J Cancer Surviv (2016) 10:131–141
DOI 10.1007/s11764-015-0459-6

Smoking behavior among adult childhood cancer survivors: what are we missing?

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Received: 21 January 2015 / Accepted: 20 May 2015 / Published online: 2 June 2015

Abstract
Purpose Childhood cancer survivors are a growing population at increased risk for smoking-related health complications. This study compared smoking prevalence, age at smoking initiation, and time trend of smoking prevalence from 1997 to 2010 between adult survivors of childhood cancer and adults without a cancer history (controls) and identified predictors of smoking among these survivors.
Methods Data were pooled from the 1997–2010 National Health Interview Survey (survivors, n=1438; controls, n=383,805). Smoking prevalence by age group was calculated using weighted least square regression analysis and weighted linear regression of prevalence on year for trend analysis. Logistic regression analyses adjusting for sample weights and design effects were performed to identify predictors of smoking among survivors.
Results Compared to controls, survivors were significantly more likely to be younger, female, non-Hispanic White, unemployed, with lower income, and to weigh less and smoke more. Survivors initiated smoking earlier than controls. Smoking prevalence among survivors peaked at age 30 and 40 years old, compared to age 25 years in controls. Smoking prevalence decreased consistently from 1997 to 2010 among controls, with larger significant declines in survivors that were subject to more year-to-year variability. Compared to non-smoking survivors, those who smoke were significantly more likely to be non-Hispanic White, young, uninsured, poor, to have a high school education or less, and to report drinking alcohol.
Conclusion Smoking in adult survivors of childhood cancer continues as a persistent risk factor across socioeconomic groups.
Implications for Cancer Survivors Targeted and tailored smoking cessation/prevention interventions for these survivors are needed.

Keywords Childhood cancer survivors · Smoking prevalence · Smoking trends · Smoking initiation · Predictors of current smoking

Electronic supplementary material The online version of this article (doi:10.1007/s11764-015-0459-6) contains supplementary material, which is available to authorized users.

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Introduction

Although cancer in children is rare, it is the leading cause of death in young people who are past infancy in the United States (US) [1]. In 2014, it is estimated that 15,780 children and adolescents less than 19 years of age will be diagnosed with cancer [1]. Due to major advances in the field of pediatric oncology, long-term survival (more than 5 years after cancer diagnosis) is anticipated for 80 % of this population [2]. As of January 2010, there were approximately 380,000 childhood and adolescent cancer survivors in the US [1].

However, long-term survivorship presents unique challenges for this growing population. Cancer and its therapy predispose these young people to a variety of late-onset health effects, thereby increasing their risk of morbidity and early mortality [3–6]. By age of 45, 95 % of these survivors experience chronic health conditions, with 80 % encountering life threatening or disabling conditions [7]. The most common late effects observed in these survivors include pulmonary (65.2 %) and cardiac dysfunctions (56.4 %), two of the most common causes of their later mortality [8]. Risks associated with these and other adverse health outcomes may be further potentiated by tobacco use [9–11]. Thus, there is now a growing population of childhood cancer survivors who are living long enough to be at risk for health complications that can be exacerbated by smoking.

Cigarette smoking is the most preventable cause of premature morbidity and mortality in the US [12]. While a significant decrease in smoking prevalence rates has been achieved through a variety of prevention and cessation programs in the US [13], smoking rates in medically vulnerable population groups such as survivors of childhood cancers are still high [14–16]. Previous studies found that adult survivors of childhood cancer have lower rates of smoking than the general population [17, 18] and healthy control subjects [19–23], except in two studies which found similar levels of smoking among survivors and control subjects [24, 25]. Although these studies are an important contribution to the literature, comparing results from these studies is challenging for many reasons. First, these studies used a different definition for smoking status. For example, Larcombe et al. (2002) defined current smokers as "smoked one cigarette per week" [22], Corkery et al. (1979) used the definition "smoked 21 cigarettes daily" [26], and Troyer et al. (2004) did not provide a definition for current smoker [24]. Second, they often relied on small clinic-based or other convenience samples that are subject to selection bias (e.g., lack of diversity in socioeconomic background, good access to health care, and high motivation for behavioral risk factor change) or were geographically restricted. The largest retrospective cohort survey study to date was the North American Childhood Cancer Survivor Study that was conducted among 9709 survivors [17]. In this study, smoking rates among adult survivors were similar to the general population, with 28 % of survivors reporting ever smoking and 17 % reporting current smoking [27]. However, the study included Canadian participants in addition to the American participants, and only survivors who had specific cancers diagnosed between 1970 and 1986 at one of the collaborating institutions. Therefore, this study provided information only about a certain cohort of survivors with good access to health care and missed those diagnosed before 1970 or after 1986. Thus, there is a great need for additional studies in a large, representative, and diverse sample of adult survivors of childhood cancer that uses a standardized definition for smoking status to document the prevalence of smoking behavior survivors in the US and to be able to compare it with individuals without a history of cancer.

Prior research suggests that survivors of childhood cancer are more likely to never start smoking than individuals without a cancer history [19]. Yet, for those individuals who are survivors, once they start smoking and become addicted to tobacco, they become less likely to quit smoking than individuals without a cancer history [19, 20, 22]. In this context, identifying age of smoking initiation among survivors is important to determine the best time to provide prevention and treatment interventions for this high-risk population. Finally, according to the new Surgeon General's Report, smoking rates among adults in the US declined from 40 % in 1994 to 18 % in 2014, but they remain very high in young adults aged 18–25 years (31.8 %) [14]. Comparable trend data on smoking prevalence among adult survivors of childhood cancer has not been established yet.

Addressing some of the limitations of prior research, the current study extends the focus of these previous studies by using a nationally representative sample of US adults to the following: (a) document and compare current smoking prevalence and age of smoking initiation between adult survivors of childhood cancer (diagnosed with cancer before the age of 21 years) and adults without a cancer history (never diagnosed with cancer at any age—controls) stratified by gender and US region (Northeast, Midwest, South, and West); (b) compare smoking prevalence between survivors and noncancer controls by age groups; (c) compare the time-trend prevalence of current cigarette smoking from 1997 to 2010 between survivors and controls in the US; and (d) identify predictors of smoking among survivors, specifically sociodemographic characteristics and risk factors, such as BMI, alcohol consumption, and physical activity that often cluster with smoking. Mapping and documenting smoking prevalence among survivors in the US will guide future prevention and cessation efforts among this high-risk population.

Methods

Data were pooled from 14 years (1997–2010) from the National Health Interview Survey (NHIS), which is an annual cross-sectional multistage probability household survey of the noninstitutionalized civilian US population [28, 29]. We selected all respondents (≥18 years) during the survey period. The study sample was composed of two groups: (1) adult survivors of childhood cancer (were defined as adults ≥18 years of age who responded "yes" to the question, "Have you ever been told by a doctor or health professional that you had cancer or a malignancy of any kind," and reported that their cancer was diagnosed before the age of 21 years); and (2) adults without a cancer history (controls) (were defined as

adults ≥18 years who responded "no" to the ever cancer history question). We included in the study those who might be on active treatment (currently are greater than 18 years and are diagnosed between the age 18–20) as the American Cancer Society defines someone as a cancer survivor from the time of diagnosis and for the balance of life (http://www.cancer.org/research/infographicgallery/survivorship-life-after-cancer). Therefore, even those who are on active treatment are considered to be survivors.

Measures

Smoking

Smoking status was assessed from two self-reported items in the data: "Have you smoked at least 100 cigarettes in your lifetime?" and "Do you smoke cigarettes now?" Smoking status was categorized into three groups: (a) current smokers who reported they smoked at least 100 cigarettes in their lifetime and currently smoke either every day or some days; (2) former smokers who reported they smoked at least 100 cigarettes in their lifetime, but do not smoke now; and (3) never smokers who reported they have not smoked 100 cigarettes in their lifetime and do not smoke now. Age at smoking initiation was derived from the question: "At what age did you first start to smoke fairly regularly?"

Sociodemographic characteristics

Participants reported their age, gender, educational attainment (<high school, high school, or >high school), health insurance (insured, uninsured), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, and Other), employment status (white collar, blue collar, service worker, farm worker, or unemployed), poverty status (≥ or <2 times the federal poverty level), and region of the US where you live (Northwest, Midwest, West, or South).

Health risk behaviors

Three health risk behaviors were included: physical activity, body mass index (BMI), and alcohol consumption. Consistent with the Healthy People 2010 guidelines, individuals were denoted as compliant with recommendations if they reported moderate physical activity for at least 30 min per day on five or more days per week or vigorous physical activity for at least 20 min per day on 3 or more days per week [30]. BMI was measured based on self-reported height and weight, calculated as weight in kg divided by height in meters squared. Consistent with established guidelines [31], individuals with a BMI of less than 25 kg/m^2 were considered underweight or normal weight, BMI between 25 and 29.9 kg/m^2 were considered overweight, and ≥30 kg/m^2 were considered obese. Self-reported alcohol consumption was defined using the NHIS definitions: "lifetime abstainer" as less than 12 drinks in a lifetime; "former" as 12+ drinks in a lifetime but none in the past year; and "current" as 12+ drinks in a lifetime and 12+ drinks in the past year.

Statistical analysis

NHIS data were pooled, and analyses were conducted using SAS version 9.3 (SAS Institute Inc., Cary, North Carolina), adjusting for sample weights and design effects [32]. Records from each survey year were weighted according to person-level weights provided in the annual NHIS data files. Weights were then adjusted according to the number of representative years used in the analyses by dividing the original weight by 14, the number of years combined [33]. Prevalence estimates and standard errors (SEs) for the demographic characteristics were calculated. Differences in demographic characteristics between survivors and controls were compared using the Chi-square test for categorical variables and Student's *t* test for continuous variables. Prevalence rates of cigarette smoking by gender and by US regions and 95 % confidence intervals were also calculated. Age of initiation was expressed as mean±standard deviation [34]. An ANOVA test was performed to test significant differences between survivors and the controls. Smoking prevalence by age groups was calculated using weighted least square regression analysis. To evaluate meaningful changes in prevalence of current smoking over time, we conducted trend analysis using weighted linear regression of prevalence on year. Multivariable logistic regression analyses for smoking status as the dependent variable were undertaken. The model included all sociodemographic characteristics, health risk behaviors, and US regions.

Results

Sociodemographic characteristics

The sociodemographic characteristics of the sample are shown in Table 1. Between 1997 and 2010, there were a total of 1438 survivors of childhood cancer and 383,805 noncancer controls. Compared to the control group, survivors were significantly younger (in the 18–40-year age group) (45.9 vs 55.6 %, respectively), female (51.4 vs 65.1 %, respectively), non-Hispanic White (70.5 vs 85.4 %, respectively), unemployed (37.9 vs 50.9 %, respectively), and living below double of the federal poverty line (11.8 vs 18.4 %, respectively) ($P<0.001$ for all). In addition, survivors were significantly more likely to be underweight or normal weight than the control group (46.1 vs 40.9 %, respectively) ($P=0.002$). The distribution of CCSs and the controls was slightly, but significantly, different by region where more CCSs than controls

Table 1 Demographic characteristics of adult survivors of childhood cancer compared with adults without a cancer history in the US, data from the National Health Interview Survey (1997–2010)

Characteristic	Adult survivors of childhood cancer[a] (*N*=1438)[b]				Noncancer controls (*N*=383,805)[b]				
	Sample *N*	Weighted *N*	%	SE	Sample *N*	Weighted *N*	%	SE	*p* value
Sex									
Male	430	275933	34.88	1.63	169343	95878194	48.58	0.11	**<0.0001**
Female	1008	515270	65.12	1.63	214462	101496032	51.42	0.11	
Age									
18–40	789	439487	55.55	1.65	169538	90639729	45.92	0.18	**<0.0001**
41–64	378	213745	27.02	1.48	150009	79426850	40.24	0.14	
>65	271	137972	17.44	1.39	64258	27307646	13.84	0.11	
Race/ethnicity									
Non-Hispanic White	1124	675322	85.35	0.96	239381	139127740	70.49	0.24	**<0.0001**
Non-Hispanic Black	152	58575	7.40	0.71	57591	23532329	11.92	0.18	
Hispanic	135	45098	5.69	0.59	69160	25020764	12.68	0.17	
Others	27	12208	1.54	0.35	17673	9693393	4.91	0.09	
Education									
>High school	755	419158	53.69	1.69	197245	105833095	54.16	0.22	0.91
=High school	402	227199	29.09	1.58	108069	57024088	29.18	0.15	
<High school	265	134399	17.21	1.24	74530	32562900	16.66	0.14	
Poverty level									
Poor/near poor (<2 times federal level)	286	119337	18.36	1.28	49217	18884397	11.84	0.15	**<0.0001**
Not poor (≥2 times federal level)	898	530700	81.64	1.28	258668	140663202	88.16	0.15	
Employment									
White collar	426	241390	30.51	1.50	134152	72025590	36.49	0.16	**<0.0001**
Service	148	80627	10.19	0.92	37847	19233276	9.74	0.07	
Farm	5	3958	0.50	0.23	4254	2018148	1.02	0.03	
Blue collar	104	62913	7.95	0.86	53251	29328036	14.86	0.11	
Unemployed	755	402316	50.85	1.60	154301	74769175	37.88	0.15	
Health insurance status									
Uninsured	265	144574	18.31	1.29	67711	33042259	16.80	0.18	0.23
Insured	1170	644834	81.68	1.29	314807	163583763	83.20	0.18	
Body mass index									
Under/normal weight	634	354276	46.06	1.71	150323	77447250	40.90	0.13	**0.002**
Overweight	419	230825	30.01	1.53	128701	66481606	35.11	0.10	
Obese	347	184092	23.93	1.35	88503	45440795	24.00	0.11	
Drinking status									
Current	874	495835	63.82	1.63	228814	1217011480	63.05	0.19	0.06
Former	250	124380	16.01	1.09	55439	27127783	14.05	0.09	
Nondrinker	292	156712	20.17	1.40	90797	44196896	22.90	0.18	
Smoking status									
Current	518	271453	34.58	1.54	84308	43098236	22.05	0.12	**<0.0001**
Former	300	180491	23.00	1.48	78201	40647381	20.79	0.10	
Nonsmoker	611	333005	42.42	1.56	217399	111744077	57.16	0.15	
Physical activities[c]									
Yes	411	238004	31.60	1.67	108873	59634003	32.08	0.16	0.77
No	954	515242	68.40	1.67	248497	126239012	67.92	0.16	
Geographic region									
Northeast	206	122880	15.53	1.16	68884	36714764	18.60	0.20	**0.03**
Midwest	337	187678	23.72	1.53	87151	48283959	24.46	0.28	
South	563	317464	40.12	1.66	140184	71431896	36.19	0.29	
West	332	163181	20.62	1.32	87586	40943607	20.74	0.24	

[a] Cancer was diagnosed before the age of 21 years

[b] Differences in subtotal population sample due to nonresponse or missing data

[c] Compliance with physical activities according to Healthy People 2010

were located in the South (40.1 vs 36.2 %, respectively) (P= 0.03). Finally, survivors were more likely to be current smokers than the controls (34.6 vs 22.1 %, respectively) (P<0.0001).

Smoking prevalence and age of smoking initiation stratified by gender and region

Smoking prevalence among female survivors was double that for women without a cancer history (39.0 %; 95 % confidence interval 35.2–42.7; and 19.3 %; 19.1–19.6, respectively), while smoking was similar among male survivors and their noncancer counterparts (26.4 %; 21.2–31.5, and 24.9 %; 24.6–25.2, respectively) (Table 2). The highest prevalence of smoking for survivors was in the Southern US region (37.5 %; 32.8–42.1) while the highest prevalence for the control group was in the Midwest (24.7 %; 24.2–25.2).

The mean age of uptake for smoking among female survivors was significantly earlier than the control group in the Midwest (16.6 vs 17.9; P<0.01), Northeast (15.9 vs 17.8; P<0.001), and South of the US (16.4 vs 18.3; P<0.001) (Fig. 1). The same result was found among male survivors in the Midwest (15.6 vs 17.2; P<0.016) and West (14.7 vs 17.7; P<0.001). The lowest age of smoking initiation among male survivors was found in the West (14.7±0.61) and the highest was in the South (18.2±1.16). Among female survivors, the earliest age of smoking initiation was in the Northeast (15.9±0.42), while the highest was in the West (17.3± 0.80).

Prevalence of current smoking by age group

A comparison of the proportion of current smokers by age group between adult survivors and the noncancer control group is shown in Supplementary Fig. S1. Current smoking prevalence was higher among survivors than noncancer controls in all ages. Smoking prevalence among survivors increased dramatically between age 25 and 30 years (from 42.6 to 45 %) and again between age 35 and 40 years (from 38.9 to 47.3 %); prevalence of smoking peaked only between age 20 and 25 years (from 21.5 to 26.7 %) for noncancer controls.

Trends in smoking prevalence

Over the 14-year period, the trend analysis revealed that the prevalence of current smoking decreased slightly and steadily from 25 % in 1997 to 19.5 % in 2010 among the control group; however, this pattern was not present among survivors. The survivors had a higher prevalence of smoking compared

Table 2 Smoking status among adult survivors of childhood cancer compared with adults without a cancer history stratified by US region and by gender, data from the National Health Interview Survey (1997–2010)

Region	Childhood cancer survivors						Noncancer controls					
	Current smokers		Former smokers		Never smokers		Current smokers		Former smokers		Never smokers	
	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI	%	95 % CI
All												
Total	34.6	31.6–37.6	23.0	20.1–25.9	42.4	39.4–45.5	22.0	21.8–22.3	20.8	20.6–21.0	57.2	56.9–57.5
Northeast	33.4	25.3–41.4	27.6	19.8–35.3	39.1	30.8–47.3	20.8	20.3–21.4	23.2	22.8–23.7	56.0	55.3–56.6
Midwest	35.2	29.0–41.4	23.3	15.7–30.9	41.5	35.6–47.4	24.7	24.2–25.2	21.2	20.8–21.6	54.5	53.5–54.7
South	37.5	32.8–42.1	20.7	16.8–24.6	41.9	37.1–46.6	23.2	22.8–23.6	19.4	19.0–19.7	57.4	56.9–57.9
West	29.2	22.9–35.5	23.8	18.2–29.4	47.0	40.1–54.0	18.0	17.5–18.4	20.6	20.2–21.0	61.4	60.8–62.1
Male												
Total	26.4	21.2–31.5	32.1	26.8–37.4	41.6	36.2–46.9	24.9	24.6–25.2	21.1	23.8–24.4	51.0	50.6–51.3
Northeast	22.2	11.4–33.1	33.8	20.4–47.2	43.9	30.4–57.5	22.7	22.0–23.5	26.2	25.5–26.9	51.3	50.3–51.9
Midwest	27.3	16.7–37.8	27.3	16.4–38.1	45.5	33.4–57.5	27.4	26.8–28.0	24.3	23.8–24.9	48.3	47.6–49.0
South	28.8	20.3–37.2	32.2	23.8–40.6	39.0	30.5–47.5	26.6	26.1–27.1	23.1	22.6–23.5	50.3	49.7–51.0
West	23.8	12.8–34.9	34.7	23.5–45.9	41.5	30.4–52.5	21.1	20.5–21.8	23.8	23.1–24.4	55.1	54.4–55.8
Female												
Total	39.0	35.2–42.7	18.1	14.4–21.8	42.9	39.1–46.7	19.3	19.1–19.6	17.7	17.5–17.9	63.0	62.6–63.3
Northeast	39.4	29.6–49.2	24.2	14.2–34.2	36.4	26.0–46.8	19.1	18.5–19.7	20.6	20.0–21.1	60.3	59.5–61.1
Midwest	38.3	30.3–46.2	21.8	11.5–32.0	40.0	32.6–47.3	22.1	21.5–22.7	18.2	17.8–18.7	59.7	59.0–60.3
South	42.5	37.0–48.0	13.9	9.9–17.9	43.5	38.0–49.1	20.1	19.7–20.5	15.9	15.5–16.3	64.0	63.4–64.5
West	32.6	24.4–40.7	16.9	11.4–22.5	50.5	42.6–58.4	14.8	14.3–15.3	17.5	17.0–18.0	67.7	67.0–68.5

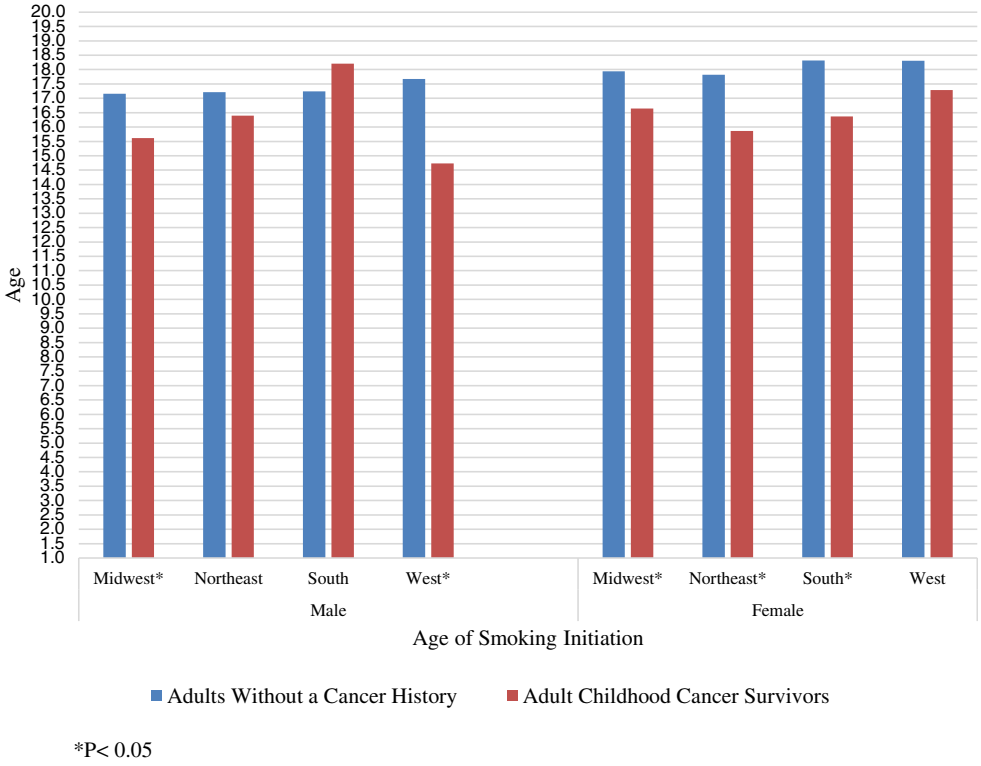

Fig. 1 Age of smoking initiation in adult childhood cancer survivors compared to adults without a cancer history stratified by gender and by US region, data from the National Health Interview Survey (1997–2010)

to controls at all years except 2007 (see Supplementary Fig. S2). In 2007, smoking prevalence declined dramatically from 32.3 to 21 % among survivors and declined slightly from 20.8 to 19.7 % in controls. In 2008, smoking prevalence increased again dramatically from 21 to 33 % in survivors, and it returned to its previous level in the control group. The rate of annual decline in smoking prevalence was significant in the control group (−0.39±standard error 0.03; $P<0.001$) and in the survivors (−1.07±0.44; $P=0.024$). While the rate of decline was greater in the survivors versus controls, there was no significant difference in the trajectory of the two slopes ($P=0.139$).

Risk factors associated with current smoking among survivors of childhood cancer

In the multivariable analysis, three models were constructed for the odds of current smoking among survivors (Table 3). The first model included all survivors ($N=1438$); the second was only for male survivors ($N=430$); and the third was only for female survivors ($N=1008$).

In the first model, the odds of current smoking were significantly lower among non-Hispanic Blacks (odds ratio=0.49 [95 % confidence intervals=0.28–0.85]) and Hispanics (0.44 [0.23–0.85]) compared with non-Hispanic Whites. Younger versus older survivors (0.98 [0.97–0.99]) were less likely to be current smokers. Survivors without health insurance versus those with health insurance (2.54 [1.64–3.94]), and survivors living below the poverty level versus those who live at or above the poverty level (1.87 [1.34–2.62]) were significantly more likely to be current smokers. Individuals with a high school education (1.80 [1.20–2.63]) or less (2.20 [1.65–4.17]) were significantly more likely to currently smoke relative to those with a greater than high school education. Finally, survivors who reported currently drinking alcohol were significantly more likely to be current smokers (2.07 [1.42–3.01]) than nondrinkers (Table 3).

In the second model examining male survivors, individuals with a high school education were three times as likely to be current smokers relative to those with more than high school education (2.97 [1.40–6.30]). Male survivors without health insurance were also three times as likely to be current smokers compared to males with health insurance (3.21 [1.42–7.26]). In the third model examining female survivors, the odds of smoking were significantly higher among young versus older survivors (0.97 [0.96–0.99]). Compared to non-Hispanic Whites, non-Hispanic Black and Hispanic females were less likely to be current smokers (0.38 [0.20–0.73]; 0.37 [0.17–0.81], respectively). Those who lived at or below the poverty level versus above were significantly more likely to be a current smoker (2.37 [1.62–3.47]). Female survivors with less than a high school education were three times as likely to smoke than those with more than a high school

Table 3 Risk factors predicting current smoker status among adult childhood cancer survivors from the National Health Interview Survey (1997–2010)

Characteristics	All childhood cancer survivors (*N*=1438) OR (95 % CI)	Male survivors of childhood cancer (*N*=430) OR (95 % CI)	Female survivors of childhood cancer (*N*=1008) OR (95 % CI)
Age (continuous)	**0.98 (0.97–0.99)**	0.98 (0.96–1.00)	**0.97 (0.96–0.99)**
Gender			
Male	1		
Female	1.40 (0.94–2.09)	——	——
Race/ethnicity			
Non-Hispanic White	1	1	1
Non-Hispanic Blacks	**0.49 (0.28–0.85)**	0.57 (0.15 - 2.11)	**0.38 (0.20–0.73)**
Hispanic	**0.44 (0.23–0.85)**	0.61 (0.18–2.09)	**0.37 (0.17–0.81)**
Other	0.89 (0.33–2.39)	1.35 (0.13–14.31)	0.69 (0.22–2.11)
Education			
More than high school	1	1	1
High school	**1.80 (1.20–2.69)**	**2.97 (1.40–6.30)**	1.40 (0.86–2.29)
Less than high school	**2.63 (1.65–4.17)**	1.98 (0.71–5.52)	**3.14 (1.83–5.38)**
Employment status			
Employed	1	1	1
Unemployed	1.23 (0.84–1.82)	0.75 (0.33–1.72)	**1.70 (1.12–2.58)**
Health insurance status			
Insured	1	1	1
Uninsured	**2.54 (1.64–3.94)**	**3.21 (1.42–7.26)**	1.52 (0.99–2.34)
Poverty level			
At or above	1	1	1
Under	**1.87 (1.34–2.62)**	1.06 (0.53–2.14)	**2.37 (1.62–3.47)**
Body mass index			
Overweight and obese	1	1	1
Under/normal weight	1.23 (0.89–1.70)	1.74 (0.89–3.41)	1.05 (0.71–1.55)
Drinking status			
Nondrinker/former	1	1	1
Current	**2.07 (1.42–3.01)**	1.27 (0.60–2.68)	**2.65 (1.69–4.15)**
Physical activity[2]			
Yes	1	1	1
No	1.39 (0.95–1.95)	0.98 (0.50–1.91)	**1.57 (1.01–2.44)**
Geographical region			
Northeast	1	1	1
Midwest	1.08 (0.63–1.86)	0.71 (0.26–1.98)	1.25 (0.67–2.35)
South	1.06 (0.65–1.73)	0.68 (0.28–1.66)	1.32 (0.75–2.35)
West	0.95 (0.53–1.71)	0.73 (0.25–2.16)	1.10 (0.54–2.23)

education (3.14 [1.83–5.38]), and unemployed versus employed female survivors were significantly more likely to smoke (1.70 [1.12–2.58]). Finally, female survivors who reported currently drinking alcohol versus nondrinking survivors were more likely to be current smokers (2.65 [1.69–4.15]), and those who were noncompliant with physical activity recommendations versus compliant were significantly more likely to smoke (1.57 [1.01–2.44]).

Discussion

Using a nationally representative sample of the US population, results of the current study provide benchmark estimates of the prevalence of smoking among adult survivors of childhood cancer compared to adults without a cancer history (control). Overall, our data indicate that the smoking profile among survivors is different than that of the control group. A striking

number of adult survivors smoke cigarettes (34.7 %) despite the possible potentiated risks associated with their history of cancer and its treatment. Moreover, smoking prevalence in adult survivors was significantly higher than the control group in the US, especially among women, and it varied markedly by geographic region. The highest smoking rate for survivors was in the South, while it was in the Midwest for the control group. While smoking prevalence decreased slightly and consistently from 1997 to 2010 among individuals without a cancer history, it was higher than controls and did not show a clear time-trend pattern among survivors. Finally, survivors were more likely to smoke if they were young, non-Hispanic White, poor, less educated, uninsured, and reporting drinking alcohol. These results may indicate that health disparities due to socioeconomic factors or poor access to health care strongly affect survivors, especially female survivors, and highlight the relative lack of progress in tobacco control efforts among survivors of childhood cancer in the US. Therefore, more tailored prevention and cessation interventions to meet the special needs and characteristics of this high-risk population are needed.

Smoking prevalence in our study was higher than those reported in the North American Childhood Cancer Survivor Study (17 % were current smokers) [27]. However, it is important to mention that participants in that study were on long-term regular medical follow-up, which would not be the case for all survivors of childhood cancer across the Nation. Survivors attending clinical cancer follow-up programs have a lower level of smoking than survivors not attending such programs [35], highlighting the importance of such survivorship plans and long-term follow-up health care visits for not only cancer-related outcomes, but lifestyle factors. Many other studies have reported levels of current smoking among survivors that varied from 14 to 33 % [18, 19, 24, 36–38]. However, comparisons of smoking rates of survivors in different studies often are very difficult because of uncontrolled confounding factors, including the age of the survivors, and the time from diagnosis; in addition, the methods used to classify smoking status often vary among studies. Even though these methodological differences make it difficult to consolidate findings and definitively characterize the smoking rates in this population, findings consistently show that a concerning number of survivors choose to smoke despite having an elevated medical risk. Therefore, based on the large sample employed in the current study, present findings indicate that smoking is a significant and relevant concern for survivors of childhood cancer during adulthood. More importantly, a large difference was identified in smoking rates between adult survivors compared to controls, suggesting that having a cancer history does not dissuade some survivors from smoking and that survivors may not be reached by tobacco control efforts targeted to the general population. In order to understand what types of prevention and cessation interventions would be more effective among survivors, it would be necessary to carry out qualitative research to further understand and explore reasons for smoking in this high-risk population [39].

Results of this study indicate that adult survivors of childhood cancer initiated smoking at an earlier age than adults without a cancer history and that their smoking prevalence increased at two age groups (25 and 35 years). In contrast, smoking prevalence increased at only one age group (20 years) in the controls. This smoking profile identifies two important time periods in which to intervene in this population. First, since smoking initiation during adolescence has been found to predict regular smoking among adult survivors [40], interventions to prevent initiation of smoking among recently diagnosed survivors of cancer, ideally those aged 12–18 years, need to start early in a survivor's life. Second, efforts are needed to ensure that all individuals diagnosed with childhood cancer are identified during their extended medical care after adulthood and asked about their smoking status in an effort to provide evidence-based smoking cessation programs (including counseling and medications as appropriate). Unfortunately, this does not always occur. A recent survey evaluated smoking-related services available to childhood cancer survivors in 132 institutions affiliated with the Children's Oncology Group from 2003 to 2004 found that only 3 % of these institutions assessed smoking status at every visit, as recommended by the PHS guidelines; 39 % of the sites offered smoking prevention, 25 % provide cessation services, and 58 % of sites had a mechanism in place to refer survivors for cessation services [41]. This situation highlights an important need to improve the availability of smoking services for these survivors.

The current study is the first to report on the time-trends of smoking prevalence in this population. Results suggest that smoking prevalence decreased faster in survivors than the controls indicating that the gap between the two groups is closing (the gap decreased from 15 % in 1997 to 10 % in 2010). However, a large difference in smoking prevalence between survivors and controls still exists. This indicates that previous tobacco control efforts targeting the general population did not have the same impact on reducing smoking in this particular population. In addition, our data indicate that there was a dramatic national smoking prevalence decline in the US among both survivors and controls in 2007. One possible explanation for this reduction could be the economic collapse in the US during that time. Previous research examining the associations between economic crises and smoking behaviors indicated that smoking prevalence declines abruptly during and after economic downturns [42, 43] due to lower affordability to buy cigarettes [43]. A change in income also influences success in quit attempts. For example, it was found that former smokers who experienced a decline in income were less likely to relapse when they attempted to quit smoking; and conversely, an increase in income raises the risk of relapse

during the quit attempt [43]. Therefore, survivors could be very sensitive to cigarette prices, and the use of a policy to steadily increase cigarette cost is likely to help survivors in reducing their consumption and eventually quit smoking [44].

Predictors of current smoking for the all survivor sample were as follows: being younger, non-Hispanic White, less educated, living at or below the poverty level, not having health insurance, and reporting drinking alcohol. Stratifying by gender indicates that while male survivors had only two main risk factors for smoking, lower education, and not being insured, female survivors had numerous factors associated with smoking (age, race/ethnicity, education, employment status, poverty level, health insurance status, alcohol consumption, and physical inactivity). Lower educational attainment, lower household income, and unemployment may be a proxy for poorer access to health care and may indicate the existence of health disparities which can strongly affect smoking behavior in survivors, especially female survivors. These factors are common denominators of smoking among young people and underlie deeper roots of unhealthy behavior and difficulty in health promotion in sectors of society that have many challenges but the least resources to address them [45, 46].

Employment can play an important role in health outcomes where prior research has documented that being unemployed negatively affects health status [47]. Employment discrimination has been reported by survivors of childhood cancer [48]. A study of adult survivors of childhood cancer found that 45 % of survivors had been denied employment because of their cancer history [49]. Consistent with these findings, our results show that survivors of childhood cancer were significantly more likely to be unemployed compared to their control counterparts and lack of employment was a risk factor for current smoking among female survivors. Being uninsured (often associated with unemployment historically in the US) was a risk factor for being a smoker among survivors. Prior research has shown that adult childhood cancer survivors are less likely to have health insurance coverage compared to their noncancer sibling [50]. More importantly, being a smoker was significantly associated with an increased likelihood of being uninsured [50]. Given that all childhood cancer survivors are at high risk for long-term complications because of their cancer and its treatment (including the development of recurrent and new cancers), any disparity in availability and quality of health insurance coverage should be of great concern. Health insurance is an important component in receiving timely access to medical care among this vulnerable population. Therefore, exploring strategies for decreasing barriers to full coverage in order to ensure a sustainable survivorship care and follow-up among this vulnerable and expanding population is a high priority [51]. Recently, as a result of the Affordable Care Act (ACA), survivors of childhood cancer (especially young survivors age 18 to 26) in the US can continue to have health insurance under a parent's insurance. The ACA also is expanding tax credits for workplace wellness programs to increase access to smoking cessation services and treatment, which could result in additional use of these services by survivors [52]. However, how these will affect childhood cancer survivors during the next decade is uncertain, but if promoted and utilized, it has the potential to reduce smoking in this population.

Limitations

The repeated cross-sectional design prevents making causal inference of observed associations. A second possible limitation of this study is the accuracy of the self-reported smoking data. The smoking data for all participants were based on responses to a questionnaire rather than on biochemical data, which could result in under-reporting due to social desirability bias. Finally, because of the data source, we were unable to include and comment on the type of cancer or treatment modalities/intensity among childhood cancer survivors in relation to their smoking behavior. These factors are found to be related to smoking initiation and also may be valuable in designing interventions for this at risk group. Despite these limitations, this study is the first to use 14 years of national data to provide novel and important contributions for documenting the smoking profile of childhood cancer survivors compared to those without a cancer history in the US.

Conclusions

Results demonstrate that more than a third of survivors of childhood cancer were current smokers. This indicates that large numbers of adult childhood cancer survivors remain at risk for smoking-related health outcomes, which are likely amplified given their cancer survivorship status. Findings also show that while the gap in smoking prevalence rates between survivors and controls has narrowed over time, rates remain substantially higher among the survivors. This indicates that survivors have not benefited from ongoing tobacco control efforts targeted at the general population. Future prevention and cessation interventions among survivors of childhood cancer should use qualitative methods to design and test tailored interventions that suit this unique population. In addition, efforts to prevent smoking initiation should start early in life among this population as the age of initiation was earlier than the control group and smoking prevalence was highest among younger survivors. Moreover, efforts must be focused on promoting and integrating smoking cessation treatment into long-term survivorship care and follow-up plan of childhood cancer survivors. Finally, more efforts are needed to reduce the burden of health disparities among survivors. This can be achieved through appropriate public policy measures that include reducing gaps in health coverage, improving

economic conditions, and increasing educational and employment opportunities for these at risk populations.

Acknowledgments Funding for this study was provided by the Bankhead Coley Cancer Research grant 1BG06-341963 (P.I. Dr. Lee); European Regional Development Fund and European Social Fund to the University of Exeter Medical School (PI Dr Fleming).

This submitted manuscript or any similar manuscript has not been published anywhere, in whole or in part, previously and it is not simultaneously being considered for any other publication. Approval from all coauthors was obtained prior to submission.

Conflict of interest None of the authors have any proprietary interests or conflicts of interest to disclose.

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