RESEARCH ARTICLE

Tobacco and E-cigarette use among cancer survivors in the United States

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Abstract

Background

Limited information exist on tobacco and e-cigarette use patterns in cancer survivors. The purpose of this study is to report on use patterns in cancer survivors compared with non-cancer participants from the Population Assessment of Tobacco and Health (PATH) Study.

Methods

Sociodemographic data and tobacco product use were analyzed for 32,244 adult participants from the PATH Study in 2013–2014 by cancer status and age. Logistic regression examined the patterns of and factors associated with tobacco use by cancer status.

Results

Overall, cancer survivors represented 7.1% (n = 1,527) of participants, were older, and had a higher proportion of females and non-Hispanic whites than non-cancer participants. In cancer survivors, current and former cigarette smoking was reported in 12.7% and 32.9% respectively, compared with 18.5% and 19.0% in non-cancer adults. Current e-cigarette use was reported by 3.8% of survivors compared with 5.7% of non-cancer participants. Dual tobacco use was reported by 25.0% and poly use by 6.9% of cancer survivors who currently smoked. All other forms of current tobacco use were individually reported by <5% of survivors. Young adult cancer survivors (aged 18–44) reported the highest rates of current cigarette smoking (27.9%) and current e-cigarette use (11.8%). The effects of age, sex, race/ethnicity, education, and income on tobacco use status were comparable for cancer survivors and non-cancer participants. Cancer survivors who were younger, male, of lower
educational attainment, and those diagnosed with a tobacco-related cancer were more likely to report current tobacco use.

Conclusions

Among cancer survivors, cigarette smoking remains the predominant form of tobacco use, although other tobacco/nicotine use and dual/poly use are common. The PATH Study provides detailed tobacco product use patterns in survivors, including their adoption of emerging alternative tobacco products.

Introduction

Many cancer survivors continue to use tobacco products after their cancer diagnosis despite the mounting evidence showing reduced effectiveness of cancer treatments, increased overall and cancer-specific mortality and increased risk for a second primary cancer.[1] Tobacco use has also been associated with poorer response to cancer treatment and cancer recurrence leading to significantly increased costs associated with cancer treatment.[2] Cigarette smoking rates among cancer survivors have been reported in prior studies using two national data sources. First, using the National Health Interview Survey (NHIS), current smoking prevalence among cancer survivors was 20.2% in a study that combined four waves of the NHIS (1998–2001).[3] Second, using the National Cancer Institute (NCI)’s Health Information National Trends Survey (HINTS), current smoking prevalence was 18.7% in a combined three waves of HINTS (2003, 2005, and 2007).[4]

The use of e-cigarettes and other tobacco products have increased considerably in recent years,[5,6] and a recent analysis of the NHIS showed an increasing trend in the prevalence of e-cigarette ever use among cancer survivors from 8.5% in 2014–2015 to 10.7% in 2016–2017. [7] Another analysis of the 2014–2015 NHIS focusing on the use of e-cigarettes among adults with medical comorbidities found that former smokers with cancer had lower odds of e-cigarette use.[8] Further, a recent study of cancer patients at Mid-South cancer centers found that among cigarette smokers, nearly one-third reported using two or more tobacco products.[9]

The Population Assessment of Tobacco and Health (PATH) Study was established in 2011 following the Family and Smoking Prevention and Tobacco Control Act of 2009.[10] The purpose of the PATH Study is to produce national epidemiologic information on tobacco use behavior and health in the U.S. population.[11] In contrast to other national surveys that have been used for the surveillance of tobacco use, the PATH Study provides a detailed assessment of use behaviors for the various nicotine and tobacco products available in the U.S. in a manner that is in more depth than prior population health assessments.[11,12]

A recent analysis of data from the PATH Study examined dual use of cigarettes and e-cigarettes in cancer survivors and found that among smokers, cancer survivors were using e-cigarettes at similar rates as non-cancer participants and both groups were motivated to use e-cigarettes largely for perceived health-related reasons.[12] Given its focus on dual use, the analysis excluded participants who were not current cigarette smokers and it did not investigate the use of other tobacco products. Therefore, the current study examines tobacco and e-cigarette use information in cancer survivors who participated in the PATH Study to address a knowledge gap in characterizing use patterns for cigarettes and alternative products from a nationally representative sample of U.S. adults.
Methods

Data source

Data were obtained from the PATH Study, a household-based, longitudinal, nationally representative cohort study of 45,971 adults and youth in the U.S. that is designed to measure prevalence and correlates of tobacco use. The current study was limited to adults who participated in Wave 1 of the PATH Study between September 2013 and December 2014. PATH recruitment was completed using a four-stage, stratified probability sample design in which a predetermined number of participants (N = 32,320 for adults) was randomly recruited by home address. The sample included current, former, and never tobacco users who completed computer- and audio-assisted structured interviews and received $35 compensation. The time required to complete the survey was approximately 45 minutes. The PATH Study was weighted to reflect the U.S. population including adjustments for oversampling and nonresponse.[13] The weighted interview response rate for adults in Wave 1 was 74.0%. Additional details of survey methodology are available elsewhere.[11] Although data from subsequent waves of the PATH Study are available, we limited the analysis to Wave 1 due to missing capture of the former tobacco use status measures in Waves 2 and 3, which impacts the ability to estimate reliable prevalence rates.

Tobacco and nicotine use categories

The PATH Study uses pictures to assist respondents in answering questions about their awareness and use of noncigarette tobacco and nicotine products. Prevalence of current, former, or never use was assessed for the following tobacco and nicotine products: cigarettes, e-cigarettes (electronic cigarettes), traditional cigars, cigarillos, filtered cigars, smokeless tobacco, snus, pipe tobacco, and hookah. For cigarettes, current smoking status was assigned to participants who had smoked more than 100 cigarettes in their lifetime and currently smoke cigarettes every day or some days, and former smoking was assigned to those who had smoked at least 100 cigarettes in their lifetime but now do not smoke at all. Never smoking was assigned to those who had never smoked a cigarette, even one or two puffs. Current cigarette smokers were further classified into daily and less than daily smokers. Pack-year history was also calculated for current and former cigarette smokers. For all other tobacco and nicotine-delivery products, current use was assigned to those who have ever used the product and now use it every day or some days, whereas former use was assigned to those who had ever used the product fairly regularly but now do not use it at all. Never use was assigned to those who had never used the product even once or twice. Among current users of any tobacco/nicotine products, we further classified product use into mono use (1 product only), dual use (any 2 products), or poly use (>2 products).

Reasons for noncigarette product use

Participants who reported current use of any noncigarette product or who had quit such products in the past 12 months were asked a series of yes or no questions about 13 reasons for using these products. There were 3 health-related reasons—“they might be less harmful to me than cigarettes,” “they might be less harmful to people around me than cigarettes,” and “using them helps people to quit smoking cigarettes.” The remaining reasons were not health-related, including, “I can use them at times when or in places where smoking cigarettes isn’t allowed,” “they don’t smell,” “they are more acceptable to non-tobacco users,” “they come in flavors I like.” Each reason was analyzed separately.
Cancer status

Participants were defined as cancer survivors if they responded affirmatively to the following question, ‘Have you ever been told by a doctor or other health professional that you had cancer?’ Cancer survivors were further classified as having a tobacco-related cancer if the cancer site reported was one of the following: bladder, cervix, colon, esophagus, kidney, larynx, liver, lung, mouth, pancreas, rectum, stomach, and throat.

Sociodemographic measures

The following demographic characteristics of participants were included: gender (male or female), age (in years) aggregated into groups (18–44, 45–64, and 65 or more), race/ethnicity (non-Hispanic white, non-Hispanic black, and other), educational attainment (not a high school graduate, GED or high school graduate, some college or associate degree, bachelor’s degree or higher), annual household income (less than $25,000, $25,000 to $49,999, $50,000 to $99,999, and $100,000 or more), and U.S. Census region (Northeast, South, Midwest, and West).

Statistical analyses

Frequencies and percentages weighted to the U.S. population were calculated by cancer status (i.e., cancer survivor vs. no history of cancer) and age group across all adults who completed the survey for current/former/never use of the following nicotine and tobacco product categories: cigarettes, e-cigarettes, any cigars (i.e., cigars, cigarillos, and filtered cigars), smokeless tobacco and snus, pipe tobacco, and hookah. We also classified participants who had used any tobacco/nicotine products as mono (one product), dual (two products), and poly (more than two) tobacco/nicotine product users among those who reported current use of any types of tobacco or nicotine products. Weighted percentages were calculated for use of the aforementioned categories by cigarette smoking status and stratified by cancer status (cancer survivor vs. no history of cancer). Among cancer survivors, weighted percentages and 95% confidence intervals (CIs) were calculated using the logit transformation method[5] to describe the leading reasons for noncigarette product use. The differences in demographic characteristics by cancer status were assessed using Rao-Scott adjusted Pearson Chi-square tests. Differences in continuous variables (e.g., pack-year history) by cancer status were assessed using adjusted Wald tests and p-values were estimated based on F-distributions. Multivariable logistic regression was used to identify demographic and socioeconomic characteristics associated with (1) any tobacco or nicotine product use and (2) dual/poly use of at least two products. The models reported estimated adjusted odds ratios (AORs) and their 95% CIs for each independent variable. The models for cancer survivors included as an additional variable whether a tobacco-related cancer was reported. Percentages and AOR estimates were weighted to the U.S. adult population to account for the complex sampling scheme using PATH Survey weights, and 95% CIs were estimated with the method of balanced repeated replications[14] with Fay’s adjustment set to 0.3 to increase estimate stability.[15] We excluded cases with missing cancer status. All statistical analyses were conducted using STATA/SE software (version 15.1; StataCorp, College Station, TX, USA) survey procedures using the “svy:” command, and all statistical tests were two-tailed. All analyses were prepared in a reproducible manner and available upon request. This study was deemed exempt by the University of Florida Institutional Review Board.
Results
Sample characteristics
Characteristics of adult respondents in Wave 1 of the PATH Study, stratified by cancer status, are presented in Table 1. Cancer survivors (n = 1,527) represented 7.1% of the overall sample (weighted prevalence), and were generally older than non-cancer respondents: 10.6% of cancer survivors were under age 45 as compared with 50.1% of non-cancer respondents. Among cancer survivors, 58.2% were female, compared with 51.4% among non-cancer respondents. Only 10.6% of cancer survivors were from racial or ethnic minority groups, compared with 23.0% of non-cancer respondents. Though statistically different, patterns of education and household income were similar in cancer survivors and non-cancer participants. Almost one-third of cancer survivors (28.7%) reported having been diagnosed with a tobacco-related cancer.

Table 1. Baseline characteristics of adult respondents (N = 32,320) by cancer status: Population Assessment of Health and Tobacco (PATH) Study, 2013–2014.

| Characteristics                  | Cancer survivor (n = 1,527) | No history of cancer (n = 30,717) | P value |
|----------------------------------|-----------------------------|----------------------------------|---------|
| Age, in years                    |                             |                                  |         |
| 18–44                            | 296                         | 20,054                           | 10.6    |
| 45–64                            | 653                         | 8,141                            | 38.0    |
| ≥65                              | 578                         | 2,516                            | 51.4    |
| Sex                              |                             |                                  |         |
| Female                           | 898                         | 15,061                           | 58.3    |
| Male                             | 629                         | 15,656                           | 41.7    |
| Race/ethnicity                   |                             |                                  |         |
| White, non-Hispanic              | 1,298                       | 22,531                           | 89.5    |
| Black, non-Hispanic              | 133                         | 4,904                            | 6.0     |
| Other                            | 96                          | 3,282                            | 4.6     |
| Education                        |                             |                                  |         |
| Not high school graduate         | 186                         | 4,039                            | 10.1    |
| GED or high school graduate      | 417                         | 9,333                            | 29.1    |
| Some college or associate degree | 511                         | 10,780                           | 29.5    |
| Bachelor’s degree or higher      | 408                         | 6,393                            | 31.3    |
| Annual household income          |                             |                                  |         |
| Less than $25,000                | 669                         | 14,859                           | 38.2    |
| $25,000 to $49,999               | 314                         | 6,352                            | 21.2    |
| $50,000 to $99,999               | 315                         | 5,821                            | 23.5    |
| $100,000 or more                 | 229                         | 3,685                            | 17.2    |
| U.S. Census region               |                             |                                  |         |
| Northeast                        | 226                         | 4,811                            | 16.7    |
| Midwest                          | 426                         | 7,251                            | 25.8    |
| South                            | 535                         | 11,658                           | 36.4    |
| West                             | 340                         | 6,997                            | 21.2    |
| Tobacco-related cancer           |                             |                                  |         |
| Yes                              | 538                         | NA                               | 28.7    |
| No                               | 979                         | NA                               | 71.4    |

Note: Tobacco related cancers include bladder, cervix, colon, esophagus, kidney, larynx, liver, lung, mouth, pancreas, rectum, stomach, and throat cancer. 76 cases were excluded because cancer status was missing. Abbreviation: NA, not applicable.

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**Tobacco use in cancer survivors**

Weighted prevalence of current, former, and never use of tobacco and nicotine products stratified by cancer status is reported in Table 2. Overall, 17.2% of cancer survivors were current users of any tobacco or nicotine product (12.6% were daily users), compared with 26.9% (18.1% daily users) among non-cancer respondents. The most common currently used product was conventional cigarettes among both cancer survivors (12.7%; 10.5% were daily smokers) and non-cancer respondents (18.5%; 14.7% were daily smokers), followed by any cigars (4.2 vs. 7.6%), e-cigarettes (3.8% vs. 5.7%), and smokeless tobacco and snus (1.6% vs. 3.4%), hookah (1.0% vs. 4.3%), and pipe tobacco (0.9% vs. 1.1%). Among cancer survivors on average, current smokers had a 28.9 pack-year history compared to a 19.6 pack-year history among non-cancer respondents.

Former use of any tobacco or nicotine product was higher in cancer survivors as compared with non-cancer participants (33.1% vs. 18.2%) as was former use of conventional cigarettes (32.9% vs. 19.0%), pipe tobacco (6.6% vs. 2.3%), and any cigars (4.2% vs. 3.3%). In contrast, lower prevalence of former tobacco use was reported among cancer survivors vs. non-cancer respondents for e-cigarettes (0.7% vs. 1.0%), smokeless tobacco and snus (2.5% vs. 3.3%) and hookah (0.2% vs. 0.8%). Among cancer survivors on average, former smokers had a 29.0 pack-year history compared to 21.2 pack-year history among non-cancer respondents.

Among cancer survivors who were current tobacco or nicotine product users and reported complete information on product use (n = 636), 68.1% used only one product (mono users), 25.0% were dual users, and 6.9% used more than two products (Fig 1). Among non-cancer respondents (n = 15,009), 64.2% were mono users, 24.4% dual users, and 11.4% poly users.

Table 3 shows the weighted prevalence of current, former, and never use of tobacco and nicotine products among cancer survivor stratified by age group (i.e., 18–44, 45–64, and 65 or more). Current cigarette smoking was highest among the 18–44 age group (27.9%) and former smoking was highest among those 65 or more (40.9%). Young adult cancer survivors (18–44 years) had the highest rates any tobacco use (37.7%) across all age groups, as well as for the following individual products: e-cigarette use (11.8%), cigar smoking (10.6%), hookah smoking (6.2%), and smokeless tobacco/snus (3.7%).

**Dual and poly use of cigarettes and non-cigarette products**

Table 4 displays the weighted prevalence of current, former, and never use of tobacco and nicotine products evaluated against current, former, and never cigarette smoking status by cancer status. Among cancer survivors who reported current cigarette smoking, 58.8% were exclusive cigarette smokers, whereas 22.0% also reported current use of e-cigarettes, 15.0% were current any cigar smokers, 4.7% were also current users of smokeless tobacco or snus, 4.0% were also current hookah smokers, and 2.0% were also current smokers of pipe tobacco. On average, cancer survivors who were exclusive cigarette smokers reported smoking 16.7 cigarettes per day, compared with 15.8 cigarettes per day among current e-cigarette users, 12.7 cigarettes per day among former e-cigarette users and 19.9 cigarettes per day among never e-cigarette users (cigarettes per day not reported in the table).

Among non-cancer respondents who were current cigarette smokers (n = 10,872), 54.2% were exclusive cigarette smokers, whereas 21.2% were also current users of e-cigarettes, 20.6% were also current smokers of any cigars, 10.0% were also current hookah smokers, 7.0% were also current users of smokeless tobacco or snus, and 3.1% were also current smokers of pipe tobacco. On average, non-cancer respondents who were exclusive cigarette smokers reported smoking 15.7 cigarettes per day, compared with 16.8 cigarettes per day among
Table 2. Tobacco and nicotine product use stratified by cancer status: Population Assessment of Health and Tobacco (PATH) Study, 2013–2014.

| Tobacco/nicotine product | Cancer survivor (n = 1,527) | No history of cancer (n = 30,717) | P value |
|--------------------------|-----------------------------|-----------------------------------|---------|
|                          | Weighted % (95% CI)         | Weighted % (95% CI)               |         |
| **Cigarettes**           |                             |                                   |         |
| Current smoker           | 12.7 (11.3, 14.1)           | 18.5 (18.0, 19.0)                 | <0.001  |
| Pack-years, mean (SE)    | 28.9 (1.1)                  | 19.6 (0.50)                       | <0.001  |
| Daily smoker             | 10.5 (9.3, 12.0)            | 14.7 (14.2, 15.2)                 |         |
| Less than daily smoker   | 2.1 (1.6, 2.7)              | 3.8 (3.6, 4.0)                    |         |
| Former smoker            | 32.9 (29.9, 36.0)           | 19.0 (18.2, 19.9)                 |         |
| Pack-years, mean (SE)    | 29.0 (2.6)                  | 21.2 (1.05)                       | 0.005   |
| Never smoker             | 54.5 (51.0, 57.9)           | 62.5 (61.4, 63.6)                 |         |
| **E-cigarettes**         |                             |                                   |         |
| Current user             | 3.8 (3.1, 4.7)              | 5.7 (5.4, 5.9)                    | <0.001  |
| Daily user               | 1.0 (0.7, 1.4)              | 1.2 (1.1, 1.3)                    |         |
| Less than daily user     | 2.8 (2.2, 3.6)              | 4.5 (4.3, 4.7)                    |         |
| Former user              | 0.7 (0.4, 1.0)              | 1.0 (1.0, 1.1)                    |         |
| Never user               | 95.5 (94.6, 96.3)           | 93.3 (93.0, 93.6)                 |         |
| **Any cigars (cigars, cigarillos, and filtered cigars)** | | | |
| Current smoker           | 4.2 (3.5, 5.1)              | 7.6 (7.3, 7.9)                    | <0.001  |
| Daily smoker             | 0.8 (0.5, 1.3)              | 0.9 (0.8, 1.0)                    |         |
| Less than daily smoker   | 3.4 (2.7, 4.2)              | 6.7 (6.5, 7.0)                    |         |
| Former smoker            | 4.2 (3.3, 5.5)              | 3.3 (3.0, 3.6)                    |         |
| Never smoker             | 91.6 (90.1, 92.8)           | 89.1 (88.7, 89.5)                 |         |
| **Smokeless tobacco and snus** | | | |
| Current user             | 1.6 (1.2, 2.1)              | 3.4 (3.2, 3.7)                    | <0.001  |
| Daily user               | 0.7 (0.5, 1.0)              | 1.8 (1.6, 2.0)                    |         |
| Less than daily user     | 0.9 (0.6, 1.4)              | 1.6 (1.5, 1.8)                    |         |
| Former user              | 2.5 (1.8, 3.4)              | 3.3 (3.0, 3.6)                    |         |
| Never user               | 95.9 (94.9, 96.8)           | 93.3 (92.8, 93.7)                 |         |
| **Hookah**               |                             |                                   |         |
| Current smoker           | 1.0 (0.7, 1.4)              | 4.3 (4.0, 4.6)                    | <0.001  |
| Daily smoker             | NA                          | 0.1 (0.1, 0.1)                    |         |
| Less than daily smoker   | 0.9 (0.6, 1.4)              | 4.2 (3.9, 4.5)                    |         |
| Former smoker            | 0.2 (0.1, 0.4)              | 0.8 (0.7, 0.9)                    |         |
| Never smoker             | 98.9 (98.4, 99.2)           | 94.9 (94.6, 95.2)                 |         |
| **Pipe tobacco**         |                             |                                   |         |
| Current smoker           | 0.9 (0.6, 1.2)              | 1.1 (1.0, 1.3)                    | <0.001  |
| Daily smoker             | 0.2 (0.1, 0.4)              | 0.1 (0.1, 0.1)                    |         |
| Less than daily smoker   | 0.6 (0.4, 1.0)              | 1.0 (0.9, 1.2)                    |         |
| Former smoker            | 6.6 (3.2, 8.4)              | 2.3 (2.1, 2.6)                    |         |
| Never smoker             | 92.5 (90.7, 94.0)           | 96.6 (96.3, 96.8)                 |         |
| **Any product**          |                             |                                   |         |
| Current user             | 17.2 (15.5, 19.0)           | 26.9 (26.3, 27.5)                 | <0.001  |
| Daily user               | 12.6 (11.2, 14.2)           | 18.1 (17.6, 18.7)                 |         |
| Less than daily user     | 4.6 (4.0, 5.3)              | 8.8 (8.5, 9.1)                    |         |
| Former user              | 33.1 (30.0, 36.3)           | 18.2 (17.4, 19.1)                 |         |

(Continued)
Table 2. (Continued)

| Tobacco/nicotine product | Cancer survivor (n = 1,527) | No history of cancer (n = 30,717) | P value |
|--------------------------|----------------------------|----------------------------------|---------|
|                          | Weighted % (95% CI)        | Weighted % (95% CI)              |         |
| Never user               | 49.7 (46.2, 53.3)          | 54.9 (53.7, 56.0)               |         |

Notes: Data were collected from September 12, 2013, through December 15, 2014. The columns in the table are not mutually exclusive; participants who used one product may also have used another product. Percentages were weighted to the U.S. population and confidence intervals were estimated with the method of balanced, repeated replications. Complete data about every type of tobacco product were required to define nonuse of any tobacco; similarly, complete data about every type of cigar were required to define nonuse of any cigar, and complete data about smokeless tobacco and snus were required to define nonuse of smokeless tobacco including snus pouches. P-values for pack-year history are the result of the adjusted Wald test and estimated based on F distribution.

Abbreviation: NA, not available (suppressed)

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Fig 1. Mono, dual and poly tobacco/nicotine use among current users of any tobacco/nicotine products, by cancer status. Note: 44 cancer survivors and 766 adults with no history of cancer were excluded due to missing values for any tobacco or nicotine product use.

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Table 3. Tobacco and nicotine product use among cancer survivors, stratified by age group: Population Assessment of Health and Tobacco (PATH) Study, 2013–2014.

| Cancer survivor Age group, in years | 18–44 (n = 296) | 45–64 (n = 653) | ≥65 (n = 578) | P value |
|-----------------------------------|-----------------|-----------------|---------------|---------|
| Tobacco/nicotine product          | Weighted % (95% CI) | Weighted % (95% CI) | Weighted % (95% CI) |         |
| Cigarettes                        |                 |                 |               | <0.001  |
| Current smoker                    | 27.9 (22.5, 34.0) | 16.9 (14.4, 19.8) | 6.4 (5.2, 7.8) |         |
| Daily smoker                       | 23.1 (18.3, 28.8) | 13.5 (11.3, 16.1) | 5.8 (4.7, 7.1) |         |
| Less than daily                   | 4.7 (2.9, 7.7)   | 3.4 (2.5, 4.6)   | 0.6 (0.3, 1.1) |         |
| Former smoker                      | 17.6 (12.6, 24.1) | 26.3 (22.4, 30.6) | 40.9 (35.8, 46.2) |         |
| Never smoker                       | 54.5 (47.1, 61.7) | 56.8 (52.0, 61.4) | 52.7 (47.3, 58.1) |         |
| E-cigarettes                       |                 |                 |               | <0.001  |
| Current user                       | 11.8 (8.6, 16.0) | 5.4 (4.0, 7.2)   | 1.0 (0.6, 1.7) |         |
| Daily user                         | 2.7 (1.5, 4.6)   | 1.5 (0.9, 2.5)   | 0.3 (0.1, 0.6) |         |
| Less than daily                   | 9.2 (6.4, 12.9)  | 3.9 (2.7, 5.4)   | 0.8 (0.4, 1.4) |         |
| Former user                        | 1.8 (0.9, 3.8)   | 0.9 (0.5, 1.7)   | 0.3 (0.1, 0.8) |         |
| Never user                         | 86.4 (81.9, 89.8) | 93.8 (91.8, 95.3) | 98.7 (97.9, 99.2) |         |
| Any cigars                         |                 |                 |               | <0.001  |
| Current smoker                    | 10.6 (7.6, 14.6) | 5.2 (3.9, 6.9)   | 2.1 (1.5, 3.1) |         |
| Daily smoker                       | NA              | 1.0 (0.6, 1.7)   | 0.7 (0.3, 1.5) |         |
| Less than daily                   | 9.7 (6.7, 13.7)  | 4.2 (3.1, 5.8)   | 1.4 (0.9, 2.2) |         |
| Former smoker                      | 3.6 (2.0, 6.5)   | 3.3 (2.1, 5.2)   | 5.1 (3.4, 7.4) |         |
| Never smoker                       | 85.8 (81.3, 89.3) | 91.5 (89.1, 93.4) | 92.8 (90.5, 94.6) |         |
| Smokeless tobacco and snus         |                 |                 |               | 0.023   |
| Current user                       | 3.7 (2.0, 6.7)   | 1.9 (1.3, 2.9)   | 0.9 (0.5, 1.5) |         |
| Daily user                         | NA              | 1.0 (0.5, 1.7)   | 0.5 (0.2, 0.9) |         |
| Less than daily                   | 2.7 (1.3, 5.5)   | 1.0 (0.5, 1.8)   | NA           |         |
| Former user                        | 4.3 (1.7, 10.4)  | 2.7 (1.6, 4.3)   | 1.9 (1.2, 3.3) |         |
| Never user                         | 92.0 (86.2, 95.5) | 95.4 (93.6, 96.7) | 97.2 (95.8, 98.1) |         |
| Hookah                             |                 |                 |               | <0.001  |
| Current smoker                    | 6.2 (4.1, 9.5)   | NA              | NA           |         |
| Daily smoker                       | NA              | NA              | NA           |         |
| Less than daily                   | 6.2 (4.1, 9.5)   | NA              | NA           |         |
| Former smoker                      | NA              | NA              | NA           |         |
| Never smoker                       | 92.9 (89.5, 95.3) | 99.3 (98.4, 99.7) | 99.8 (99.5, 100.0) |         |
| Pipe tobacco                       |                 |                 |               | <0.001  |
| Current smoker                    | NA              | 1.0 (0.7, 1.7)   | NA           |         |
| Daily smoker                       | NA              | NA              | NA           |         |
| Less than daily                   | NA              | 0.8 (0.4, 1.4)   | NA           |         |
| Former smoker                      | NA              | 3.7 (2.4, 5.7)   | 9.9 (7.3, 13.2) |         |
| Never smoker                       | 96.7 (94.0, 98.3) | 95.3 (93.4, 96.6) | 89.6 (86.4, 92.1) |         |
| Any product                        |                 |                 |               | <0.001  |
| Current user                       | 37.7 (31.4, 44.4) | 22.5 (19.4, 26.0) | 9.1 (7.6, 10.8) |         |
| Daily user                         | 26.9 (21.6, 32.9) | 16.3 (13.8, 19.2) | 6.9 (5.7, 8.5) |         |
| Less than daily                   | 10.8 (7.8, 14.8) | 6.2 (4.8, 7.9)   | 2.1 (1.5, 3.0) |         |
| Former user                        | 15.9 (10.8, 22.7) | 25.1 (21.2, 29.4) | 42.6 (37.4, 47.9) |         |
| Never user                         | 46.5 (38.6, 54.5) | 52.5 (47.6, 57.3) | 48.4 (43.1, 53.7) |         |

Rao-Scott adjusted Pearson Chi-square tests were performed to test statistical significant associations between tobacco/nicotine use status and age group. Abbreviation: NA, not available (suppressed)

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current e-cigarette users, 16.7 cigarettes per day among former e-cigarette users and 17.2 cigarettes per day among never e-cigarette users.

Fig 2 presents the most common combinations of tobacco and nicotine products used among current tobacco/nicotine product users, stratified by cancer survivors and non-cancer survivors.

### Table 4. Tobacco and nicotine product use across three categories of cigarette smoking status (current, former, and never smoker): Population Assessment of Health and Tobacco (PATH) Study, 2013–2014.

| Tobacco product       | Current (n = 507) | Former (n = 416) | Never (n = 604) | Current (n = 10,872) | Former (n = 4,491) | Never (n = 15,354) |
|-----------------------|------------------|-----------------|-----------------|----------------------|------------------|-------------------|
| **Cigarettes**        |                  |                 |                 |                      |                  |                   |
| Any cigarette smoker  | 100.0 (100.0, 100.0) | -   | -   | 100.0 (100.0, 100.0) | -   | -                 |
| Exclusive smoker      | 58.8 (53.3, 64.0) | -   | -   | 54.2 (53.1, 55.4)   | -   | -                 |
| **E-cigarettes**      |                  |                 |                 |                      |                  |                   |
| Current user          | 22.0 (18.0, 26.5) | 1.7 (1.1, 2.8) | 0.9 (0.5, 1.4)  | 21.2 (20.4, 22.1)   | 4.2 (3.7, 4.8)   | 1.5 (1.4, 1.6)    |
| Former user           | 2.6 (1.5, 4.6)   | 0.5 (0.3, 1.1) | 0.3 (0.1, 0.7)  | 3.5 (3.1, 3.9)      | 1.5 (1.3, 1.7)   | 0.2 (0.2, 0.3)    |
| Never user            | 75.4 (70.8, 79.5) | 97.7 (96.6, 98.5) | 98.8 (98.2, 99.2) | 75.3 (74.4, 76.2)   | 94.3 (93.7, 94.8) | 98.3 (98.2, 98.5) |
| **Any cigars**        |                  |                 |                 |                      |                  |                   |
| Current smoker        | 15.0 (11.5, 19.3) | 4.0 (2.9, 5.4) | 1.8 (1.3, 2.6)  | 20.6 (19.8, 21.6)   | 5.6 (5.1, 6.2)   | 4.3 (4.0, 4.6)    |
| Former smoker         | 5.4 (3.4, 8.3)   | 8.3 (5.7, 12.0) | 1.5 (0.8, 2.9)  | 5.6 (5.1, 6.1)      | 8.0 (7.0, 9.3)   | 1.2 (1.0, 1.4)    |
| Never smoker          | 79.7 (74.9, 83.7) | 87.7 (84.2, 90.5) | 96.7 (95.2, 97.7) | 73.8 (72.8, 74.8)   | 86.3 (85.0, 87.6) | 94.5 (94.2, 94.8) |
| **Smokeless tobacco and snus** |               |                 |                 |                      |                  |                   |
| Current user          | 4.7 (3.3, 6.6)   | 1.0 (0.6, 1.7)  | 1.2 (0.8, 1.8)  | 7.0 (6.5, 7.7)      | 4.4 (3.9, 5.0)   | 2.0 (1.9, 2.3)    |
| Former user           | 4.8 (3.2, 7.3)   | 3.7 (2.3, 5.7)  | 1.2 (0.5, 2.6)  | 5.7 (5.2, 6.2)      | 7.0 (6.0, 8.1)   | 1.5 (1.2, 1.8)    |
| Never user            | 90.5 (87.5, 92.8) | 95.3 (93.2, 96.8) | 97.6 (96.3, 98.4) | 87.3 (86.5, 88.1)   | 88.6 (87.4, 89.7) | 96.5 (96.1, 96.8) |
| **Hookah**            |                  |                 |                 |                      |                  |                   |
| Current smoker        | 4.0 (2.5, 6.4)   | 0.4 (0.1, 1.1)  | 0.6 (0.3, 1.1)  | 10.0 (9.3, 10.8)    | 2.0 (1.7, 2.3)   | 3.3 (3.1, 3.6)    |
| Former smoker         | NA               | 0.3 (0.1, 0.9)  | 0.1 (0.0, 0.4)  | 1.5 (1.2, 1.7)      | 1.1 (0.9, 1.4)   | 0.5 (0.4, 0.6)    |
| Never smoker          | 96.0 (93.7, 97.5) | 99.3 (98.5, 99.7) | 99.3 (98.8, 99.6) | 88.5 (87.7, 89.3)   | 96.9 (96.4, 97.3) | 96.2 (95.9, 96.4) |
| **Pipe tobacco**      |                  |                 |                 |                      |                  |                   |
| Current smoker        | 2.0 (1.0, 3.7)   | 0.9 (0.5, 1.6)  | 0.6 (0.3, 1.1)  | 3.1 (2.7, 3.6)      | 0.9 (0.7, 1.1)   | 0.6 (0.5, 0.7)    |
| Former smoker         | 5.3 (3.4, 8.2)   | 12.1 (8.6, 16.9) | 3.6 (2.3, 5.6)  | 2.5 (2.2, 2.8)      | 6.7 (5.7, 7.9)   | 0.9 (0.7, 1.2)    |
| Never smoker          | 92.7 (89.9, 94.9) | 87.0 (82.2, 90.7) | 95.8 (93.8, 97.2) | 94.4 (93.9, 94.9)   | 92.4 (91.2, 93.4) | 98.5 (98.2, 98.7) |

Abbreviation: NA, not available (suppressed)

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respondents. Among cancer survivors who reported current use of any tobacco or nicotine products (n = 636), the most common combinations were cigarettes only (46.1%), followed by cigarettes and e-cigarettes (12.4%). Among non-cancer respondents who reported current use of any tobacco or nicotine products (n = 15,009), the most common combinations were cigarettes only (39.4%), followed by cigars only (9.2%), and cigarettes and e-cigarettes (8.4%).

Reasons for non-cigarette product use
The reasons for non-cigarette product use among cancer survivors are described in Table 5. Among e-cigarette users, the most commonly endorsed reason was “they might be less harmful to people around me than cigarettes” (85.0%). Among users of other products, a commonly
endorsed reason was “they come in flavors I like”–which was endorsed by 97.8% among cigar smokers, 100.0% among smokeless tobacco/snus users, 80.9% among hookah smokers, and 66.4% among pipe smokers.

### Correlates of any tobacco or nicotine product use

Results from the multivariable logistic regression modeling of current tobacco/nicotine product use stratified by cancer status are reported in Table 6. The factors associated with any current tobacco/nicotine use were similar in cancer survivors and non-cancer respondents. Compared with young adults (18–44 years), adults 45–64 and those ≥65 years old were less likely to be current tobacco/nicotine users in both cancer survivors and in non-cancer respondents. Males were more likely than females to be current tobacco users among both cancer survivors (AOR = 1.79, 95% CI = 1.39, 2.30) and non-cancer respondents (AOR = 2.10, 95% CI = 1.99, 2.22). Whereas black non-cancer respondents were less likely to be current tobacco/nicotine users than whites (AOR = 0.90, 95% CI = 0.82, 0.99), there were no significant...
Table 6. Multivariable logistic regression models of any (≥1 products vs. none) and dual/poly (≥2 products vs. 1 product) tobacco/nicotine product use, by cancer status: Population Assessment of Health and Tobacco (PATH) Study, 2013–2014.

| Characteristics          | Cancer survivor (n = 1,527) | No history of cancer (n = 30,717) |
|--------------------------|-----------------------------|----------------------------------|
|                          | Any use (OR 95% CI) P       | Dual/poly use (OR 95% CI) P       | Any use (OR 95% CI) P | Dual/poly use (OR 95% CI) P |
| Age, in years            |                             |                                  |                      |                           |
| 18–44                    | 0.44 (0.30, 0.64) <0.001    | 0.56 (0.35, 0.89) 0.015           | 0.67 (0.63, 0.72) <0.001 | 0.53 (0.49, 0.59) <0.001 |
| ≥65                      | 0.12 (0.08, 0.17) <0.001    | 0.26 (0.14, 0.49) <0.001          | 0.23 (0.21, 0.25) <0.001 | 0.30 (0.24, 0.37) <0.001 |
| Sex                      |                             |                                  |                      |                           |
| Female                   | Reference                   | Reference                        | Reference            | Reference                |
| Male                     | 1.79 (1.39, 2.30) <0.001    | 1.19 (0.80, 1.78) 0.395           | 2.10 (1.99, 2.22) <0.001 | 1.59 (1.47, 1.73) <0.001 |
| Race                     |                             |                                  |                      |                           |
| White, non-Hispanic      | Reference                   | Reference                        | Reference            | Reference                |
| Black, non-Hispanic      | 0.88 (0.58, 1.33) 0.551     | 0.84 (0.42, 1.71) 0.634           | 0.90 (0.82, 0.99) 0.023 | 0.94 (0.83, 1.06) 0.312 |
| Other                    | 0.65 (0.32, 1.31) 0.225     | 2.28 (0.99, 5.27) 0.054           | 0.78 (0.69, 0.88) <0.001 | 1.11 (0.98, 1.26) 0.092 |
| Education                |                             |                                  |                      |                           |
| Not high school graduate | Reference                   | Reference                        | Reference            | Reference                |
| GED or high school graduate | 0.56 (0.36, 0.88) 0.012   | 0.99 (0.58, 1.67) 0.959           | 1.02 (0.92, 1.14) 0.689 | 1.04 (0.92, 1.18) 0.479 |
| Some college or associate degree | 0.55 (0.35, 0.87) 0.010 | 1.25 (0.69, 2.28) 0.453           | 0.92 (0.82, 1.02) 0.118 | 1.22 (1.07, 1.38) 0.003 |
| Bachelor’s degree or higher | 0.23 (0.13, 0.40) <0.001 | 1.27 (0.57, 2.83) 0.551           | 0.43 (0.38, 0.49) <0.001 | 0.98 (0.84, 1.14) 0.788 |
| Household income         |                             |                                  |                      |                           |
| <$25,000                 | Reference                   | Reference                        | Reference            | Reference                |
| $25,000 to $49,999       | 0.80 (0.55, 1.15) 0.221     | 0.65 (0.38, 1.11) 0.113           | 0.89 (0.82, 0.96) 0.004 | 0.89 (0.81, 0.98) 0.020 |
| $50,000 to $99,999       | 0.58 (0.41, 0.81) 0.002     | 1.31 (0.77, 2.25) 0.317           | 0.67 (0.62, 0.72) <0.001 | 0.83 (0.75, 0.92) 0.001 |
| $100,000 or more         | 0.53 (0.36, 0.78) 0.002     | 0.34 (0.16, 0.75) 0.008           | 0.57 (0.52, 0.63) <0.001 | 0.68 (0.60, 0.77) <0.001 |
| U.S. Census region       |                             |                                  |                      |                           |
| Northeast                | Reference                   | Reference                        | Reference            | Reference                |
| Midwest                  | 1.01 (0.72, 1.42) 0.952     | 1.44 (0.69, 3.01) 0.333           | 1.15 (1.05, 1.26) 0.004 | 1.17 (1.05, 1.30) 0.006 |
| South                    | 0.99 (0.66, 1.49) 0.973     | 1.88 (0.94, 3.79) 0.074           | 1.02 (0.94, 1.11) 0.557 | 1.15 (1.04, 1.27) 0.006 |
| West                     | 1.10 (0.77, 1.59) 0.596     | 1.39 (0.58, 3.34) 0.461           | 0.75 (0.67, 0.85) <0.001 | 1.20 (1.07, 1.34) 0.002 |
| Tobacco-related cancer   |                             |                                  |                      |                           |
| No                       | Reference                   | Reference                        | -                    | -                        |
| Yes                      | 1.58 (1.18, 2.11) 0.002     | 1.19 (0.76, 1.88) 0.440           | -                    | -                        |

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Differences in current tobacco/nicotine use between black and white cancer survivors (AOR = 0.88, 95% CI = 0.58, 1.31). Compared with non-Hispanic whites, respondents of other racial/ethnic groups were less likely to be current tobacco/nicotine users in non-cancer respondents (AOR = 0.78, 95% CI = 0.69, 0.88).

Adults with higher than a high school education were less likely than those without a high school degree to be current tobacco/nicotine users regardless of cancer history. For example, adults with a bachelor’s degree or higher were less likely than the referent education level to be current tobacco/nicotine users in both cancer survivors (AOR = 0.23, 95% CI = 0.13, 0.40) and in non-cancer respondents (AOR = 0.43, 95% CI = 0.38, 0.49). Additionally, adults with higher income were less likely to be current tobacco/nicotine users compared to adults with a lower annual household income. Among cancer survivors, those with a tobacco-related cancer diagnosis were more likely to be current tobacco/nicotine users (AOR = 1.58, 95% CI = 1.18, 2.11) than those diagnosed with a non-tobacco-related cancer.
Correlates of dual and poly tobacco/nicotine use

In general, among those who reported current use of any tobacco or nicotine products, the correlates of dual and poly tobacco/nicotine use (vs. mono use) were similar to those variables associated with any tobacco or nicotine product use, with some exceptions (Table 6). First, there were no significant differences by sex in dual use among cancer survivors. However, among cancer survivors, education level was not significantly associated with dual or poly use and only membership in the highest annual household income level ($100,000 or more) was associated with lower odds of dual tobacco/nicotine use (AOR = 0.34, 95% CI = 0.16, 0.75). Meanwhile, having a tobacco-related cancer diagnosis was not significantly associated with the likelihood of being a dual or poly tobacco/nicotine user.

Discussion

This cross-sectional analysis of tobacco-use behaviors among adult cancer survivors compared with non-cancer respondents provides an update on the prevalence of cigarette smoking and e-cigarette use, in addition to benchmark estimates of current and former use of other tobacco products in this population. Among adult cancer survivors participating in the PATH Study, approximately 17% are current tobacco users, including 13% who are current cigarette smokers, 5% who are current e-cigarette users, and 2% who are current cigar smokers. Many correlates of tobacco use in cancer survivors are consistent with those in the general population of U.S. adults: younger age, male gender, and lower household income.[16] In addition, cancer survivors diagnosed with tobacco-related cancers were more likely to be current smokers.

The estimated prevalence of current cigarette smoking among adult cancer survivors is consistent with estimates published by the National Cancer Institute[17]—12.8% in 2014 (data source: National Health Interview Survey [NHIS]). Despite overall and cancer-specific declines in cigarette smoking rates according to the NHIS, cigarettes remain the most commonly used tobacco product among cancer survivors across all age groups. Meanwhile, our analysis highlights differences in patterns by age group, with higher prevalence of e-cigarette and non-cigarette tobacco product use in younger cancer survivors as compared with older survivors. While specific evidence on the health effects of non-cigarette products in cancer survivors remains scarce, both combustible and non-combustible products have been associated with significant health risks in the general population.[1]

Although many correlates of tobacco use were consistent across cancer survivors and non-cancer participants, there were notable differences. Racial/ethnic and geographical associations of tobacco product use appeared to be more pronounced for non-cancer participants compared with cancer survivors, suggesting that cancer survivors nationwide exhibited less disparate tobacco use patterns than adults who did have a history of cancer. However, more research is needed to examine the racial/ethnic and geographic patterns in tobacco use among cancer survivors.

A previous analysis of the PATH Study data had focused on investigating e-cigarette use in cancer survivors who were cigarette smokers.[12] Similar to that study, we observed no differences in the prevalence of e-cigarettes among cancer survivors when compared to non-cancer participants. The National Academies of Science, Engineering, and Medicine (NASEM) recently detailed concerns about the use of e-cigarettes[18] and concern for the use of e-cigarettes by cancer patients has been raised by the International Association for the Study of Lung Cancer (IASLC).[19] However, while there are concerns about e-cigarette use after a cancer diagnosis, the adverse effects of continued smoking are unquestionable[1] and the use patterns in older adults strongly favors continued cigarette smoking over other tobacco products.
Our study took a broader approach than Symes et al.\cite{12} by characterizing the prevalence of cigarettes, e-cigarettes, and four other categories of tobacco products in cancer survivors. The data demonstrate that 13% of cancer survivors report current cigarette smoking and nearly 17% use at least one tobacco or nicotine product. These rates appear to be lower than the 18–20% rates from the NHIS and HINTS data\cite{3,4} which suggest a decreasing trend for tobacco use in cancer survivors, while highlighting the rise in alternative tobacco product use, especially among younger cancer survivors. Among cancer survivors who were current tobacco/nicotine users, nearly one-third were using two or more products, a rate that is similar to that among non-cancer respondents. This finding was consistent with the results of the Fahey et al. study which reported on a regional sample of cancer patients.\cite{9} Further, our study identified the continued use of alternative tobacco products among cancer survivors who are former or never smokers, underscoring the need for interventions that extend beyond addressing cigarette smoking in this population.

As described in the Symes et al. study,\cite{12} a majority of cancer survivors reported using e-cigarettes for perceived health-related reasons. Our study extended this finding to smokeless tobacco and snus users, as well as cigar smokers. Among both groups, a majority endorsed the statements related to harm reduction and cigarette smoking cessation. Additionally, a majority of hookah users shared the perception of harm reduction.

Although we found the prevalence of cigarette smoking and any product use to be lower among cancer survivors compared with non-cancer participants in the PATH Study, almost one in five cancer survivors reported current use of a tobacco or nicotine product. Continued tobacco use by cancer patients not only increases the risk for adverse cancer treatment outcomes,\cite{1} but also significantly increases the cost of subsequent cancer treatment.\cite{2} This study underscores the need for the integration of tobacco dependence treatment strategies in cancer care settings.\cite{20–22} It also provides clinicians in cancer care settings with population-based benchmark estimates of cigarette and non-cigarette tobacco product use among cancer survivors. The American Society of Clinical Oncology (ASCO) and the National Comprehensive Cancer Network (NCCN) both recommend universal assessment and documentation of tobacco use for cancer patients in all clinical settings, as well as the provision of tobacco use treatment.\cite{23,24} A large survey of oncologists by the IASLC demonstrates that while the majority of oncologists ask about tobacco and advise patients to quit, few assist patients with quitting.\cite{25} A lack of time, training, and resources are predictive barriers to providing cessation support by oncologists.\cite{26} Long term follow-up data from the Cancer Prevention Study II between 1992–2009 demonstrated a higher two-year quit rate in cancer survivors (31%) as compared with the general population (20%).\cite{27} However, these results were outside of the context of a structured smoking cessation intervention. Recognizing the deficits in providing cessation support, the NCI recently funded the development of tobacco treatment programs at 42 NCI-Designated Cancer Centers.\cite{28} This effort is expected to implement and sustain evidence-based smoking cessation on a broad scale for cancer centers, but it will take several years to realize results.

There are several limitations to this study. First, the PATH Study relies on self-reported cancer diagnosis, which typically underestimates cancer prevalence.\cite{29} Tobacco and e-cigarette use is also based on self-reports, and data have shown that approximately 30% of cancer patients who smoke may misrepresent tobacco use.\cite{30–32} Data are likely to underestimate tobacco use in this cohort, but the same risks are true for prior studies that have evaluated smoking in cancer cohorts.\cite{30–32} This cross-sectional study design cannot support causal inferences and does not allow for the examination of the extent and timing of changes in tobacco use status among cancer survivors. This study is further limited by the inability to examine tobacco use in relation to time since diagnosis for cancer survivors. Furthermore,
given the fast-changing landscape of e-cigarettes and emerging alternative tobacco products use, patterns from 2013–2014 may not reflect the latest experiences of these products among the US population. Despite these limitations, the current study provides new knowledge regarding the prevalence of tobacco and nicotine product use among adult cancer survivors in the U.S. from the well-designed and broadly implemented PATH Study.

Conclusions

Findings from the current study demonstrate dynamic use patterns for cigarettes, e-cigarettes, and other tobacco products among cancer survivors compared with the general population. As data from the PATH Study mature, future analyses can evaluate changes in patterns of use and begin to better define opportunities for assessment of health risk and intervention.

Author Contributions

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References

1. US Department of Health and Human Services. The Health Consequences of Smoking: 50 Years of Progress. A Report of the Surgeon General. In: 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.
2. Warren GW, Cartmell KB, Garrett-Mayer E, Salloum RG, Cummings KM. Attributable Failure of First-line Cancer Treatment and Incremental Costs Associated With Smoking by Patients With Cancer. JAMA Netw Open. 2019; 2: e191703. https://doi.org/10.1001/jamanetworkopen.2019.1703 PMID: 30951159
3. Bellizzi KM, Rowland JH, Jeffery DD, McNeel T. Health behaviors of cancer survivors: Examining opportunities for cancer control intervention. J Clin Oncol. 2005; 23: 8884–8893. https://doi.org/10.1200/JCO.2005.02.2343 PMID: 16314649
4. Mayer DK, Carlson J. Smoking patterns in cancer survivors. Nicotine Tob Res. 2011; 13: 34–40. https://doi.org/10.1093/ntr/nlt199 PMID: 21097514
5. Kasza KA, Ambrose BK, Conway KP, Borek N, Taylor K, Goniewicz ML, et al. Tobacco-Product Use by Adults and Youths in the United States in 2013 and 2014. N Engl J Med. 2017; 376: 342–353. https://doi.org/10.1056/NEJMs a1607538 PMID: 28121512
6. Salloum RG, Getz KP, Tan ASL, Carter-Harris L, Young-Wolff KC, George TJ, et al. Use of Electronic Cigarettes Among Cancer Survivors in the U.S. Am J Prev Med. 2016; 51: 762–766. https://doi.org/10.1016/j.amepre.2016.04.015
7. Sanford NN, Sher DJ, Xu X, Aizer AA, Mahal BA. Trends in Smoking and e-Cigarette Use among US Patients with Cancer, 2014–2017. JAMA Oncology. 2019. https://doi.org/10.1010/jamaoncol.2018. 6858 PMID: 30763430
8. Kruse GR, Kalkhoran S, Rigotti NA. Use of Electronic Cigarettes Among U.S. Adults With Medical Comorbidities. 2017. https://doi.org/10.1016/j.amerepre.2016.12.004 PMID: 28108191
9. Fahey MC, Bursac Z, Ebbert JO, Klesges RC, Little MA. Prevalence and correlates of dual tobacco use in cancer survivors. 2019; 4: 217–223. https://doi.org/10.1055/s-10552-019-1132-6 PMID: 30671688

10. Congress 111th United States. Family Smoking Prevention and Tobacco Control Act. United States of America; 2009.

11. Hyland A, Ambrose BK, Conway KP, Borek N, Lambert E, Carusi C, et al. Design and methods of the Population Assessment of Tobacco and Health (PATH) Study. Tob Control. 2017; 26: 371–378. https://doi.org/10.1136/tobaccocontrol-2016-052934 PMID: 27507901

12. Symes YR, Ribisi KM, Boynton MH, Westmaas JL, Mayer DK, Golden SD. Dual cigarette and e-cigarette use in cancer survivors: an analysis using Population Assessment of Tobacco Health (PATH) data. Journal of Cancer Survivorship. 2019. https://doi.org/10.1007/s11764-019-1132-6 PMID: 30671688

13. Hyland A, Ambrose BK, Conway KP, Borek N, Lambert E, Carusi C, et al. Design and methods of the Population Assessment of Tobacco and Health (PATH) Study. Tob Control. 2016; tobaccocontrol-2016-052934. https://doi.org/10.1136/tobaccocontrol-2016-052934 PMID: 27507901

14. McCarthy PJ. Pseudoreplication Further Evaluation and Application of the Balanced Half-Sample Technique. Vital Heal Stat. 1969; 2: 1–24. Available: https://www.cdc.gov/nchs/data/sr_02/sr02_031acc.pdf

15. Judkins DR. Fay’s method for variance estimation. Journal of Official Statistics. 1990. pp. 223–239. Available: http://www.jos.nu/Articles/abstract.asp?article=63223%0Ahttp://search.proquest.com/ openview/060dad1a8066daa33ec1bc9f207958/1.pdf?pq-origsite=gscholar&cbl=105444

16. King B, Dube SR, Tynan M. Current tobacco use among adults in the United States: Findings from the National Adult Tobacco Survey. Am J Public Health. 2012; 102: 93–100. https://doi.org/10.2105/AJPH.2012.301002 PMID: 22994278

17. National Cancer Institute. Cancer Survivors and Smoking. In: Cancer Trends Progress Report [Internet]. 2015 [cited 29 Oct 2018]. http://progressreport.cancer.gov/after/smoking

18. The National Academies of Science-Engineering-Medicine. Public Health Consequences of E-Cigarettes: Highlights. Washington, DC; 2018. https://www.nap.edu/resource/24952/012318ecigaretteHighlights.pdf

19. Cummings KM, Dresler CM, Field JK, Fox J, Gritz ER, Hanna NH, et al. E-cigarettes and cancer patients. Journal of Thoracic Oncology. 2014. pp. 438–441. https://doi.org/10.1097/JTO.0000000000000129 PMID: 24736063

20. Morgan G, Schnoll RA, Alfano CM, Evans SE, Goldstein A, Ostroff J, et al. National Cancer Institute Conference on Treating Tobacco Dependence at Cancer Centers. J Oncol Pract. 2011; 7: 178–182. https://doi.org/10.1200/JOP.2010.000175 PMID: 21886500

21. Warren GW, Sobus S, Gritz ER. The biological and clinical effects of smoking by patients with cancer and strategies to implement evidence-based tobacco cessation support. The Lancet Oncology. 2014. pp. e568–e580. https://doi.org/10.1016/S1470-2045(14)70266-9 PMID: 25439699

22. Gritz ER, Fingeret MC, Vidrine DJ, Lazev AB, Mehta NV, Reece GP. Successes and failures of the teachable moment. Cancer. 2005. pp. 17–27.

23. Hanna N, Mulshine J, Wollins DS, Tyne C, Dresler C. Tobacco Cessation and Control a Decade Later: American Society of Clinical Oncology Policy Statement Update. J Clin Oncol. 2013; 31: 3147–3157. https://doi.org/10.1200/JCO.2013.48.8932 PMID: 23897958

24. Shields PG, Herbst RS, Arenberg D, Benowitz NL, Bierut L, Luckart JB, et al. Smoking cessation, version 1.2016 clinical practice guidelines in oncology. JNCCN J Natl Compr Cancer Netw. 2016; 14: 1430–1468. PMID: 27795913

25. Warren GW, Marshall JR, Cummings KM, Toll B, Gritz ER, Hutson A, et al. Practice patterns and perceptions of thoracic oncology providers on tobacco use and cessation in cancer patients. J Thorac Oncol. 2013; 8: 543–548. https://doi.org/10.1097/JTO.0b013e318288dc96 PMID: 23529191

26. Warren GW, Dibaj S, Hutson A, Cummings KM, Dresler C, Marshall JR. Identifying targeted strategies to improve smoking cessation support for cancer patients. J Thorac Oncol. 2015; 10: 1532–1537. https://doi.org/10.1097/JTO.0000000000000659 PMID: 26317914

27. Westmaas JL, Newton CC, Stevens VL, Flanders WD, Gapstur SM, Jacobs EJ. Does a recent cancer diagnosis predict smoking cessation? An analysis from a large prospective US cohort. J Natl Cancer Inst. 2015; 107: 1647–1652. https://doi.org/10.1093/jnci/dju163 PMID: 25897151

28. Croyte RT, Morgan GD, Fiore MC. Addressing a Core Gap in Cancer Care—The NCI Moonshot Program to Help Oncology Patients Stop Smoking. N Engl J Med. 2019; 380: 512–515. https://doi.org/10.1056/NEJMmp1813913 PMID: 30601710

29. Hewitt M, Breen N, Devesa S. Cancer prevalence and survivorship issues: Analyses of the 1992 national health interview survey. J Natl Cancer Inst. 1999; 91: 1480–1486. https://doi.org/10.1093/jnci/91.17.1480 PMID: 10469749
30. Morales NA, Romano MA, Michael Cummings K, Marshall JR, Hyland AJ, Hutson A, et al. Accuracy of self-reported tobacco use in newly diagnosed cancer patients. Cancer Causes Control. 2013; 24: 1223–1230. https://doi.org/10.1007/s10552-013-0202-4 PMID: 23553611
31. Warren GW, Arnold SM, Valentino JP, Gal TJ, Hyland AJ, Singh AK, et al. Accuracy of self-reported tobacco assessments in a head and neck cancer treatment population. Radiother Oncol. 2012; 103: 45–48. https://doi.org/10.1016/j.radonc.2011.11.003 PMID: 22119370
32. Khuri FR, Kim ES, Lee JackJ, Winn RJ, Benner SE, Lippman SM, et al. The impact of smoking status, disease stage, and index tumor site on second primary tumor incidence and tumor recurrence in the head and neck retinoid chemoprevention trial. Cancer Epidemiol Biomarkers Prev. 2001; 10: 823–829. PMID: 11489748