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## Risk Factors for Smoking among Adolescent Survivors of Childhood Cancer: A Report from the Childhood Cancer Survivor Study

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### Abstract

**Background**—Few studies have examined risk factors for smoking among adolescent survivors of childhood cancer. The present study reports on the rate of smoking and identifies factors associated with smoking in a sample of adolescent survivors from the Childhood Cancer Survivor Study (CCSS).

**Procedure**—Participants included 307 adolescent survivors and 97 healthy siblings (ages 14–20) who completed a self-report survey of health, quality of life, and health behaviors.

**Results**—Smoking rates did not differ significantly between survivor and sibling groups (Ever Smokers: 28% vs. 33%, Recent Smokers: 10% vs. 9%, respectively). Ever smoking was significantly associated with peer smoking, smokers in the household, bingeing, suicidal behavior, and no history of CRT. There were significant interactions of peer smoking with gender and CRT for ever smoking and with bingeing for recent smoking. Recent smoking was more likely for survivors with other household smokers (RR=2.24, CI=1.21–4.16), past suicidality (RR=1.89,

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CI=1.00-3.56), and no CRT (RR=2.40, CI=1.12-5.17). Among survivors with few smoking friends, ever smoking was more likely for survivors with no CRT (RR=4.47, CI=1.43-13.9), and recent smoking was more likely among survivors who binged (RR=3.37, CI=1.17-9.71).

**Conclusions**—Despite the health risks associated with survivorship, nearly one in three adolescent survivors of childhood cancer has smoked. Exposure to other smokers, in particular, appears to increase the likelihood of smoking for some survivors. Providing smoking cessation programs targeted to family members, helping survivors choose nonsmoking friends, and teaching ways to resist smoking influences from peers may be important pathways for smoking prevention with adolescent survivors.

### Keywords

adolescents; childhood cancer; survivors; smoking

## INTRODUCTION

After treatment, long-term survivors of childhood cancer suffer an increased risk of mortality that is significantly higher than that of the general population including excess mortality from subsequent cancers, cardiac, and pulmonary causes [1,2]. Notably, cigarette smoking and survivorship share many of the same medical risks, including an increased risk for the development of cancers [2,3] and cardiovascular and pulmonary diseases [2-5], including stroke [3,6]. Since smoking appears to be even more dangerous for individuals with existing cardiovascular risk factors [7], tobacco use has the potential to be more hazardous for survivors, making it a primary focus for prevention within this growing population [8].

Adolescent survivors of childhood cancer assume the weighty responsibility of making healthy choices to maintain good health and reduce the risk of cancer-related health complications. Since most smokers try their first cigarette in their teens [9], smoking prevention must target survivors before and during adolescence. Experimenting with cigarettes may be a developmentally typical experience for many healthy teens, but such behavior bears greater consequence for survivors given their medical vulnerability. The current rate of smoking among adolescent survivors (i.e., those under the age of 20 years) of childhood cancer remains somewhat unclear. Estimates based on self-reported tobacco use vary broadly across studies, ranging from 13-53% for ever smoking [10-15] and 4-14% for current smoking [10,12,14].

Most smoking research with adolescent survivors has focused on the intention to smoke as the primary outcome. Having intentions to smoke in the future has been associated with older age, previous smoking experience, parental smoking, less knowledge about smoking risks, more favorable smoking beliefs, and aggressive behavior [10,14-16]. Less is known about the factors associated with smoking itself during adolescence. Many of the same variables associated with smoking in healthy subjects are associated with smoking in samples of *adult* survivors of childhood cancer, including lower income [17], less education [17-19], older age [18-20], and Caucasian race [17,19]. We only identified one study that reported specific risk factors for smoking with *adolescent* survivors [15]: experimentation with cigarettes was associated with older age and parental divorce in a cohort of adolescents post-treatment for acute lymphoblastic leukemia and brain tumor.

Even though the smoking behavior of adolescent survivors is understudied, smoking during adolescence has been linked to the subsequent smoking habits of adult survivors of childhood cancer. In a British sample of adult survivors, more than half of the current smokers reported starting to smoke by the age of 16, while 88% started by the age of 20

[21]. Younger age at smoking initiation (before age 14) was found to be predictive of continued smoking in adulthood among survivors in the US [17]. As such, adolescent survivors appear to represent a critical target population for smoking prevention efforts. Identification of the characteristics associated with smoking in adolescence is essential to assist clinicians in screening for those survivors at greatest risk and to identify factors that can be targeted in interventions to promote healthier decision-making during adolescence and beyond.

The goals of this study were to describe the smoking rates of adolescent survivors from the Childhood Cancer Survivor Study (CCSS) compared to a healthy sibling control group and to identify risk factors associated with survivor smoking. In particular, we examined other health behaviors that are associated with smoking among healthy teens and young adults in the general population but have not been examined in survivor populations (e.g., inactivity [22,23], eating disordered behaviors [24-26]). Other psychosocial risk factors associated with smoking among healthy adolescents were also explored, including peer and family smoking [27-29] and indicators of psychological distress [30]. Associations between smoking and demographic and medical variables were also examined in this adolescent survivor sample.

## METHODS

The CCSS is a large, multi-institutional study that examines long-term outcomes following childhood cancer and treatment. Participants in the original CCSS cohort were treated for childhood cancer at 26 clinical centers in the US and Canada and met the following eligibility criteria: (a) diagnosis of leukemia, central nervous system malignancy, Hodgkin disease, non-Hodgkin lymphoma, neuroblastoma, soft tissue sarcoma, kidney cancer, or bone cancer, (b) diagnosed from 1970-1986, (c) < 21 years of age at diagnosis, (d) alive 5 years post-diagnosis, (e) English or Spanish speaking, and (f) resident of the United States or Canada. CCSS baseline surveys were distributed beginning in 1994. Detailed disease and treatment information was abstracted from medical records at each participating clinical center. More details about the CCSS study design and cohort characteristics are published elsewhere [31,32].

### Participants

The current study examined data from a subset of adolescent survivors in the CCSS cohort. CCSS participants who were 15-19 years of age were eligible to complete a supplemental questionnaire, the CCSS Teen Health Survey (THS), distributed between 2001-2005. Of the 702 adolescent survivors, parental consent was obtained for 444 to receive the CCSS THS, and 307 (69%) surveys were completed and returned. When compared to non-respondents, participants were significantly more likely to complete the CCSS THS if they were female, white, higher income, and younger at diagnosis (data not shown). The CCSS sibling cohort consists of a randomly selected group of siblings of survivors. 303 siblings in the same age range (15-19) were also invited to complete the CCSS THS; 189 consented, and 97 (51.3%) participated. Due to delays in consenting and returning measures, the current report includes 3 adolescent survivors and siblings who turned 20 years of age between contact and submission of the questionnaire data.

### Measures

Items relevant to the present research objectives were selected for analysis from the CCSS THS, which was mailed to the survivor (or sibling), completed in the home, and returned by mail. The questionnaire included 108 items from the Child Health and Illness Profile-Adolescent Edition (CHIP-AE) [33]. The CHIP-AE is a self-report measure of adolescent

health and quality of life. Adequate reliability and validity of the CHIP-AE were demonstrated through testing with diverse samples of adolescents from urban and rural areas [34]. The measure was able to discriminate among healthy, acutely ill, and chronically ill adolescents [35]. Demographic and clinical data were available for analyses from the CCSS baseline survey and medical record abstractions. The following variables were derived from CHIP-AE items and subdomains.

**Smoking**—Participants rated the last time they smoked a cigarette on a 5-point scale (never, more than a year ago, in the past year, in the past month, in the past week). For our analyses, two smoking variables were derived from this item. Participants were categorized as “Never Smokers” if they responded that they *never* smoked a cigarette, while all others were categorized as “Ever Smokers.” Participants who endorsed smoking *in the past week* were categorized as “Recent Smokers,” while all others were categorized as “Non-Smokers.”

**Peer Smoking**—Participants reported on how many of their friends smoke cigarettes (*None, Some, Most, All*). A dichotomous Peer Smoking variable was derived due to the restricted variability across responses in this sample. Due to the low frequency of the *None* response on this item (i.e., only four ever smokers and one recent smoker reported having no smoking friends), responses of *None* or *Some* friends who smoke were categorized as having “few” smoking friends while responses of *Most* or *All* friends who smoke were categorized as “many” smokers in the peer network.

**Household Smoking**—Participants reported whether anyone else in the household smokes cigarettes. This item produced a dichotomous variable (Yes, No).

**Binge Eating**—Participants reported the number of times they engaged in binge eating over the past 12 months. This item was dichotomized to identify participants who had ever (versus never) engaged in binge eating in the past year.

**Purging**—Participants reported the number of times they had vomited on purpose to lose weight over the past 12 months. This item was dichotomized to identify participants who had ever (versus never) engaged in intentional purging behavior in the past year.

**Physical Inactivity**—Participants reported on their involvement in physical activity of several types, including hard exercise, sit-ups, walking, running, and team sports. These 5 items combine to produce the CHIP-AE Physical Activity subdomain. Using these subdomain scores, a dichotomous classification of Physical Inactivity was produced. Participants were categorized as being “physically inactive” based on Physical Activity subdomain scores that were less than the mean score of the lowest 10% (least active) of participants in the sibling comparison group. All other survivors were categorized as being “physically active.”

**Emotional Discomfort**—Participants reported on their experience of various symptoms of emotional distress (e.g., feeling depressed or blue, nervous or uptight, afraid of things). These 14 items combine to produce the CHIP-AE Emotional Comfort subdomain. From these subdomain scores, we created a dichotomous classification of Emotional Discomfort. Participants were classified as having “emotional discomfort” based on Emotional Comfort subdomain scores that were less than the mean score of the lowest 10% (most emotionally distressed) participants in the sibling comparison group. All other survivors were categorized as not having “emotional discomfort.”

**Suicidal Behavior**—Participants reported on whether they had attempted to seriously hurt or kill themselves in the past. This item was dichotomized to identify participants who had ever (versus never) engaged in suicidal behavior.

### Data Analyses

Smoking rates were compared between survivors and siblings, using generalized linear modeling adjusting for gender, age, and intra-family correlation. Multivariable generalized linear models were used to examine relationships between our dependent measures (Ever Smoker vs. Never Smoker; Current Smoker vs. Non-Smoker) and our primary predictors and covariates. Because smoking was a relatively common outcome (~28%) for our cohort, relative risks (RR) were calculated directly based on a generalized linear model with a log link function and Poisson distribution with robust error variances [36]. Univariate associations with smoking variables were examined first. Variables significantly associated with either dependent variable at the univariate level of analysis or those determined *a priori* (e.g. age, gender) were evaluated in the multivariable models. For each dependent measure, final multivariable models were developed to include all significant demographic, medical, and health behavior predictor terms. Two-way interactions were assessed for each model. Due to the small sample size and number of covariates, variables were retained at a significance level of 0.10. Age and gender were retained in all models even when non-significant due to the well established associations of these variables with smoking behavior. RRs and 95% confidence intervals (CI), and two-sided p-values are reported.

## RESULTS

### Smoking among Adolescent Survivors and Sibling Controls

Characteristics of smokers from the adolescent survivor sample are reported in Table I. Ever smoking was reported by 28% and recent smoking by 10% of adolescent survivors. Smoking rates were similar for healthy siblings, with 33% reporting ever smoking and 9% reporting recent smoking. No differences were identified between adolescent survivors and siblings on RRs of ever smoking and recent smoking, adjusted for age and gender (Table II).

### Ever Smoking among Adolescent Survivors

Associations of ever smoking with demographic and clinical characteristics as well as behavioral and psychosocial factors listed in Table I were evaluated among survivors. In univariate analyses, ever smoking was significantly associated with purging (RR = 2.49, 95% CI: 1.60-3.88,  $p < 0.001$ ), bingeing (RR = 1.57, 95% CI: 1.08-2.31  $p < 0.05$ ), suicidal behavior (RR = 2.12, 95% CI: 1.47-3.07  $p < 0.001$ ), peer smoking (RR = 3.21, 95% CI: 2.35-4.38  $p < 0.001$ ), having smokers in the household (RR = 1.73, 95% CI: 1.22-2.46  $p < 0.01$ ), and having no history of cranial radiation therapy (CRT; RR = 1.92, 95% CI: 1.05-3.45,  $p < 0.05$ ). A multivariable regression model, adjusted for age and gender, included all variables significantly associated with ever smoking in univariate analyses (Table III). When peer smoking was added to the model, most associations were no longer significant and there were significant interactions for peer smoking with both gender and CRT variables. As a result, the effects of gender and CRT were stratified by peer smoking. Among those with few smoking friends, survivors without a history of CRT were 4 times more likely to report ever smoking than those treated with CRT. Among those with many smoking friends, there was a suggestion that males were more likely to have ever smoked compared to females ( $p=0.057$ ).

## Recent Smoking among Adolescent Survivors

Similar analyses examined associations for recent smoking with demographic, clinical, behavioral, and psychosocial characteristics. Univariate analyses identified significant associations between recent smoking and purging (RR = 4.44, 95% CI: 2.08-9.50  $p < 0.001$ ), bingeing (RR = 2.55, 95% CI: 1.32-4.90  $p < 0.01$ ), suicidal behavior (RR = 3.61, 95% CI: 1.89-6.89  $p < 0.001$ ), emotional discomfort (RR = 2.75, 95% CI: 1.38-5.49  $p < 0.01$ ), peer smoking (RR = 7.18, 95% CI: 3.85-13.40  $p < 0.001$ ), and having smokers in the household (RR = 3.03, 95% CI: 1.58-5.82  $p < 0.01$ ). A multivariable regression model examined variables significantly associated with recent smoking in univariate analyses, adjusting for age and gender (Table IV). Emotional discomfort was excluded from the final model due to collinearity with eating disorder. History of CRT was also included, although non-significant in univariate analyses with recent smoking, given the significant association found with ever smoking. Several significant associations emerged, including an interaction between binge eating and peer smoking. Among those with few smoking friends, recent smoking was more likely among binge eaters compared to non-bingers. Recent smoking was also associated with suicidal behavior, having smokers in the household, and having no history of CRT.

## DISCUSSION

A striking number of adolescent cancer survivors smoke cigarettes despite the medical risks associated with cancer and treatment. With nearly 1 in 3 reporting ever smoking and 1 in 10 reporting smoking within the last week, a concerning minority of adolescent survivors appears to be making risky health behavior decisions. Previous studies of smoking rates in this age range of survivors have relied upon small samples, yielding notable variability in smoking rates reported across studies [10-15]. Based on the large sample employed here, present findings indicate that smoking, indeed, is a significant and relevant concern for survivors of childhood cancer during adolescence. Importantly, no difference was identified in smoking rates between adolescent survivors and sibling controls, suggesting that a cancer history alone does not appear to dissuade some survivors from trying cigarettes.

The presence of smokers in the social environment emerged as one of the strongest correlates of smoking by adolescent survivors, consistent with findings among healthy adolescents [27-29]. We found that males with many friends who smoke appear to be susceptible to experimenting with cigarettes. Having other smokers in the home doubled the risk for recent smoking for both male and female survivors. These findings have important implications for prevention and intervention efforts. Smokers in the environment may influence survivors' smoking through various mechanisms (e.g., increased availability of cigarettes and opportunities for experimentation, social modeling, normalizing smoking behavior). Helping family members quit smoking once a child is diagnosed with cancer could be an essential avenue to promoting the child's long-term survival by decreasing the likelihood that he or she will become a smoker post-treatment. It seems more challenging to directly modify smoking within a survivor's peer network; however, prevention efforts may focus on helping survivors understand their unique medical risks (as compared to their healthy peers), choose friends who make healthy choices, resist pressures to join friends in smoking behavior, and find alternative ways to meet the needs that a cigarette's instrumental value may offer.

Consistent with findings among adult survivors of childhood cancer [17,37,38], adolescent survivors without a history of CRT were twice as likely to be recent smokers as survivors who had received CRT. The association was not as direct for ever smoking, where survivors treated with CRT only exhibited less smoking risk when they had few friends who smoked. This finding supports what many have proposed as a possible mechanism underlying the



“protective” effect of CRT against smoking: due to the cognitive and social impairments associated with CRT [39,40], these survivors may occupy social environments that do not support the development of smoking behavior (e.g., a limited social network results in fewer exposures to friends who smoke) [17,37,38]. Still, it is important to recognize that not all survivors who received CRT are buffered from smoking. Among survivors with many smoking friends, no difference by CRT history was identified.

Although most associations between disordered eating behaviors and smoking were better accounted for by social factors in multivariable models, recent smoking was three times more likely among adolescent survivors who engaged in binge eating for those with few smokers in their network of friends compared to those with many smoking friends. Associations between smoking and weight control practices and disordered eating behaviors among healthy adolescents are well established [24-26,41,42] and may bear particular significance for some survivors of childhood cancer due to their increased risk for obesity and being overweight [43,44]. For survivors who struggle to regulate their eating, smoking could be viewed as a means of weight control, a commonly reported smoking expectancy among healthy adolescents [45-47]. Alternatively, binge eating could be a symptom of a larger impulse control deficiency that leaves survivors at risk for a range of unhealthy behaviors including smoking. Unfortunately, data on weight and body image were not concurrently available for these survivors, which would have been useful to better understand this association. Future research should examine both the instrumental value of smoking (e.g., weight control) and the potential for an underlying impulse control disturbance that may contribute to a general vulnerability to multiple poor health behavior choices (e.g., bingeing and smoking).

Psychological distress plays a key role in the development of smoking behavior among healthy adolescents. Negative affect is associated with progression to regular smoking and nicotine dependence in teens and young adults [30]. We attempted to examine two indicators of psychological distress in this study (emotional distress and past suicidal behavior); however, the emotional distress variable was too highly correlated with eating behavior variables to be included in multivariable modeling. Recent smoking was more likely among survivors who reported past suicidal behavior, consistent with a growing literature documenting similar associations in physically healthy teens [48-50]. This finding suggests that psychological distress is an important risk factor for smoking among adolescent survivors, as previously identified among adult survivors [18]. Since we were limited in our ability to comprehensively measure and fully explore the role of psychological distress in the development of smoking behaviors among adolescent survivors, emotional wellbeing and suicidality should be emphasized in future health behavior investigations with this population.

Some psychosocial and behavioral variables expected to be influential in survivor smoking did not emerge as significant after controlling for age, gender, and smokers in the social environment. In particular, physical inactivity was not related to survivor ever or recent smoking, despite such associations commonly identified for healthy adolescents [22,23]. Purging was significantly associated with ever and recent smoking in univariate analyses, consistent with the increased smoking risk identified among healthy teens who engage in disordered eating behaviors [24-26]. However, after household and peer smoking variables were added to the models, the association was no longer significant. Taken together, our inability to detect these associations in the final models suggests that having smokers in the social environment is more influential than these other health behaviors in determining smoking risk. Future studies should include more specific measures of physical activity and disordered eating behaviors than were available in this survey to confirm these findings.

Although the number of survivors of childhood cancer continues to rise, childhood cancer is rare. As such, survivorship research is often limited by small samples. To our knowledge, this is the largest sample of adolescent survivors to date in which risk factors for smoking have been examined separately from adults. A report on Canadian survivors of childhood cancer identified lower education and higher stress as risk factors for smoking in a large sample that included a sizeable number of adolescents; however, adolescents were not examined separately from adults in that study [38]. Since most smokers begin smoking during adolescence [9], understanding the factors that influence survivors' early smoking behavior is imperative.

Comparison across studies of survivor smoking is challenging. There are notable differences in sample size and sample composition (e.g., age range, medical history, socioeconomic distribution) across studies. Additionally, there is inconsistency in the methods used to assess smoking. For example, the present study identified smokers based on survivors' responses to when they last smoked a cigarette. In contrast, an Australian study identified adolescent smokers based on survivors' endorsements of being an "occasional smoker," "light smoker," "medium smoker," or "heavy smoker" [51]. Even this seemingly subtle difference in measurement could yield large discrepancies in smoking rates: two recent studies reported that roughly half of healthy college students who reported recently smoking cigarettes did not endorse being a "smoker" [52,53]. Further, studies differ in the methods used to compare smoking rates between survivors and healthy comparison groups. Compared to population-based prevalence estimates, survivors were found to smoke at lower rates in a sample of adults [17] and in a combined sample of adolescents and adults [21] previously treated for childhood cancer. We found no difference in smoking rates between adolescent survivors and sibling controls in the present study, but it was beyond the scope of our investigation to compare the smoking rates in our adolescent survivor sample to current US prevalence rates. Even though these methodological differences make it difficult to consolidate findings and definitively characterize the smoking rates and risk factors of the larger survivor population, findings consistently show that a concerning minority of survivors chooses to smoke despite having an elevated medical risk. Clearly, this is a subgroup that requires targeted intervention.

These findings move us toward an improved understanding of adolescent survivor smoking. Still, results must be considered in light of study limitations. Most notably, the cross-sectional design precludes us from drawing conclusions about the development of smoking behaviors over time. Additionally, self-reported smoking was not validated through bioverification (i.e., cotinine tests), although it seems likely that survivors would be inclined to under-report smoking if any reporting inaccuracies occurred. However, this misclassification of smoking status, if non-differential, would tend to reduce the RR toward the null. Finally, the restricted age-range at diagnosis for the survivors in this sample (0-3) could limit the applicability of findings to survivors diagnosed later in childhood. For example, adolescents for whom diagnosis and treatment were recent could be more aware of their own medical risk thereby promoting abstinence. Alternatively, recent separation from peers during treatment could motivate some survivors to engage in age-typical but risky behaviors like smoking experimentation to resume social normalcy. Further, younger age at diagnosis (<10 years) was found to be associated with reduced smoking risk among adult survivors of childhood cancer [18], suggesting that the smoking rate reported in the present study may underestimate smoking prevalence for the larger adolescent survivor population.

## Conclusions

Adolescent survivors of childhood cancer choose to smoke at concerning rates despite their medical vulnerability. Survivors who engage in other concerning behaviors, including



suicidality and binge eating, may be especially vulnerable to smoking. Smokers in the social environment, both friends and family members, appear to be particularly influential in survivors' smoking risk. Smoking cessation efforts with family members may be an important pathway to reducing later smoking risk and promoting long-term survival after children complete treatment. Additionally, helping adolescents choose nonsmoking friends or resist smoking influences within the social environment may also be an effective avenue for prevention. In addition to screening for smoking intentions and past cigarette use, asking survivors to report on the number of friends and family members who smoke will help clinicians identify survivors at greatest risk for smoking. Since smoking initiation during adolescence has been found to predict regular smoking among adult survivors [17,21], smoking prevention and intervention programs must be developed that target high-risk adolescent survivors of childhood cancer.

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## Abbreviations

<b>CCSS</b>	Childhood Cancer Survivor Study
<b>CHIP-AE</b>	Child Health and Illness Profile-Adolescent Edition
<b>CNS</b>	central nervous system
<b>CRT</b>	cranial radiation therapy
<b>RT</b>	radiation therapy
<b>THS</b>	Teen Health Survey

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**Table 1**

Characteristics of Adolescent Survivors by Smoking Status

Characteristic	All Participants		Ever Smokers		Recent Smokers	
	N	n (%)	n (%)	p-value	n (%)	p-value
Total sample	307	85 (27.7)			32 (10.4)	
Sex						
Female	184	54 (29.3)		ref	19 (10.3)	ref
Male	123	31 (25.2)		0.397	13 (10.6)	0.971
Race/Ethnicity <sup>a</sup>						
White, non-Hispanic	269	76 (28.3)		0.607	27 (10.0)	0.523
Non-white	37	9 (24.3)		ref	5 (13.5)	ref
Household Income <sup>a</sup>						
<\$20,000	21	4 (19.0)		0.693	3 (14.3)	0.583
\$20,000-39,999	82	34 (41.5)		0.002	9 (11.0)	0.890
\$40,000+	194	44 (22.7)		ref	20 (10.3)	ref
Mother's Education <sup>a</sup>						
Did not finish high school	22	6 (27.3)		ref	2 (9.1)	ref
Diploma/GED	69	22 (31.9)		0.689	8 (11.6)	0.746
Some college	66	15 (22.7)		0.661	8 (12.1)	0.702
College degree	101	28 (27.7)		0.924	8 (7.9)	0.876
Graduate or professional school	35	10 (28.6)		0.916	4 (11.4)	0.781
Don't know	12	3 (25.0)		0.886	2 (16.7)	0.516
Father's Education <sup>a</sup>						
Did not finish high school	21	7 (33.3)		ref	3 (14.3)	ref
Diploma/GED	78	27 (34.6)		0.913	7 (9.0)	0.471
Some college	61	12 (19.7)		0.204	5 (8.2)	0.431
College degree	77	21 (27.3)		0.602	6 (7.8)	0.371
Graduate or professional school	50	12 (24.0)		0.409	8 (16.0)	0.856
Don't know	18	5 (27.8)		0.710	3 (16.7)	0.837
Cancer Diagnosis						



Characteristic	All Participants		Ever Smokers		Recent Smokers	
	N	n (%)	n (%)	p-value	n (%)	p-value
CNS	40	10 (25.0)	2 (5.0)	ref	2 (5.0)	ref
Leukemia	95	27 (28.4)	12 (12.6)	0.721	12 (12.6)	0.218
Other <sup>b</sup>	172	48 (27.9)	18 (10.5)	0.777	18 (10.5)	0.325
Cancer Treatment <sup>a</sup>						
No radiation or chemotherapy	43	13 (30.2)	4 (9.3)	ref	4 (9.3)	ref
Chemotherapy without radiation	144	48 (33.3)	19 (13.2)	0.775	19 (13.2)	0.532
Radiation	110	21 (19.1)	8 (7.3)	0.117	8 (7.3)	0.656
History of CRT <sup>a</sup>						
No	231	72 (31.2)	27 (11.7)	ref	27 (11.7)	ref
Yes	62	10 (16.1)	4 (6.5)	0.034	4 (6.5)	0.259
Physical Inactivity						
No	239	70 (29.3)	24 (10.0)	ref	24 (10.0)	ref
Yes	68	15 (22.1)	8 (11.8)	0.241	8 (11.8)	0.697
Purging <sup>a</sup>						
No	290	77 (26.6)	27 (9.3)	ref	27 (9.3)	ref
Yes	12	8 (66.7)	5 (41.7)	<0.0001	5 (41.7)	0.0001
Binge Eating <sup>a</sup>						
No	244	62 (25.4)	20 (8.2)	ref	20 (8.2)	ref
Yes	57	23 (40.4)	12 (21.1)	0.020	12 (21.1)	0.005
Emotional Discomfort						
No	269	72 (26.8)	23 (8.6)	ref	23 (8.6)	ref
Yes	38	13 (34.2)	9 (23.7)	0.334	9 (23.7)	0.004
Suicidal Behavior <sup>a</sup>						
No	263	65 (24.7)	21 (8.0)	ref	21 (8.0)	ref
Yes	39	20 (51.3)	11 (28.2)	<0.0001	11 (28.2)	<0.0001
Peer Smoking <sup>a</sup>						
Few smoking friends	259	54 (20.8)	14 (5.4)	ref	14 (5.4)	ref
Many smoking friends	46	31 (67.4)	18 (39.1)	71<0.0001	18 (39.1)	<0.0001

Characteristic	All Participants		Ever Smokers		Recent Smokers	
	N		n (%)	p-value	n (%)	p-value
Household Smoking <sup>a</sup>						
No	213		49 (23.0)	ref	14 (6.6)	ref
Yes	91		36 (39.6)	0.002	18 (19.8)	0.001
		M±SD (Range)	M±SD (Range)		M±SD (Range)	
Age at Survey (years)		17.6 ± 1.1 (15-20)	17.7 ± 1.1 (15-20)		17.8 ± 1.1 (16-19)	
Age at Cancer Diagnosis (years)		1.1 ± 1.0 (0-3)	1.1 ± 1.0 (0-3)		1.2 ± 1.0 (0-3)	

Note. n (%) = participants in each row that have ever smoked or recently smoked. Percent of row total.

Abbreviations: CRT = cranial radiation therapy; CNS = central nervous system tumor; Chemo = chemotherapy; RT = radiation therapy; M = mean, SD = standard deviation, ref = reference level.

<sup>a</sup>Missing information: Treatment (n=10), Race (n=1), Household Income (n=10), Parent Education (n=2), Cancer Treatment (n=10), CRT (n=14), Purging (n=5), Binge Eating (n=6), Suicidal Behavior (n=5), Peer Smoking (n=2), Household Smoking (n=3).

<sup>b</sup>Other cancer diagnosis includes solid tumors (n=168) and lymphomas (n=4). P-value indicates result from univariate models for relative risk comparing ever smoking and recent smoking across demographic, clinical, behavioral, and psychosocial variables.

**Table II**

Comparison of Ever and Recent Smoking between Adolescent Survivors ( $n=307$ ) and Sibling Controls ( $n=97$ )  
Adjusting for Age and Gender

	<i>n</i> (%)	RR	95% CI	<i>p</i>
Ever Smoked				
Survivors	85 (27.7)	0.68	0.40-1.14	0.146
Siblings	32 (33.0)	1.00		
Recent Smoking				
Survivors	32 (10.4)	1.06	0.47-2.36	0.892
Siblings	9 (9.3)	1.00		

Note. RR = relative risk; CI = confidence interval. RR of 1.0 indicates the reference group.

**Table III**

## Multivariate Poisson Regression Model of Ever Smoking among Survivors

Variable	RR	95% CI	p
Age	1.11	0.95-1.31	0.189
<u>Peer Smoking × Gender</u>			
Peer Smoking: Many smoking friends			
Female	1.00		
Male	1.48	0.99-2.21	0.057
Peer Smoking: Few smoking friends			
Female	1.00		
Male	0.71	0.43-1.18	0.187
<u>Peer Smoking × History of CRT</u>			
Peer Smoking: Many smoking friends			
CRT	1.00		
No CRT	0.98	0.65-1.49	0.930
Peer Smoking: Few smoking friends			
CRT	1.00		
No CRT	4.47	1.43-13.9	0.010

Note. RR = relative risk; CI = confidence interval. RR of 1.0 indicates the reference group.

**Table IV**

## Multivariate Poisson Regression Model of Recent Smoking among Survivors

Variable	RR	95% CI	p
Age	1.12	0.86-1.45	0.408
Gender			
Female	1.00		
Male	1.65	0.91-3.00	0.097
History of CRT			
Yes	1.00		
No	2.40	1.12-5.17	0.025
Suicidal Behavior			
No	1.00		
Yes	1.89	1.00-3.56	0.049
Household Smoking			
No	1.00		
Yes	2.24	1.21-4.16	0.011
<u>Peer Smoking × Binge Eating</u>			
Peer Smoking: Many smoking friends			
No Binge Eating	1.00		
Binge Eating	0.79	0.34-1.85	0.593
Peer Smoking: Few smoking friends			
No Binge Eating	1.00		
Binge Eating	3.37	1.17-9.71	0.024

Note. RR = relative risk; CI = confidence interval. RR of 1.0 indicates the reference group.