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Research Article

Cancer Epidemiology, Biomarkers & Prevention

Secondhand Smoke Exposure Among Community-Dwelling Adult Cancer Survivors in the United States: 1999–2012

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Abstract

Background: Little is known about the prevalence of secondhand smoke exposure (SHSe) among cancer survivors. We sought to determine the prevalence, trends, and correlates of SHSe among nonsmoking adult cancer survivors in the United States.

Methods: Interview and serum cotinine data for nonsmoking adults, age 20 years and older, with a history of cancer ($N = 686$) were obtained from consecutive two-year cross-sectional cycles of the National Health and Nutrition Examination Survey from 1999 to 2012. SHSe was defined as serum cotinine 0.05–10 ng/mL among nonsmokers. We calculated and trended the prevalence of SHSe among nonsmoking cancer survivors. Multivariable logistic regression was used to examine the associations of SHSe with sociodemographic, smoking, and clinical characteristics. Survey weights were applied in estimating prevalence rates, adjusted ORs, and confidence intervals (CI).

Results: The weighted aggregate SHSe and self-reported indoor SHSe prevalence rates over the study period were 28.26% (95% CI: 24.97%–31.55%) and 4.53% (95% CI: 3.48%–5.57%), respectively. SHS exposure declined from 39.61% (95% CI: 27.88%–51.34%) in 1999/2000 to 15.68% (95% CI: 9.38%–21.98%) in 2011/2012 ($P_{trend} < 0.001$). Age $\geq$ 60 years was protective against SHSe, while being black, having less than high school education, poverty, and a smoking-related cancer history were associated with higher odds of SHSe.

Conclusions: Fortunately, SHSe among nonsmoking cancer survivors in the United States is on the decline, although certain subgroups remain disproportionately burdened.

Impact: These findings highlight clinical and public health imperatives to target socioeconomically disadvantaged nonsmoking cancer survivors to reduce their SHSe. *Cancer Epidemiol Biomarkers Prev; 26(8); 1296–305. ©2017 AACR.*

Introduction

It is well-established that tobacco use and exposure accounts for about a third of all cancer-related deaths in the United States (1). Moreover, tobacco use following the diagnosis of cancer is associated with increased treatment-related toxicity, increased risk of second primary cancers, decreased quality of life, and decreased survival among patients diagnosed with tobacco-related and non-tobacco–related cancers. Quitting smoking improves the prognosis of cancer patients (2). Similarly, exposure to secondhand tobacco smoke has been causally linked to cancer, respiratory, and cardiovascular diseases (2, 3). In fact, secondhand smoke exposure (SHSe) specifically accounts for about 7,000 lung cancer–related deaths annually in the United States (4). SHSe has also been shown to adversely affect overall and progression-free survival among cancers such as non–small lung cancers (5). SHSe among nonsmokers also increases the risk of noncancer deaths via a causal relationship with stroke and coronary artery disease (2, 3). Importantly, concurrent household or spousal SHSe also reduces the likelihood of successful smoking cessation attempts among smoking cancer patients and survivors (6–8).

The prevalence of active smoking among cancer survivors is well documented. For instance, it has been shown that less than half of smoking cancer patients quit smoking after cancer diagnosis, and about 10% of cancer survivors still smoke almost one decade after a cancer diagnosis (9, 10). Data regarding the national prevalence of SHSe among cancer survivors is very sparse. Very few cancer clinical trials assess SHSe among participants, and there are no studies that have specifically estimated the prevalence of SHSe among adult cancer survivors in the household setting in the United States (11).

Therefore, we sought to estimate the prevalence and correlates of SHSe among community-dwelling cancer survivors in the United States. Our study objectives were: (i) to estimate the national prevalence of SHSe among nonsmoking adult cancer survivors in the United States; (ii) to estimate the national prevalence of self-reported indoor household SHSe among nonsmoking adult cancer survivors in the United

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States; (iii) to identify temporal trends in SHSe among nonsmoking adult cancer survivors in the United States; and (iv) to identify sociodemographic and clinical factors associated with SHSe among nonsmoking adult cancer survivors in the United States.

Materials and Methods

Data source and study population

Data were obtained from the United States National Health and Nutrition Examination Survey (NHANES) for adults age 20 years and older. NHANES is a temporal series of ongoing cross-sectional surveys designed to capture the health and nutritional status of the noninstitutionalized resident civilian population of the United States. NHANES is conducted by the National Center for Health Statistics (NCHS) at the Centers for Disease Control and Prevention (CDC), and utilizes a stratified multistage, clustered probability sampling technique. Further details regarding the objectives, sampling methodology, and operations of NHANES are available elsewhere (12).

NHANES evaluation of each consenting participant involves conducting a home interview followed by a physical examination and collection of biologic specimens at a mobile examination center. Analysis of serum cotinine is conducted for participants aged at least 3 years. Since 1999, NHANES data has been released to the public in 2-year cycles with the most recent interview and physical examination data available for the 2013/2014 cycles. However, the most recent data regarding laboratory parameters, such as serum cotinine, is available for the 2011/2012 cycles (12).

Our study sample reflects adult respondents who were nonsmoking cancer survivors. Adult cancer survivors were defined as respondents age 20 years and older with a self-reported history of a cancer diagnosis. Cancer survivors were identified as those who responded "Yes" to the question, "Have you [SP] ever been told by a doctor or other health professional that you [she/he] had a cancer or malignancy of any kind?"

Variables

Smoking history and SHSe. Participants were defined as nonsmokers if they: (i) had a lifetime smoking history of less than 100 cigarettes (never smokers) or had a lifetime smoking history of more than 100 cigarettes but were not currently smoking (former smokers); and (ii) did not report using any nicotine containing products in the 5-day period preceding their evaluation; and (iii) had serum cotinine levels less than 10 ng/mL.

Among former smokers, we calculated cigarette pack-years smoked by dividing the number of cigarettes smoked, at the time of quitting by 20 years, and multiplying this quotient by the duration of cigarette smoking in years.

Serum cotinine measurement and analysis was performed using isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry (13). The level of detection of serum cotinine was 0.05 ng/mL for the 1999/2000 cycle and some participants in the 2001/2002 cycle but this decreased to 0.015 ng/mL for all participants subsequently. However, a serum level of 0.05 ng/mL was used across all survey cycles in our analysis for consistency given that one of our objectives involved trend analysis.

Nonsmokers with average SHSe have serum cotinine levels <1 ng/mL, while levels 1–10 ng/mL correlate with heavy SHSe. On the other hand, most active smokers have serum cotinine levels >10 ng/mL (14). Therefore, serum cotinine level >10 ng/mL was used as the threshold for screening out likely smokers among those who did not report active smoking.

Exposure to indoor household smoking was assessed from responses to the following items on the NHANES questionnaire: "Does anyone who lives here smoke cigarettes, cigars, or pipes anywhere inside this home?" and "Total number of smokers inside home?" (15).

Indoor household SHSe was defined as having at least one member of the household who smoked cigarettes, cigars, or pipes inside the home. Among respondents who reported exposure to indoor household smoking, the number of household members who smoked indoors was categorized as: 1; 2; 3 or more.

Sociodemographic variables. These were: age in years (20–39; 40–59; ≥60); gender (female; male); race/ethnicity (non-Hispanic whites; non-Hispanic blacks; Mexican Hispanics; others); educational attainment (> high school; high school; <high school); household income level, relative to the federal poverty level (FPL; ≥300% FPL; 100%–299% FPL; <100% FPL); and marital status (married or living with partner; divorced, separated, or widowed; never married).

Clinical and healthcare utilization variables. These included: a history of a smoking-related cancer (yes; no); a history of cardiovascular disease (yes; no); a history of chronic lung diseases (yes; no); and, having a routine place of medical care (yes; no).

Smoking-related cancers were defined as a self-reported history of diagnosis with cancer of any of the following types or organs: bladder, cervix, colon, esophagus, kidney, larynx, leukemia, liver, lung, mouth/tongue/lip, pancreas, rectum, and stomach (3). Of note, acute myeloid leukemia (AML) is the leukemia type with which smoking has been causally linked (3), but AML was not specified as a cancer option in the survey. Rather, leukemia was the specified cancer option, hence we sought to identify patients with AML by including all those who reported a history of leukemia.

Cardiovascular disease was defined as a self-reported history of any of the following conditions: congestive heart failure, coronary heart disease, angina/angina pectoris, heart attack, or stroke.

Chronic lung disease was defined as a self-reported history of diagnosis with any of the following conditions: emphysema, chronic bronchitis, or asthma.

Statistical analysis

SHSe prevalence and the prevalence of indoor household SHSe were estimated for the entire study population over the study period and by survey cycle. SHSe and self-reported indoor household SHSe prevalence rates were computed for subgroups defined by: sociodemographic factors, smoking history, having a smoking-related cancer site, time since first cancer diagnosis, history of cardiovascular disease, history of chronic lung disease, and having a regular place of medical care (13, 16).

Trends in the prevalence of SHSe and self-reported indoor household SHSe across the study period for the entire populations

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and by their sociodemographic as well as smoking history were obtained.

To assess the validity of our analysis, we also computed SHSe prevalence for all adults age ≥20 years, regardless of whether they had a prior cancer diagnosis, for comparison with data on adult SHSe prevalence published by the CDC.

χ^2 tests were used to examine bivariate associations between SHSe and potential predictor variables to help in variable selection for the multivariate analysis. Age, gender, and race/ethnicity were automatically selected as predictors in the multivariate model. Other sociodemographic and clinical/healthcare utilization characteristics described in the preceding section on covariates comprised the set of potential predictor variables that were tested in the bivariate analysis. A statistical significance level of 0.05 was utilized in the bivariate analyses for variable selection into the multivariate model.

Multivariable logistic regression modeling was utilized in examining the independent association(s) between SHSe and: age, gender, race/ethnicity, and all other predictor variables that were significantly associated with SHSe on bivariate analyses. The multivariable regression analysis was also stratified by smoking history. A statistical significance level of 0.05 was utilized in the multivariate analysis.

Given the lower limit of detection, 0.015 ng/mL, for all participants in the 2003/2004 cycle onwards, we conducted sensitivity analysis comparing the similarity of results from trend and regression analyses using 0.015 ng/mL as the SHSe threshold to results obtained with the 0.05 ng/mL threshold. The subsample for the sensitivity analyses were participants from 2003 to 2012.

Survey weights correcting for the sample design and nonresponse were applied in obtaining the population-based prevalence rates, adjusted ORs (aOR), and 95% confidence intervals (CI). All analysis were performed with Stata 14 (StataCorp), and Joinpoint Regression Program 4.2.02 (National Cancer Institute, Bethesda, MD; ref. 17).

Ethical board review

The NHANES Institutional Review Board reviewed and approved the protocol for collection and public reporting of the NHANES data.

Results

Study sample

The final study sample comprised 686 nonsmoking adult cancer survivors (Fig. 1). 293 (43%) were never smokers and 391 (57%) were former smokers (Table 1). There were slightly more males (51%; Table 1), with the majority age ≥60 years old (73%), non-Hispanic whites (67%), and married or living with a partner (59%). 206 (30%) and 69 (10%) reported having less than high school education and household incomes less than federal poverty levels, respectively. Twenty-five (4%) were children or teenagers at the time of receipt of their first cancer diagnosis. 196 (29%) reported a smoking-related cancer and 282 (41%) had their first cancer at least 10 years earlier (Table 1). There were 117 respondents in the subsample that self-reported SHSe from indoor household sources (Table 1).

SHSe prevalence

The weighted aggregate prevalence rates of SHSe among nonsmoking adult cancer survivors over the entire study period was 28.26% (95% CI: 24.97%–31.55%; Table 2). Young adults ages 20–39 years had SHSe prevalence of 39.66% (95% CI: 28.80%–50.52%) while those age ≥60 years had a prevalence of 26.05% (95% CI: 22.89%–29.20%). SHSe was prevalent among 27.24% (95% CI: 23.16%–31.31%) and 29.66% (95% CI: 25.52%–33.80%) of females and males, respectively (Table 2). Non-Hispanic blacks had a SHSe prevalence of 55.64% (95% CI: 48.08%–63.20%), compared with 26.14% (95% CI: 22.71%–29.57%) among non-Hispanic whites, and 27.69% (95% CI: 17.87%–37.51%) among Mexican Hispanics (Table 2). Never-smokers and former smokers had SHSe prevalence of 22.98% (95% CI: 19.79%–26.18%) and 34.39% (95% CI: 29.49%–39.29%), respectively. SHSe prevalence was 35.59% (95% CI: 29.23%–41.95%) among those with a prior history of smoking-related cancers while it was 26.33% (95% CI: 22.88%–29.78%) among those whose cancer types were not related to smoking (Table 2).

Prevalence of self-reported indoor SHSe among nonsmoking cancer survivors

Weighted aggregate prevalence of self-reported indoor household SHSe among nonsmoking adult cancer survivors over the study period was 4.53% (95% CI: 3.48%–5.57%; Table 2). Overall, patterns of self-reported indoor household SHSe prevalence were similar to SHSe prevalence across sociodemographic strata and other subgroups (Table 2).

Temporal trends in SHSe

The prevalence of SHSe declined from 39.61% (95% CI: 27.88%–51.34%) in 1999/2000 to 15.68% (95% CI: 9.38%–21.98%) in 2011/2012 (Table 3; Fig. 2). The average annual percent change (AAPC), defined as the change in SHSe prevalence between successive survey cycles, was −6.31% (95% CI: −11.1% to −1.2%; Table 3). Statistically significant declining trends in SHSe from 1999 to 2012 were noted for the following sociodemographic subgroups: those age ≥60 years (AAPC: −7.15%, 95% CI: −12.8% to −1.1%); females (AAPC: −6.06%; 95% CI: −11.3% to −0.6%); having > high school education (AAPC: −7.66%; 95% CI: −13.9% to −1.9%); and having annual household incomes 100%–299% FPL (AAPC: −5.12%; 95% CI: −9.9% to −0.1%), or <100% FPL (AAPC: −7.5%; 95% CI: −14.3% to −0.3%; Table 3).

SHSe prevalence among all adults ages 20 years and older

The weighted prevalence of SHSe among adults age ≥20 years, regardless of whether they had a history of cancer diagnosis or not, computed for validation of our study results were: 47.26% (95% CI: 42.17%–52.36%) in 1999/2000; 36.77% (95% CI: 31.33%–42.21%) in 2001/2002; 41.79% (95% CI: 34.71%–48.87%) in 2003/2004; 35.62% (95% CI: 32.47%–38.76%) in 2005/2006; 36.62% (95% CI: 31.84%–41.41%) in 2007/2008; 26.74% (95% CI: 23.78%–29.70%) in 2009/2010; and 21.13% (95% CI: 18.52%–23.74%) in 2011/2012.

Regression analysis

On the basis of bivariate testing with χ^2 tests of association, variables that were associated with SHSe were: education, household income, marital status, smoking history, a history of smoking-related cancer, time since first cancer diagnosis, and a history of cardiovascular disease (Supplementary Table S1).

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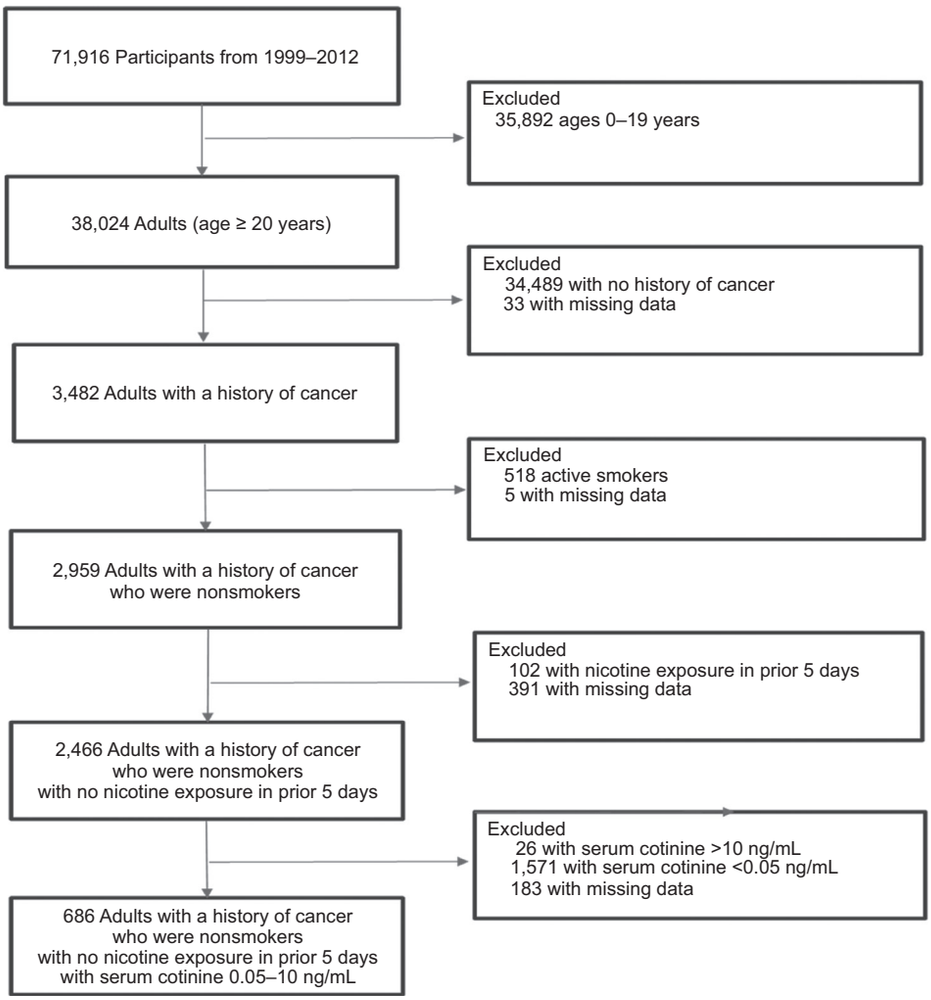

Figure 1.
Selection schema of adult nonsmoking cancer survivors: NHANES 1999–2012. Figure 1 illustrates the process of selection of the final sample of adult nonsmoking cancer survivors used in our analysis as drawn from NHANES survey cycles from 1999 to 2012. This sample comprised adults at least 20 years of age with a self-reported history of cancer who at the time of interview were not current smokers, had no recent nicotine exposure, and had serum cotinine levels between 0.05–10 ng/mL.

On multivariate analysis, survey respondents in 2009/2010 and 2011/2012 were less likely to have SHSe than those in 1999/2000 [(aOR: 0.42; 95% CI: 0.21–0.84) and (aOR: 0.27; 95% CI: 0.12–0.59), respectively; Table 4]. Those age ≥60 years had a 56% lower odds of SHSe compared with those ages 20–39 years (aOR: 0.44; 95% CI: 0.27–0.73; Table 4). Non-Hispanic blacks had almost three times the odds of SHSe compared with non-Hispanic whites (aOR: 2.96; 95% CI: 2.00–4.37; Table 4). The odds of SHSe were higher among those with only high school education as well as those with less than high school education compared with having greater than high school education [(aOR: 1.83; 95% CI: 1.35–2.49) and (aOR: 2.00; 95% CI: 1.33–3.03), respectively]. Those living below federal poverty levels (FPL) had almost three times the odds of SHSe compared with the highest income level (≥3 times FPL; aOR: 2.83; 95% CI: 1.62–4.94; Table 4). Those with a history of smoking-related cancers had a 40% higher odds of SHSe, relative to those with nonsmoking–related cancers (aOR: 1.40; 95% CI: 1.04–1.88; Table 4). Neither time since cancer diagnosis nor a history of cardiovascular disease was significantly associated with SHSe (Table 4).

Stratified multivariate analysis by smoking history generally showed similar patterns of associations among never smokers and former smokers with a few exceptions. Females were less likely than males to have SHSe among never smokers (aOR 0.63; 95% CI: 0.43–0.93) but not among former smokers (aOR 0.83; 95% CI: 0.58–1.20). Higher odds of SHSe was seen among those with a history of smoking-related cancers, relative to those with non-smoking–related cancers, among never smokers (aOR 1.84; 95% CI: 1.17–2.90) but not among former smokers (aOR 0.90; 95% CI 0.57–1.42; Table 4).

Sensitivity analysis

Trend and regression analyses limited to the 2003–2012 subsample of nonsmoking adult cancer survivors using the 0.015 ng/mL threshold for defining nonsmokers produced similar patterns to the results reported above for the sample from 1999 to 2012 using the 0.05 ng/mL threshold (Supplementary Tables S2 and S3 in the Supplementary Data).

Discussion

Our analyses show that at least 29% of nonsmoking adult cancer survivors in the United States from 1999 to 2012 had SHSe, and 5% self-reported household indoor SHSe. Temporal trends and age effects were seen with declining SHSe rates over time and with increasing age, respectively. Relatively higher

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Table 1. Characteristics of sample of adult cancer survivors in the United States from the NHANES 1999–2012

	Nonsmoking cancer survivors with SHSe (*N* = 686)	Nonsmoking cancer survivors with indoor household SHSe (*N* = 117) *N* (%)
Age		
20–39 years	42 (6.12)	8 (6.84)
40–59 years	142 (20.70)	30 (25.64)
≥60 years	502 (73.18)	79 (67.52)
Gender		
Female	333 (48.54)	61 (52.14)
Male	353 (51.46)	56 (47.86)
Race/Ethnicity		
Non-Hispanic whites	460 (67.06)	80 (68.38)
Non-Hispanic blacks	142 (20.70)	26 (22.22)
Mexican Hispanics	40 (5.83)	6 (5.13)
Others	44 (6.41)	5 (4.27)
Educational level		
Less than high school	206 (30.03)	39 (33.33)
High school	181 (26.38)	33 (28.21)
Greater than high school	298 (43.44)	45 (38.46)
Missing	1 (0.15)	0 (0)
Household income level		
≥300% federal poverty level	235 (34.26)	35 (29.91)
100–299% federal poverty level	282 (41.11)	54 (46.15)
<100% federal poverty level	100 (14.58)	21 (17.95)
Missing	69 (10.06)	7 (5.98)
Marital status		
Married/living with partner	408 (59.48)	75 (64.10)
Widowed/divorced/separated	240 (34.99)	35 (29.91)
Never married	30 (4.37)	6 (5.13)
Missing	8 (1.17)	1 (0.85)
Smoking status		
Never smokers	295 (43.00)	45 (38.46)
Former smokers	391 (57.00)	72 (61.54)
Missing	0 (0)	0 (0)
Cigarette pack-years (former smokers)[a]		
≤20	155 (39.64)	28 (38.89)
20–40	72 (18.41)	13 (18.06)
>40	116 (29.67)	23 (31.94)
Missing	48 (12.28)	8 (11.11)
Number of indoor HH smokers		
1	89 (12.97)	97 (82.91)
2	15 (2.19)	15 (12.82)
≥3	5 (0.73)	5 (4.27)
Missing	577 (84.11)	0 (0)
Cancer site related to smoking		
No	490 (71.43)	74 (63.25)
Yes	196 (28.57)	43 (36.75)
Time of first cancer diagnosis		
Childhood/teenage	25 (3.64)	9 (7.69)
Adulthood	659 (96.06)	107 (91.45)
Missing	2 (0.29)	1 (0.85)
Number of years since first cancer diagnosis		
<2 years	98 (14.29)	15 (12.82)
2–4 years	142 (20.70)	23 (19.66)
5–9 years	162 (23.62)	23 (19.66)
≥10 years	282 (41.11)	55 (47.01)
Missing	2 (0.29)	1 (0.85)
History of cardiovascular disease		
No	485 (70.70)	76 (64.96)
Yes	195 (28.43)	38 (32.48)
Missing	6 (0.87)	3 (2.56)
History of chronic respiratory disease		
No	527 (76.82)	87 (74.36)
Yes	154 (22.45)	29 (24.79)
Missing	5 (0.73)	1 (0.85)
Routine place of medical care		
Yes	642 (93.59)	109 (93.16)
No	44 (6.41)	8 (6.84)
Survey cycle		
1999–2000	82 (11.95)	12 (10.26)
2001–2002	106 (15.45)	23 (19.66)
2003–2004	118 (17.20)	24 (20.51)
2005–2006	79 (11.52)	14 (11.97)
2007–2008	145 (21.14)	16 (13.68)
2009–2010	87 (12.68)	20 (17.09)
2011–2012	69 (10.06)	8 (6.84)

[a]*N* = 391, rather than 686 because this applied to former smokers only.

rates and higher odds of SHSe were seen among those who were young (20–39 years), blacks, those who did not complete high school, the poor, and those with smoking-related cancer history.

To the best of our knowledge, this is the first study to estimate and trend the national SHSe prevalence as well as the prevalence of indoor SHSe among nonsmoking adult cancer survivors in the United States. The SHSe prevalence and self-reported SHSe prevalence rates in our study of nonsmoking adult cancer survivors are similar to recently reported national rates of SHSe in the general nonsmoking population. Lending credence to the validity of our analysis and study findings is the observation that the SHSe prevalence rates we computed for all U.S. nonsmoking adults, regardless of prior cancer diagnosis, were similar to the rates published by the CDC (16, 17).

Kaufmann and colleagues at the CDC reported national adult SHSe prevalence of 48% in 1999/2000 declining to 37% in 2007/2008 (18). Homa and colleagues reported a further decline in adult SHSe prevalence to 21% in 2011/2012 (19).While these rates are higher than the aggregate rates among cancer survivors in our study, on subgroup analysis by smoking history, we observed that former smokers have SHSe rates that are comparable with, or higher than SHSe prevalence in the general U.S. adult population.

King and colleagues reported a national prevalence of self-reported SHSe of 6% using data from the National Adult Tobacco Survey in 2010 (20). Similarly, data from the 2008 Behavioral and Risk Factor Surveillance Survey of the nonsmoking U.S. adult population found self-reported indoor SHSe ranging from 3.2% to 10.6% across the 11 states studied (21).

Our finding of SHSe prevalence, particularly among former smokers, comparable with rates seen in the general population is concerning given what is known regarding the higher risk of adverse outcomes such as treatment toxicity, incidence of second malignancies, and mortality associated with smoking among cancer patients and survivors (2). It is very plausible that ongoing SHSe may be associated with some of these outcomes given the similar mechanistic pathways of carcinogenesis and other chronic diseases that have been shown to result from both direct and indirect tobacco exposure (3). However, further studies are needed in this regard to investigate possible deleterious effects of SHSe

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Table 2. Weighted prevalence of secondhand smoke exposure[a] among nonsmoking adult cancer survivors in the United States from the NHANES: 1999–2012

	Prevalence	
Population groups and subgroups	**Nonsmoking adult cancer survivors with SHSe % (95% CI)**	**Nonsmoking adult cancer survivors with self-reported of household SHSe % (95% CI)**
All nonsmoking adult cancer survivors	28.26 (24.97–31.55)	4.53 (3.48–5.57)
Age		
20–39 years	39.66 (28.80–50.52)	10.52 (1.34–19.70)
40–59 years	30.86 (24.60–37.12)	5.25 (3.09–7.41)
≥60 years	26.05 (22.89–29.20)	3.65 (2.74–4.57)
Gender		
Female	27.24 (23.16–31.31)	4.69 (3.13–6.25)
Male	29.66 (25.52–33.80)	4.30 (2.87–5.74)
Race/ethnicity		
Non-Hispanic whites	26.14 (22.71–29.57)	4.11 (3.09–5.13)
Non-Hispanic blacks	55.64 (48.08–63.20)	11.13 (6.34–15.91)
Mexican Hispanics	27.69 (17.87–37.51)	2.88 (0.06–5.70)
Others	41.56 (26.90–56.21)	6.46 (0.00[b]–14.98)
Educational level		
Less than high school	41.61 (34.86–48.35)	6.90 (3.88–9.92)
High school	36.28 (30.57–41.98)	5.71 (3.49–7.93)
Greater than high school	21.90 (18.31–25.49)	3.49 (2.14–4.84)
Household income level		
≥300% federal poverty level	22.80 (19.11–26.49)	3.15 (2.07–4.23)
100%–299% federal poverty level	29.58 (25.42–33.74)	5.58 (3.69–7.47)
<100% federal poverty level	53.25 (40.48–66.01)	13.87 (6.21–21.53)
Marital status		
Married/living with partner	26.59 (22.99–30.20)	4.95 (3.53–6.37)
Widowed/divorced/separated	31.40 (26.49–36.31)	3.25 (2.05–4.45)
Never married	31.98 (16.93–47.04)	5.46 (0.10–10.81)
Smoking status		
Never smokers	22.98 (19.79–26.18)	3.42 (2.16–4.68)
Former smokers	34.39 (29.49–39.29)	5.81 (4.24–7.38)
Cigarette pack-years (former smokers only)		
≤20 pack-years	30.13 (24.18–36.07)	17.00 (10.63–23.36)
>20–40 pack-years	33.85 (21.94–45.75)	16.71 (6.03–27.40)
>40 pack-years	38.15 (31.21–45.08)	16.75 (7.77–25.73)
Cancer site related to smoking		
No	26.33 (22.88–29.78)	3.70 (2.72–4.69)
Yes	35.59 (29.23–41.95)	7.65 (4.66–10.64)
Number of years since first cancer diagnosis		
<2 years	28.65 (22.91–34.40)	5.02 (2.15–7.89)
2–4 years	34.19 (28.30–40.08)	5.38 (2.45–8.32)
5–9 years	27.17 (22.10–32.24)	4.05 (2.54–5.56)
≥10 years	26.00 (21.90–30.10)	4.18 (2.77–5.59)
History of cardiovascular disease		
No	26.89 (23.34–30.45)	4.09 (2.98–5.20)
Yes	33.76 (29.31–38.21)	6.20 (3.95–8.44)
History of chronic respiratory disease		
No	27.46 (24.22–30.70)	4.06 (3.21–4.90)
Yes	30.81 (24.21–37.41)	5.96 (3.12–8.80)
Routine place of medical care		
Yes	28.08 (24.74–31.41)	4.49 (3.43–5.54)
No	31.24 (21.56–40.92)	5.24 (0.79–9.68)

Abbreviations: CI, confidence interval; SHSe, secondhand smoke exposure.
[a]Secondhand smoke exposure was defined as having serum cotinine levels 0.05–10 ng/mL among nonsmokers.
[b]Lower bound of CI less than 0%.

on treatment, recurrence, and mortality outcomes among cancer survivors.

The declining trends in SHSe among nonsmoking cancer survivors in our study is generally consistent with recent studies that indicate declining national trends in the prevalence of SHSe among nonsmokers over the last 3 decades (22, 23). Factors that have been identified as contributing to the declining trends of SHSe include declining rates of active smoking, changes in societal attitudes regarding the acceptability of smoking around nonsmokers and children, increased adoption of indoor (household and workplace) smoking restrictions, as well as the widespread implementation of comprehensive and aggressive tobacco control policies (4).

Similar to our findings, prior studies have shown that blacks, the less educated, and those living below the poverty levels are more likely to have SHSe (20, 22, 24, 25). Some explanations that have been advanced for the persistence of racial disparities in SHSe in the general population include racial differences in adoption of smoke-free rules at home, in vehicles, and at workplaces (19). Biologic differences such as a slower rate of cotinine metabolism in blacks may also partially account for the higher cotinine levels seen in blacks (24).

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Table 3. Trends in the prevalence of secondhand smoke exposure[a] among nonsmoking adult cancer survivors in the United States from the NHANES, by selected sociodemographic characteristics and smoking history: 1999–2012

	1999/2000 % (95% CI)	2001/2002 % (95% CI)	2003/2004 % (95% CI)	2005/2006 % (95% CI)	2007/2008 % (95% CI)	2009/2010 % (95% CI)	2011/2012 % (95% CI)	AAPC % (95% CI)
All nonsmoking adult cancer survivors	39.61 (27.88–51.34)	31.45 (24.60–38.30)	38.13 (30.22–46.03)	27.66 (20.26–35.06)	34.59 (21.57–47.60)	19.07 (13.17–24.98)	15.68 (9.38–21.98)	−6.3 (−11.1–−1.2)
Age								
20–39 years	39.50 (0.00[a]–83.12)	53.86 (24.31–83.42)	65.32 (33.58–97.07)	37.95 (14.05–61.85)	44.52 (10.04–79.00)	19.69 (3.70–35.68)	29.08 (4.47–53.69)	−7.5 (−15.2–0.9)
40–59 years	34.94 (14.15–55.72)	30.72 (19.01–42.44)	41.27 (24.68–57.86)	30.64 (14.69–46.59)	37.69 (17.33–58.06)	23.56 (9.49–37.69)	22.56 (8.14–36.97)	−2.9 (−7.9–2.4)
≥60 years	40.95 (29.95–51.95)	29.14 (22.46–35.81)	34.42 (26.59–42.24)	25.39 (18.11–32.67)	32.49 (21.43–43.56)	17.20 (9.66–24.73)	11.51 (6.43–16.59)	−7.1 (−12.8–1.1)
Gender								
Female	43.04 (30.37–55.70)	26.84 (17.97–35.71)	35.69 (24.29–47.09)	25.61 (15.02–36.21)	35.14 (20.65–49.62)	19.04 (11.37–26.70)	16.17 (8.23–24.10)	−6.1 (−11.3 to −0.6)
Male	35.20 (23.55–46.85)	37.71 (28.66–46.76)	41.47 (31.59–51.35)	31.59 (19.85–43.32)	33.99 (18.24–49.75)	19.13 (14.09–24.16)	15.04 (5.81–24.28)	−6.4 (−13.8–1.5)
Race/ethnicity								
Non-Hispanic whites	39.10 (26.72–51.49)	27.70 (22.27–33.13)	36.66 (28.20–45.12)	25.60 (17.74–33.47)	31.83 (17.97 45.69)	16.85 (10.21–23.49)	14.27 (6.82–21.73)	−5.9 (−11.9–0.5)
Non-Hispanic blacks	54.63 (33.38–75.89)	58.89 (45.58–72.20)	69.18 (51.48–86.88)	44.20 (23.76–64.64)	70.84 (60.85–80.83)	58.07 (35.77–80.37)	33.98 (16.97–50.99)	0.3 (−5.8–6.8)
Mexican Hispanics	21.27 (0.00[a]–42.67)	38.43 (23.62–53.25)	38.47 (14.05–62.90)	14.70 (0.00[a]–33.43)	36.93 (12.54–61.33)	17.74 (3.51–31.96)	30.82 (0.00[a]–66.43)	−3.4 (−12.1–6.1)
Others	40.80 (0.00[b]–85.34)	93.37 (8.02–100.00[c])	29.39 (0.00[a]–60.80)	51.58 (23.06–80.10)	41.15 (14.17–68.12)	28.47 (8.94–47.99)	16.81 (2.68–30.94)	−13.8 (−20.4 to −6.7)
Educational level								
Greater than high school	36.73 (22.19–51.27)	25.82 (17.96–33.68)	34.26 (23.39 45.13)	21.32 (11.79–30.85)	24.64 (13.19–36.10)	14.12 (7.65–20.59)	11.73 (3.98–19.48)	−7.7 (−13.1 to −1.9)
High school	34.37 (22.33–46.41)	39.19 (22.12–56.27)	40.28 (26.88–53.68)	36.44 (19.90–52.97)	49.43 (33.09–65.78)	19.68 (12.51–26.86)	32.96 (16.28–49.64)	−2.3 (−9.9–5.9)
Less than high school	55.01 (37.32–72.71)	42.72 (27.31–58.14)	44.37 (22.98–65.77)	39.34 (26.40–52.28)	48.06 (29.10–67.02)	44.19 (33.10–55.28)	16.89 (8.80–24.97)	−3.8 (−10.0–2.9)
Household income level								
≥300% federal poverty level	35.26 (15.33–55.18)	25.05 (16.82–33.28)	33.10 (22.48–43.72)	19.79 (11.71–27.87)	30.03 (17.24–42.82)	16.05 (10.02–22.08)	11.70 (3.86–19.54)	−6.4 (−13.1–0.7)
100%–299% federal poverty level	35.93 (21.27–50.60)	33.79 (26.70–40.91)	38.20 (28.86–47.53)	31.23 (21.18–41.27)	34.42 (19.27–49.56)	21.29 (12.49–30.09)	15.18 (6.43–23.93)	−5.1 (−9.9 to −0.1)
<100% federal poverty level	67.67 (47.02–88.32)	57.36 (13.26–100.00[c])	62.99 (38.74–87.25)	71.61 (43.90–99.32)	58.91 (35.04–82.78)	43.40 (22.67–64.13)	23.28 (2.10–44.46)	−7.5 (−14.3 to −0.3)
Smoking status								
Never smokers	32.14 (19.54–44.75)	27.49 (18.43–36.55)	27.72 (18.32–37.13)	24.56 (16.23–32.89)	29.02 (19.97–38.07)	15.43 (9.69–21.17)	13.42 (5.11–21.72)	−5.4 (−10.5–0.1)
Former smokers	48.62 (34.86–62.38)	35.62 (28.06–43.18)	46.41 (36.77–56.06)	31.44 (20.01–42.87)	41.17 (21.20–61.13)	23.97 (16.06–31.88)	18.83 (6.99–30.66)	−5.6 (−11.1–0.2)

Abbreviations: AAPC, average annual percent change; CI, confidence interval.

[a]Secondhand smoke exposure was defined as having serum cotinine levels 0.05–10 ng/mL among nonsmokers.

[b]Lower bound of CI less than 0%.

[c]Upper bound of CI greater than 100%.

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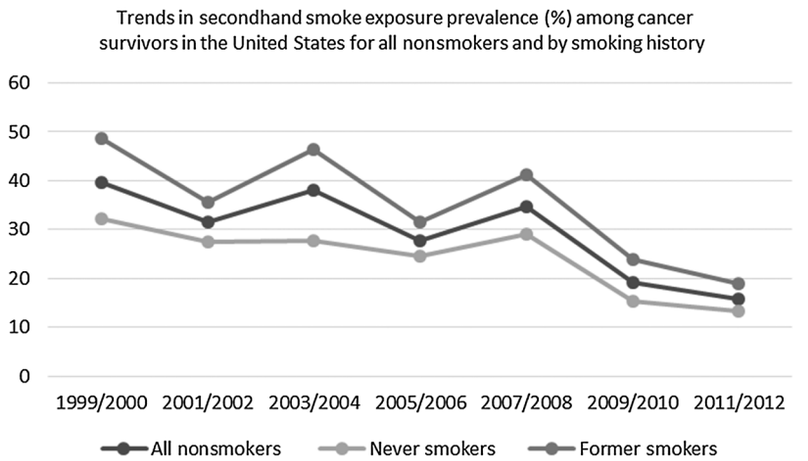

Figure 2.
Temporal trends in the prevalence of secondhand household smoke exposure among nonsmoking cancer survivors in the United States: NHANES 1999–2012. Figure 2 depicts the temporal trends in the prevalence of secondhand smoke exposure among all adult nonsmoking cancer survivors, as well as by smoking history—never smokers and former smokers. Secondhand smoke exposure was defined as having serum cotinine levels 0.05–10 ng/mL among nonsmokers. The scale of the ordinate is in percent (%) while the scale of the abscissa is in years (biennia) from 1999 to 2012.

Persons of low socioeconomic standing may be at higher risk of SHSe because they tend to live in multi-unit housings where SHSe occur more frequently from smoking in neighboring apartments (19). It is very reasonable to posit that the explanatory factors that result in higher SHSe and serum cotinine levels in blacks and those of low socioeconomic status in the general population are also likely to be at play among nonsmoking adult cancer survivors.

A notable finding in our study was the association between having a history of smoking-related cancers among former smokers and SHSe. Given that survivors with a history of smoking-related cancers are more likely to have been smokers, such survivors are more likely to have smokers in their social networks, and have social environments that facilitate tobacco exposure (25, 26). Therefore, having a history of smoking-related cancer may simply may be a marker of possible ongoing SHSe that healthcare providers caring for cancer survivors should be aware of. In this regard, a recent recommendation encourages standardized robust assessment of tobacco use and SHSe in clinical cancer research given the lack of specificity in the timing of tobacco exposure assessment as is currently reported in the literature (27, 28). It would be more informative for future studies to evaluate if smokers who quit after cancer diagnosis are more or less likely than those who had quit prior to the receipt of their diagnoses to have home and vehicle smoking restrictions or lower levels of SHSe.

The higher likelihood of survivors with smoking-related cancers to experience SHSe may also reflect a lack of appreciation of the role of SHSe in the etiology of such cancers. This is plausible given a prior report of limited knowledge regarding the dangers of continued smoking for cancer survivors (29).In any case, the diagnosis of a smoking-related cancer presents a teachable moment for encouraging such patients to adopt smoke-free home rules as well as providing smoking-cessation advice and counseling to their smoking household contacts (30–33). A clinical implication for all healthcare professionals involved in the follow-up care of cancer survivors relates to the importance of assessing SHSe (34). From a public health perspective, this holds promise for improving on the notable decline of cancer-related mortality in the United States, a trend partly attributable to declining population rates of primary tobacco exposure (35).

Further studies are indicated to demonstrate the effectiveness of smoke-free household advice and counseling on cancer-related outcomes and other health outcomes. For public health authorities, these findings reemphasize the need for intensifying efforts aimed at reducing SHSe in socioeconomically disadvantaged groups such as the widespread adoption of smoke-free home rules in public and subsidized housing—a measure that will hopefully reduce SHSe and disparities among cancer survivors as well as the general population.

Limitations

Several limitations of our study should be noted. First, the history of cancer diagnosis was obtained via self-report. Although, history of cancer diagnosis may be underreported in epidemiologic surveys utilizing self-report and result in misclassification bias, we have no reason to believe that underreporting of cancer diagnosis biased the reporting of indoor household SHSe (36). Second, SHSe was determined on the basis of serum cotinine levels with a threshold level of 0.05 ng/mL. Given that the limit of detection of serum cotinine improved to 0.015 ng/mL for all participants since the 2003/2004 cycle, the SHSe rates presented in this study should be regarded as conservative estimates. As noted earlier, the 0.05 ng/mL cutoff was utilized across all cycles to facilitate consistency for trend analyses. Third, insufficient sampling of non-Mexican Hispanic subgroups and other racial/ethnic minorities precluded estimation of SHSe prevalence and trends among cancer survivors in these groups. Fourth, indoor household SHSe was measured by self-report. Although there is the potential for misreporting, self-reported assessment of SHSe by adults across a range of environments has been shown to be reliable and has been validated using biomarkers such as cotinine, and with airborne concentrations of secondhand smoke constituents such as nicotine (4, 37–39). Fifth, we were unable to establish the timing of smoking cessation relative to cancer diagnosis among former smokers. Sixth, as explained earlier, we utilized a prior diagnosis of leukemia as a surrogate for AML and classified such patients as having smoking-related cancers. Only 12 participants in the final sample had leukemia, and any possible misclassification of those participants regarding having smoking-related cancers appears unlikely to have influenced the study results. Seventh, we did not adjust the results of our multivariable regression analyses for multiple comparisons although the number of multiple comparisons was very modest. Finally, the

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Table 4. Weighted multivariable associations between SHSe[a] among nonsmoking adult cancer survivors in the United States and their sociodemographic and clinical characteristics—the NHANES: 1999–2012

	Nonsmokers aOR (95% CI)	Never smokers aOR (95% CI)	Former smokers aOR (95% CI)
Period			
1999–2000	Ref	Ref	Ref
2001–2002	0.74 (0.38–1.42)	0.89 (0.37–2.11)	0.60 (0.30–1.24)
2003–2004	0.96 (0.48–1.89)	0.94 (0.40–2.20)	0.85 (0.40–1.80)
2005–2006	0.65 (0.32–1.31)	0.85 (0.36–1.97)	0.49 (0.21–1.15)
2007–2008	0.87 (0.43–1.78)	0.94 (0.41–2.14)	0.80 (0.30–2.12)
2009–2010	0.41 (0.21–0.84)	0.50 (0.21–1.16)	0.33 (0.15–0.74)
2011–2012	0.27 (0.12–0.59)	0.36 (0.13–1.05)	0.20 (0.08–0.48)
Age			
20–39 years	Ref	Ref	Ref
40–59 years	0.61 (0.37–1.03)	0.87 (0.39–1.93)	0.28 (0.10–0.77)
≥60 years	0.41 (0.24–0.68)	0.45 (0.22–0.92)	0.23 (0.09–0.60)
Gender			
Male	Ref	Ref	Ref
Female	0.68 (0.53–0.88)	0.65 (0.43–0.96)	0.84 (0.59–1.21)
Race/ethnicity			
Non-Hispanic whites	Ref	Ref	Ref
Non-Hispanic blacks	3.09 (2.12–4.50)	3.36 (1.88–6.03)	2.83 (1.80–4.43)
Mexican Hispanics	0.62 (0.32–1.19)	0.77 (0.32–1.87)	0.43 (0.17–1.08)
Others	1.66 (0.91–3.02)	1.21 (0.56–2.60)	3.01 (1.27–7.16)
Educational level			
Greater than high school	Ref	Ref	Ref
High school	1.83 (1.35–2.50)	2.12 (1.31–3.44)	1.54 (0.98–2.41)
Less than high school	1.99 (1.32–3.01)	2.06 (1.28–3.32)	1.97 (1.07–3.28)
Household income level			
≥300% federal poverty level	Ref	Ref	Ref
100%–299% federal poverty level	1.11 (0.83–1.50)	1.24 (0.83–1.86)	1.04 (0.70–1.55)
<100% federal poverty level	2.63 (1.49–4.62)	2.95 (1.53–5.69)	2.79 (1.40–5.58)
Cancer site related to smoking			
No	Ref	Ref	Ref
Yes	1.38 (1.02–1.86)	1.80 (1.14–2.84)	1.01 (0.68–1.51)
Number of years since first cancer diagnosis			
<2 years	Ref	Ref	Ref
2–4 years	1.14 (0.76–1.70)	1.15 (0.59–2.22)	1.08 (0.63–1.86)
5–9 years	0.90 (0.60–1.35)	0.92 (0.48–1.78)	0.83 (0.48–1.42)
≥10 years	0.82 (0.59–1.16)	0.78 (0.43–1.40)	0.77 (0.46–1.31)
Cardiovascular disease			
No	Ref	Ref	Ref
Yes	1.28 (0.99–1.66)	0.99 (0.64–1.54)	1.42 (0.97–2.07)

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; ref, reference group.
[a]Secondhand smoke exposure was defined as having serum cotinine levels 0.05–10 ng/mL among nonsmokers.

possibility of residual confounding exists although we adjusted for known confounders available from the survey.

Conclusion

SHSe of nonsmoking adult cancer survivors in the United States has declined but certain sociodemographic subgroups, former smokers, and those with smoking-related cancers are disproportionately burdened by SHSe. From a public health viewpoint, these reinforce the need for sustaining effective comprehensive tobacco control policies as well as particularly targeting these disadvantaged subgroups. These findings also provide a catalyst for healthcare professionals involved in the care of cancer survivors to assess SHSe and counsel survivors and their families regarding the need to adopt effective strategies with the goal of eliminating SHSe among adult cancer survivors in the United States.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: O. Akinboro, O. Olorunfemi
Development of methodology: O. Akinboro, O. Olorunfemi
Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): O. Akinboro
Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): O. Akinboro, O. Olorunfemi
Writing, review, and/or revision of the manuscript: O. Akinboro, O. Olorunfemi, P. Basak, D. Pomerantz, B. Bernhardt, R. Gucalp, S. Jesmajian, J.S. Ostroff
Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): O. Akinboro
Study supervision: B. Bernhardt, S. Jesmajian
Other (reviewing manuscript): E. Phillips

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References

1. Centers for Disease Control and Prevention (CDC). Smoking-attributable mortality, years of potential life lost, and productivity losses—United States, 2000–2004. MMWR Morb Mortal Wkly Rep 2008;57:1226–8.
2. U.S. Department of Health and Human Services. The health consequences of smoking – 50 years of progress: a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.
3. U.S. Department of Health and Human Services. The health consequences of involuntary exposure to tobacco smoke: a report of the surgeon general. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2006.
4. Max W, Sung H, Shi Y. Deaths from secondhand smoke exposure in the United States: economic implications. Am J Public Health 2012; 102:2173–80.
5. Zhou W, Heist RS, Liu G, Asomaning K, Miller DP, Neuberg DS, et al. Second hand smoke exposure and survival in early-stage non-small cell lung cancer patients. Clin Cancer Res 2006;12:7187–93.
6. Kashigar A, Habbous S, Eng L, Irish B, Bissada E, Irish J, et al. Social environment, secondary smoking exposure, and smoking cessation among head and neck cancer patients. Cancer 2013;119:2701–9.
7. Eng L, Su J, Qiu X, Palepu PR, Hon H, Fadhel E, et al. Second-hand smoke as a predictor of smoking cessation among lung cancer survivors. J Clin Oncol 2014;32:564–70.
8. Eng L, Qiu X, Su J, Pringle D, Niu C, Mahler M, et al. The role of second-hand smoke exposure on smoking cessation in non-tobacco-related cancers. Cancer 2015;121:2655–63.
9. Burke L, Miller L, Saad A, Abraham J. Smoking behaviors among cancer survivors: an observational clinical study. J Oncol Pract 2009;5:6–9.
10. Westmaas JL, Alcaraz KI, Berg CJ, Stein KD. Prevalence and correlates of smoking and cessation-related behavior among survivors of ten cancers: findings from a nationwide survey nine years after diagnosis. Cancer Epidemiol Biomarkers Prev 2014;23:1783–92.
11. Peters EN, Torres E, Toll BA, Cummings KM, Gritz ER, Hyland A, et al. Tobacco assessment in actively accruing national cancer institute cooperative group program clinical trials. J Clin Oncol 2012;30:2869–75.
12. National Center for Health Statistics. National Health and Nutrition Examination Survey, 2013–2014 Overview. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics; 2014. Available from:https://www.cdc.gov/nchs/nhanes/index.htm.
13. Watts RR, Langone JJ, Knight GJ, Lewtas J. Cotinine analytical workshop report: consideration of analytical methods for determining cotinine in human body fluids as a measure of passive exposure to tobacco smoke. Env Health Perspec 1990;84:173.
14. Centers for Disease Control and Prevention. Fourth national report on human exposure to environmental chemicals. Atlanta, GA: US Department of Health and Human Services, CDC; 2009. Available at: https://www.cdc.gov/biomonitoring/pdf/FourthReport_UpdatedTables_Feb2015.pdf. Accessed January 28, 2017.
15. Campisi J. Aging, cellular senescence, and cancer. Annu Rev Physiol 2013;75:685–705.
16. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al. on behalf of the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2016 update: a report from the American Heart Association. Circulation 2016;133:447–54.
17. Joinpoint Regression Program, Version 4.4.0 - January 2017; Statistical Methodology and Applications Branch, Surveillance Research Program. Bethesda, MD: National Cancer Institute; 2017.
18. Kaufmann RB, Babb S, O'Halloran A, Asman K, Bishop E, Tynan M, et al. Vital signs: Nonsmokers' exposure to secondhand smoke - United States, 1999–2008. MMWR Morb Mortal Wkly Rep 2010;59:1141–6.
19. Homa DH, Neff LJ, King BA, Caraballo RS, Bunnell RE, Babb SD, et al. Vital signs: Disparities in nonsmokers' exposure to secondhand smoke—United States, 1999–2012. MMWR Morb Mortal Wkly Rep 2015;64: 103–8.
20. King BA, Dube SR, Homa DM. Smoke-free rules and secondhand smoke exposure in homes and vehicles among US adults, 2009–2010. Prev Chronic Dis 2013;10:120218.
21. Malarcher A, Shah N, Tynan M, Maurice E, Rock V. State-specific secondhand smoke exposure and current cigarette smoking among adults - United States, 2008. MMWR Morb Mortal Wkly Rep 2009:58;1232–5.
22. Pirkle JL, Bernert JT, Caudill SP, Sosnoff CS, Pechacek TF. Trends in the exposure of nonsmokers in the U.S. population to secondhand smoke: 1988–2002. Environ Health Perspect 2006;114:853–8.
23. Ellis JA, Gwynn C, Garg RK, Philburn R, Aldous KM, Perl SB, et al. Secondhand smoke exposure among nonsmokers nationally and in New York city. Nicotine Tob Res 2009;11:362–70.
24. Perez-Stable EJ, Herrera B, Jacob P, Benowitz NL. Nicotine metabolism and intake in black and white smokers. JAMA 1998;280:152–6.
25. Christakis NA, Fowler JH. The collective dynamics of smoking in a social network. N Eng J Med 2008;358:2249–58.
26. Haddock CK, Klesges RC, Talcott GW, Lando H, Stein RJ. Smoking prevalence and risk factors for smoking in a population of United States Air Force basic trainees. Tobacco Control 1998;7:232–5.
27. Land SR, Toll BA, Moinpour CM, Mitchell SA, Ostroff JS, Hatsukami DK, et al. Research priorities, measures, and recommendations for assessment of tobacco use in clinical cancer research. Clin Cancer Res 2016;22:1907–13.
28. Burris JL, Studts JL, DeRosa AP, Ostroff JS. Systematic review of tobacco use after lung or head/neck cancer diagnosis: results and recommendations for future research. Cancer Epidemiol Biomarkers Prev 2015;24: 1450–61.
29. Burke L, Miller L, Saad A, Abraham J. Smoking behaviors among cancer survivors: an observational clinical study. J Oncol Pract 2009;5:6–9.
30. DeSantis CE, Lin CC, Mariotto AB, Siegel RL, Stein KD, Kramer JL, et al. Cancer treatment and survivorship statistics, 2014. CA Cancer J Clin 2014;64:252–71.
31. Pentz RD, Berg CJ. Smoking and Ethics: What are the duties of oncologists? Oncologist 2010;15:987–93.
32. Wolin KY, Dart H, Colditz GA. Eight ways to stay healthy after cancer: an evidence-based message. Cancer Causes Control 2013;24:827–37.
33. Vijayvergia N, Denlinger CS. Lifestyle factors in cancer survivorship: where we are and where we are headed. J Pers Med 2015;5:243–63.
34. Hyland A, Higbee C, Travers MJ, Van Deusen A, Ansal-Travers MB, King B, et al. Smoke-free homes and smoking cessation and relapse in a longitudinal population of adults. Nicotine Tob Res 2009;1:614–8.
35. Siegel RL, Miller KD, Jemal A. Cancer Statistics, 2016. CA Cancer J Clin 2016;66:7–30.
36. Desai MM, Bruce ML, Desai RA, Druss BG. Validity of Self-reported Cancer history: a comparison of health interview data and cancer registry records. Am J Epidemiol 2001;153:299–306.
37. Avila-Tang E, Elf JL, Cummings KM, Fong GT, Hovell MF, Klein JD, et al. Assessing secondhand smoke exposure with reported measures. Tobacco Control 2013;22:156–63.
38. Eisner MD, Katz PP, Yelin EH, Hammond SK, Blanc PD. Measurement of environmental tobacco smoke exposure among adults with asthma. Environ Health Perspect 2001;109:809–14.
39. Willemsen MC, Brug J, Uges DR, Vos de Wael ML. Validity and reliability of self-reported exposure to environmental tobacco smoke in work offices. J Occup Environ Med 1997;39:1111–4.

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Secondhand Smoke Exposure Among Community-Dwelling Adult Cancer Survivors in the United States: 1999–2012

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