	52 (16.94)	22 (22.68)	1 (0.33)	1 (1.03)
Illicit drugs								
Marijuana use	227 (73.94)	69 (71.13)	42 (13.68)	17 (17.53)	37 (12.05)	11 (11.34)	1 (0.33)	0 (0.00)
Cocaine/Ice/Crack use	299 (97.39)	93 (95.88)	5 (1.63)	3 (3.09)	2 (0.65)	1 (1.03)	1 (0.33)	0 (0.00)

Note. Cancer survivor $N = 307$, Sibling $N = 97$.

Table III. *Comparison of Risky Sexual Behaviors Among Childhood Cancer Survivors and Their Siblings controlling for Age and Gender*

Sexual behavior	Survivors (%)	Siblings (%)	OR (Survivor vs. Sibling) (95% CI)	*p*-value (GEE model)
Engaged in sexual intercourse				
Yes (Outcome)	110 (35.83)	30 (30.93)	0.90 (0.53–1.53)	0.69
No	195 (63.52)	67 (69.07)		
Missing	2 (0.65)	0 (0.00)		
Of those sexually active				
Age at first sexual intercourse (years)				
<16 (Outcome)	38 (34.55)	8 (26.67)	1.56 (0.59–4.10)	0.37
≥16	72 (65.45)	21 (70.00)		
Missing	0 (0.00)	1 (3.33)		
Number of opposite sex partners				
1 (Outcome)	43 (39.09)	11 (36.70)	0.89 (0.43–1.83)	0.74
2 or more	64 (58.18)	19 (63.30)		
Missing	3 (2.73)	0 (0.00)		
Used method to prevent pregnancy or STD at last intercourse				
Yes (Outcome)	97 (88.18)	27 (90.00)	0.99 (0.26–3.74)	0.98
No	11 (10.00)	3 (10.00)		
Missing	2 (1.82)	0 (0.00)		

Note. Cancer survivor $N = 307$, Sibling $N = 97$.

health outcome based on the overall Risk domain score of the CHIP—AE (Table V). Twenty-three (or 7.5%) of the survivors were classified as having a poor overall behavioral health outcome. Results indicated that survivors who reported better mental health were less likely to have a poor overall behavioral health outcome (OR = 0.24, CI: 0.13–0.43, $p = .0001$). There were no differences based on gender, race, age, annual household income, age at diagnosis, diagnosis, or history of CNS directed treatment. ORs were also examined to determine whether mental health was influential in regard to specific Risk subdomains. In age and gender adjusted models (data not provided), survivors with higher mental health scores were less likely to be experiencing poor outcomes in regard to individual health risks (OR = 0.56, CI: 0.35–0.90, $p = .02$), threats to achievement/social development (OR = .27, CI: .16–.47, $p < .0001$), and peer influences (OR = 0.41, CI: 0.25–0.66, $p = .0003$) associated with risky behavioral engagement.

Discussion

Despite the important role that behavior can play in the expression of cancer, these data suggest that adolescent

Table IV. *Comparison of Risky Health Behavior Among Childhood Cancer Survivors and Their Siblings Controlling for Age and Gender*

	(Survivor vs. Sibling/ Past vs. Never)		(Survivor vs. Sibling/ Current vs. Never)	
	OR (95% CI)	*p*-value	OR (95% CI)	*p*-value
Tobacco use				
Cigarette use	0.59 (0.30–1.14)	0.12	0.73 (0.38–1.41)	0.35
Smokeless tobacco	0.32 (0.11–0.92)	0.03	1.06 (0.21–5.42)	0.95
Alcohol consumption				
Beer/Wine	1.27 (0.67–2.42)	0.47	0.50 (0.29–0.86)	0.01
Hard liquor/Mixed drinks	0.61 (0.34–1.10)	0.10	0.56 (0.31–1.00)	0.05
Binge drinking	0.89 (0.45–1.76)	0.74	0.53 (0.29–0.97)	0.04
Illicit drugs				
Marijuana use	0.58 (0.30–1.11)	0.10	0.92 (0.44–1.95)	0.83
Cocaine/Ice/Crack use	0.42 (0.10–1.82)	0.25	0.52 (0.05–6.06)	0.60

Note. Cancer survivor $N = 307$, Sibling $N = 97$.

Table V. *Demographic, Diagnostic, and Treatment Differences Among Adolescent Survivors of Childhood Cancer With a Poor Overall Behavioral Health Outcome*

	N (%)	OR (95% CI)	*p*-value
Gender			
Male	12 (9.76)	1.00	
Female	11 (5.98)	0.67 (0.25–1.79)	0.43
Race			
White	18 (6.62)	1.00	
NonWhite	5 (14.29)	2.07 (0.55–7.83)	0.29
Age (years)			
15–17	8 (6.20)	1.00	
18–20	15 (8.43)	1.10 (0.36–3.37)	0.87
Age at diagnosis (years)			
0–1	12 (6.06)	1.00	
2–3	11 (10.09)	1.12 (0.34–3.71)	0.85
Diagnosis			
Leukemia	10 (10.53)	1.00	
Neuroblastoma	5 (5.56)	0.24 (0.04–1.50)	0.13
Other	8 (6.56)	0.36 (0.08–1.58)	0.18
CNS treatment			
No CNS treatment	13 (6.74)	1.00	
Any CNS treatment	10 (8.77)	0.30 (0.07–1.26)	0.10
Household income			
<60,000/year	17 (8.72)	1.00	
60,000+/year	5 (4.59)	0.56 (0.19–1.68)	0.30
Mental health score			
Mean	– (4.57)	0.24 (0.13–0.43)	0.0001
SD	– (0.67)		

Note. Cancer survivors $N = 307$. Cancer survivors categorized as having a Poor Overall Behavioral Health Outcome, $n = 23$.

survivors of childhood cancer are, in general, engaging in risky behaviors at rates similar to those of their healthy siblings. Adolescents with a cancer history are already at high risk for developing late health complications, including second cancers and these risks are exacerbated by engagement in risky behaviors such as the use of tobacco and/or illicit drugs. The direct relationship between tobacco and cancer risk has been well established, but less known are the relationships between marijuana use and prostate, cervical, and lung cancers, in addition to head and neck squamous cell carcinomas and gliomas (Aldington et al., 2008; Efird et al., 2004; Feng et al., 2009; Hsairi et al., 1993; Sidney et al., 1997; Zhang et al., 1999). Outside of the immediate context of cancer, antineoplastic therapies are often associated with cardiopulmonary toxicities and organ compromise which can be exacerbated by smoking and inhaled illicit drug use, resulting in adverse health complications and significantly reduced quality of life outcomes among these survivors.

The results of this study are broadly congruent with contemporary reports of risky health behavior among survivors of childhood cancer and are consistent with what would be expected based on developmental trends. Shultz and colleagues (2010) reported rates of current tobacco, marijuana, and alcohol use among young adolescent (M age = 14.3 years) and young adult (M age = 24.4 years) survivors of childhood leukemia. Current use (defined as occurring within the last 30 days) of tobacco, marijuana, and alcohol consumption was reported to be 11%, 3%, and 16% for young adolescents, and 26%, 10%, and 63% for young adults, respectively. Among the older adolescent survivors in our study (M age = 18.1 years), rates of current smoking (15%) and drinking (28%) fell in between those of the younger and older groups described by Schultz and colleagues (2010), and fall within developmentally expected ranges based on typical expression of risky behaviors among adolescents. Although current marijuana use (12%) was slightly higher in our older adolescents, as compared to the young adults (10%), these

values were in generally in the expected range and may differ due to method of data collection (paper-and-pencil questionnaire vs. telephone interview). Consistent with our findings, other recently published reports which compare risky health behaviors among childhood cancer survivors and controls also report generally null findings (Phillips-Salimi, Lommel, & Andrykowski, 2012; Thompson et al., 2009), suggesting that survivors should not be presumed to be at lower risk for engagement in risky health behavior based on their vulnerable health profile.

Concern associated with cancer-linked behavior extends beyond tobacco and illicit drug use to alcohol consumption. Alcohol use among survivors of adult malignancy has been directly linked to second aerodigestive cancers, including cancer of the larynx, pharynx, and oral cavity (Day et al., 1994). A majority of adolescent survivors in the current study reported a history of consuming alcohol either currently or in the past (55.4%), with 33.5% reporting either current or past binge drinking. Although survivors appear to be currently engaging in alcohol use at rates lower than their siblings (Lown et al., 2008), the impact that alcohol (and illicit drug use) has on impaired decision-making must not be discounted, particularly among a population that is already at risk for cognitive decline secondary to cancer therapy. The American Cancer Society (ACS) recommends that alcohol should be limited to no more than two drinks per day for men and one drink per day for women (ACS, 2011). Compliance with this recommendation has been complicated in that low/moderate alcohol use has been associated with decreased risk of heart disease, an observed late effect of cancer therapy. However, more effective ways of lowering cardiac risk exist including avoidance of tobacco and maintaining an active/healthy lifestyle, along with controlling blood pressure and cholesterol (ACS, 2011). As such, survivors who do not drink alcohol should not start, and those who do drink should limit their alcohol consumption.

The decisions that an adolescent makes to engage/not engage in key behaviors over time will affect his/her later outcomes, and impaired decision-making may result in particularly adverse outcomes. Adolescents engaging in illegal drug and alcohol use, for example, are at immediate risk for impaired driving, high-risk sex/sexual assault, unintentional injury, self-harm, and suicide, in addition to more long term problems including poor social, academic, and vocational outcomes (e.g., Deliberto & Nock, 2008; Draus, Santos, Franklin, & Foley, 2008; Sutherland & Shepherd, 2001). No significant differences were noted across adolescent groups in regard to peer influence, threats to achievement, and individual health subdomains. This suggests that survivors are not immune to the social and environmental threats experienced by teens in general, and should be appropriately educated and monitored to maximize healthy outcomes.

With the discovery that HPV (human papillomavirus; the most common sexually transmitted infection worldwide) causes cervical and other cancers, risky sexual behavior has recently been highlighted as an important health behavior that has distinct implications for childhood cancer survivors. As survivors are at risk for altered immunity (particularly those treated with hematopoietic stem cell transplantation or pelvic irradiation, or those diagnosed with Hodgkin's lymphoma), they are at relatively higher risk for HPV-related complication secondary to infection (Klosky et al., 2009). Fortunately, two HPV vaccinations have recently been FDA-approved in the United States, and the *Children's Oncology Group's Long-Term Follow-Up Guidelines for Survivors of Childhood, Adolescent and Young Adult Cancer Version 3.0* has recommended HPV vaccination for all eligible females surviving childhood cancer (American Academy of Pediatrics Section on Hematology/Oncology Children's Oncology Group, 2009). Although it is encouraging that 88% of sexually active survivors reported use of a method to prevent pregnancy or STI at last intercourse, HPV is transmitted via skin-to-skin contact (e.g. digital/genital, oral/genital, or genital/genital contact), suggesting that all sexually active survivors are at risk for infection regardless of whether standard methods of protecting against pregnancy and/or STI are utilized. Furthermore, future studies should distinctly measure behaviors associated with pregnancy and STI as differences may exist based on the teen's prioritized preventative outcome.

When one considers mechanisms driving health behavior in adolescent survivors, the results of this study suggest that mental health may be particularly influential. Previously, Cox and colleagues (2006) identified direct relationships between anxiety and cigarette and alcohol use among adolescent survivors of childhood cancer, whereas Krull and colleagues (2010) found that adolescent depression predicted physical inactivity in adulthood. These findings, in part, suggest that psychological health in adolescence impacts both short and long term behavioral health outcomes among survivors. Given that health behaviors are particularly resistant to change, and empirically supported mental health interventions are available, our findings indicate that psychological intervention could be considered as a potentially useful tool in the reduction of risky/promotion of positive health behavior in this high-risk group. Future studies examining the efficacy of these interventions on behavioral health outcomes among

adolescents on-treatment or surviving cancer are warranted.

The findings of this work must be considered within the context of its limitations. Although this is the largest study to date to report on health behaviors among adolescent survivors of childhood cancer, the design is cross-sectional, relies on self-report, and includes participants diagnosed between the ages of 0 and 3 years only. While issues regarding the generalizability of the sample secondary to the participation rate are noted, the demographic comparisons between survivors and siblings participants were nonsignificant with the exception of age, which was controlled for in the study analyses. Rates of participation were presumably suboptimal due to the method of participant enrollment. Yet, this approach may have had its advantages, particularly in regard to the reporting of risky health behaviors. When behavioral health questionnaires are administered to adolescents in the medical clinic setting (as has been the methodology used in the majority of these studies), the validity of behavioral self-report has been questioned (Horm, Cynamon & Thornberry, 1996; Griesler, Kandel, Schaffran, Hu, & Davies, 2008). It has been suggested, for example, that that adolescent survivors could be motivated to under-report illegal and cancer-promoting behaviors in the presence of his/her parents and/or the medical team who previously cured the patient's cancer (Kann, Brener, Warren, Collins & Giovino, 2002; Patrick, Cheadle, Thompson, Diehr, Koepsell & Kinne, 1994; Velicer, Prochaska, Rossi & Snow, 1992). The increased anonymity associated with questionnaire completion in this study (e.g., private participation at home, questionnaire completion outside the presence of parents, clinical staff and/or study personal, relative anonymity) may have assisted in the disclosure of more normative rates of risky behavior among our adolescent participants. Although bioverification (gold standard) of cigarette/drug/alcohol use was not utilized in this study, differences in data collection methods could have contributed to the variation in survivor-reported risky health behavior in this study as compared to others in the past.

Another study component that must be considered is whether siblings of childhood cancer survivors represent an appropriate control group as compared to the reported population-based norms of risky health behavior among U.S. adolescents. Sibling controls have commonly been utilized as a comparison group when examining health behavior outcomes among childhood cancer survivors (e.g., Buchanan et al., 2009; Krull et al., 2010; Molgaard-Hansen et al., 2011; Recklitis, Sanchez Varela, Hg, Mauch, & Bober, 2010), and this approach has consistently been considered valid given the advantages of controlling for potential confounds/covariates such as living environment and access to resources which promote better health outcomes (e.g., higher education and health care). Although advantages for utilizing sibling controls exist, it could be hypothesized that siblings of childhood cancer survivors represent a unique group as a function of having experienced their sibling's cancer diagnosis and treatment. As such, it is reasonable to question whether sibling rates of risky health behavior differ from the general adolescent U.S. population subsequent to their familial cancer experience. In efforts to explore this issue further, prevalence rates for risky health behaviors among siblings, as reported in this study, were compared to national samples (e.g., CDC 2010a). Within this study, 16.5% of siblings reported current cigarette use, which is generally consistent with the 17.5% of U.S. high school students who report current cigarette use (CDC 2010a). While siblings reported slightly lower rates of having ever engaged in sexual intercourse as compared to national norms, similar rates of utilizing protection against pregnancy/sexually transmitted infections were reported (90.0% in siblings vs. 83.0% among U.S. population peers; CDC 2010b). With respect to alcohol, siblings reported rates of current use (41.2%) and binge drinking (22.7%) that are similar to high school students across the U.S. (current alcohol use: 42.0%, binge drinking: 24.2%; CDC 2010c). As reported, these comparisons suggest that siblings of childhood cancer survivors generally engage in risky health behaviors at rates similar to adolescents nationwide. This evidence adds further support to the appropriateness of sibling comparison groups in the study of behavioral health outcomes.

Overall, the results of this study suggest that adolescent survivors of childhood cancer are engaging in risky health behaviors at rates equivalent to those of their siblings. Engagement in behaviors associated with second cancers is concerning, particularly among survivors who have a demonstrated predisposition for malignancy. Interventions designed to promote positive health behaviors/decrease risky behaviors are warranted in both survivors and siblings, particularly as behavior change is one of the few modifiable areas in which one can reduce cancer risk. It is also important that screening and delivery of preventions/interventions occur early during adolescence, regardless of medical background, so that unhealthy behaviors do not become habitual and extend into adulthood. As direct associations between mental health and risky behaviors were revealed, psychological interventions may be one avenue to behavioral health in adolescence, particularly when patients are resistant to reporting/discussing risky health behavior. As such, clinicians are urged to screen adolescent survivors to increase the likelihood that

appropriate intervention (behavioral and/or psychological) can be delivered, when necessary, in this high-risk population. Attention to these pathways to health should improve late outcomes and quality of life among adolescent survivors of childhood cancer.

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