Prevalence of health behaviors among cancer survivors in the United States

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Abstract

Purpose We determined the proportion of cancer survivors who met each of five health behavior guidelines recommended by the American Cancer Society (ACS), including consuming fruits and vegetables at least five times/day, maintaining a body mass index (BMI) < 30 kg/m^2, engaging in 150 min or more of physical activity weekly, not currently smoking, and not excessively drinking alcohol.

Methods Using data from the 2019 Behavioral Risk Factor Surveillance System (BRFSS), 42,727 survey respondents who reported a previous diagnosis of cancer (excluding skin cancer) were included. Weighted percentages with 95% confidence intervals (95% CI) were estimated for the five health behaviors accounting for BRFSS' complex survey design.

Results The weighted percentage of cancer survivors who met ACS guidelines was 15.1% (95%CI: 14.3%, 15.9%) for fruit and vegetable intake; 66.8% (95%CI: 65.9%, 67.7%) for BMI < 30 kg/m^2; 51.1% (95%CI: 50.1%, 52.1%) for physical activity; 84.9% (95%CI: 84.1%, 85.7%) for not currently smoking; and 89.5% (95%CI: 88.8%, 90.3%) for not drinking excessive alcohol. Adherence to ACS guidelines among cancer survivors generally increased with increasing age, income, and education.

Conclusions While the majority of cancer survivors met the guidelines for not smoking and limiting alcohol drinking, one-third had elevated BMI, almost half did not meet recommended physical activity levels, and the majority had inadequate fruit and vegetable intake.

Implications for Cancer Survivors Adherence to guidelines was lowest among younger cancer survivors and those with lower income and education, suggesting these may be populations where resources could be targeted to have the greatest impact.

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Abbreviations

ACS   American cancer society
BMI   Body mass index
BRFSS   Behavioral risk factor surveillance system

Introduction

Cancer is the second leading cause of death, behind cardiovascular disease, in the United States [1]. Advancements in treatment and early detection have resulted in a 31% decrease in overall cancer mortality between 1991 and 2018 [1]. Consequently, the population of cancer survivors in the United States has grown to 16.9 million in 2019 and is estimated to be 22.1 million people by 2030 [2]. The health of cancer survivors is of particular interest due to increased risk of negative health outcomes including both cancer and non-cancer morbidity and mortality [3]. Cancer survivors

also may be more motivated to learn about and make healthy choices to improve survival and quality of life [4, 5]. Studies from the American Cancer Society (ACS) reported that 88% of cancer survivors surveyed reported making a positive change to at least one health behavior after the time of diagnosis [6].

According to the Global Burden of Diseases, Injuries, and Risk Factors Study 2019 [7] and a report on US cancer cases and deaths attributable to potentially modifiable risk factors [8], cigarette smoking, alcohol use, high body mass index (BMI), low fruit and vegetable intake, and physical inactivity are leading risk factors for cancer deaths. The ACS recommends a set of guidelines related to these health behaviors to help improve quality of life and outcomes for cancer survivors, which was first published in 2012 [4] and recently updated in 2022 [9]. Previous studies have shown a beneficial impact of these healthy behaviors on cancer survivorship. In one study, a health behavior score was created based on the ACS guidelines; in that study, colon cancer survivors with higher ACS-guideline scores (scores of 5–6) had a 42% lower risk of mortality than those with low scores (0–2) [10]. Another study used the third National Health and Nutrition Examination Survey (NHANES III) to examine similar health behaviors among cancer survivors and reported that increasing the health behavior score by one of five healthy behaviors was associated with 19% lower overall mortality risk [11].

Given the evidence for beneficial effects of healthy behaviors on cancer survivorship, it is important to ascertain whether cancer survivors are adhering to health behavior guidelines. A systematic review and meta-analyses of 51 studies published prior to 2019 concluded that adherence to diet, physical activity, or multiple health behavior guidelines as recommended by the World Cancer Research Fund/American Institute for Cancer Research was low among cancer survivors [12], which was corroborated in two more recent papers reporting on Health Information National Trends Survey (HINTS) data [13, 14]. Additionally, disparities in adherence to health behaviors by age [15], sex [16], race and ethnicity [17], and socioeconomic status [15, 16] have been reported among cancer survivors and those living in areas of high cancer mortality rates.

Previous literature has reported on the prevalence of health behaviors among cancer survivors in the United States using data from the 2009 Behavioral Risk Factor Surveillance System (BRFSS) [15, 18, 19], and a more recent report from the 2017 BRFSS was limited to dietary intake data only [16]. Thus, we aimed to examine prevalence of multiple health behaviors among cancer survivors in the US with more recent data from the 2019 BRFSS and include the five health behavior guidelines: consuming fruits or vegetables at least five times per day; maintaining a BMI < 30 kg/m^2; engaging in at least 150 min of physical activity weekly;

not currently smoking; and not drinking alcohol excessively [4, 9]. We also examined whether guideline adherence differed by age, sex, race and ethnicity, income, or education to help inform future analytic studies and resource priorities for public health intervention.

Methods

Study population

The BRFSS is a state-based telephone survey performed in the United States by the Centers for Disease Control and Prevention, which collects a variety of health information, including information on cancer diagnoses and health behaviors. The BRFSS questionnaire included core component modules used by all states, optional modules that states may elect to use (including cancer survivorship), and state-added questions. The 2019 BRFSS includes data from 49 states (New Jersey did not collect sufficient data), the District of Columbia, Guam, and Puerto Rico. The BRFSS surveys non-institutionalized adults aged 18 or older using random digit dial selection of mobile and landline phone numbers compiled by Marketing Systems Group. The overall response rate in 2019 was 49.4%, and the mean cooperation rate was 63.8% (Centers for Disease Control and Prevention, 2020). All responses were self-reported. The BRFSS has been found to have similar time trends for variables related to health as compared to other national benchmark surveys, the NHANES and National Health Interview Survey [20].

History of cancer diagnosis was assessed by asking "Has a doctor, nurse, or other health professional ever told you that you had skin cancer?" and "Has a doctor, nurse, or other health professional ever told you that you had any other types of cancer?" For the individual health behaviors, we excluded respondents due to outliers, refused to answer, or answered "don't know/not sure" for questions related to fruits/vegetables, obesity, physical activity, smoking, and alcohol drinking, respectively. Specifically, outliers were defined based on cutpoints used in previous literature [21] as > 39 servings fruits and vegetables/day or BMI < 12 or > 60 kg/m^2.

Exposure assessments

Frequency of intake of fruits and vegetables was assessed by asking respondents how many times per day they drank 100% fruit juice and ate fruit, dark green vegetables, potatoes other than fried potatoes, and other vegetables. Serving sizes were not queried. Responses were summed and respondents were categorized as consuming fruits and vegetables five or more times per day or not. Obesity was defined as a BMI ≥ 30 kg/m^2 calculated based on respondents' reported weight in kilograms divided by the square of

height in meters. Physical activity was assessed by asking respondents how many minutes of different types of physical activity they perform per week and then combining for total minutes per week. Sufficient physical activity was defined as 150 or more minutes of physical activity per week or the vigorous physical activity equivalent of 75 or more minutes per week. Current smoking was defined as any respondent who had smoked at least 100 cigarettes in their lifetime and were still smoking at the time of the survey. Drinking was assessed by asking individuals, "During the past 30 days, how many days per week or per month did you have at least one drink of any alcoholic beverage such as beer, wine, a malt beverage or liquor?" and "Considering all types of alcoholic beverages, how many times during the past 30 days did you have five or more drinks for men or four or more drinks for women on an occasion?" One drink is equivalent to 12 oz of beer, five ounces of wine, or a drink with one shot of liquor. Excessive alcohol consumption was defined as a daily average of more than one drink for women or more than two drinks for men or an episode of drinking four or more drinks for women or five or more drinks for men in the last month.

Statistical analyses

Weighted percentages with 95% confidence intervals (95%CI) were estimated for the five health behaviors accounting for BRFSS' complex survey design. Considering the complex survey design of BRFSS, all statistical analyses incorporated clustering (PSU), stratification (STSTR), and weighting (LLCPWT), following the methodology established by the Centers for Disease Control and Prevention [22]. We also examined weighted percentages stratified by age (18–44, 45–64, or 65 years and older), sex (male or female), race and ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, or Other), income (<$25,000, $25,000—<$50,000, or ≥$50,000/year), and education (not completed high school, high school graduate, some college/technical school, or college or technical school graduate) and used the Chi-square test to evaluate the differences of weighted percentages between subgroups.

We further calculated a health behavior score by assigning a value of 0 if a respondent did not meet the guideline or a value of 1 if the respondent met the guideline for each of the five health behaviors, and then summing them to create an overall score between 0 and 5. We then divided respondents into groups of having low adherence (scores 0–2), moderate adherence (score 3), or high adherence (scores 4–5), and performed stratified analyses by each of the covariates on the overall health behavior score variable. All statistical analyses were performed using R software version 4.1.2, using the Survey package version 4.1–1. Two-sided p-values less than 0.05 were considered statistically significant.

Results

There were 42,727 cancer survivors who completed the 2019 BRFSS. For the individual health behaviors, we excluded 5,664, 3,004, 4,663, 1,510, and 2,511 respondents due to outliers, refused to answer, or answered "don't know/not sure" for questions related to fruits/vegetables, obesity, physical activity, smoking, and alcohol drinking, respectively. There was a higher proportion of females (60.2%) than males (39.8%) in the weighted sample (Table 1). The weighted percentage of survivors between the ages of 18–44 was 12.1%, between 45–64 was 34.0%, and 65 years or older was 53.9%. Race and ethnicity were self-reported as American Indian/Alaskan Native, Non-Hispanic (unweighted sample size $n = 616$); Asian, Non-Hispanic ($n = 363$); Black, Non-Hispanic ($n = 2483$); Hispanic ($n = 1752$); White, Non-Hispanic ($n = 36,286$); or Other race, Non-Hispanic ($n = 1227$). Due to small numbers of Non-Hispanic American Indian/Alaskan Native, Asian, and Other race, we combined these into one category of Other race and ethnicity for analyses. According to weighted percentages, 8.9% were Hispanic, 8.9% were non-Hispanic Black, 76.6% were non-Hispanic White, and 5.2% were Other races and ethnicities.

The weighted percentages estimates for meeting the ACS healthy behavior guidelines were 15.1% (95% CI: 14.3, 15.9) for sufficient fruit and vegetable consumption, 66.8% (95% CI: 65.9, 67.7) for having a BMI < 30 kg/m^2, 51.1% (95% CI: 50.1, 52.1) for sufficient physical activity, 84.9% (95% CI: 88.8, 90.3) for not currently smoking, and 89.5% (95% CI: 88.8, 90.3) for not drinking alcohol excessively (Table 2).

The weighted percentage of cancer survivors who met the health behavior guidelines increased with increasing age for smoking and alcohol guidelines but slightly decreased with age for fruit and vegetable intake and was lowest among those in mid-life (45–64 years) for both obesity and physical activity guidelines (Fig. 1a and Supplemental Table 1). Males were more likely to meet the recommendations for BMI, physical activity, and not smoking whereas females were more likely to meet the recommendations for sufficient fruit and vegetable consumption and not drinking alcohol excessively (Fig. 1b and Supplemental Table 1). People in the Other race and ethnicity group had the highest weighted percentage of BMI < 30 kg/m^2 and meeting guidelines for fruit and vegetable consumption and not drinking alcohol excessively. The highest weighted percentage of meeting physical activity and smoking guidelines was observed among non-Hispanic White respondents (Fig. 1c and Supplemental Table 1). The weighted percentage of cancer survivors meeting health behavior guidelines increased with higher incomes

Table 1 Demographics of cancer survivors ($n = 42{,}727$), BRFSS 2019

Respondent Demographics	Unweighted sample	Weighted sample	Weighted Percentage, % (95% Confidence interval)
Age (years)			
18–44	2563	2,168,169	12.1 (11.3–13.0)
45–64	11,776	6,064,317	34.0 (33.0–34.9)
≥65	28,388	9,621,212	53.9 (52.9–54.8)
Sex			
Male	16,445	7,097,207	39.8 (38.8–40.7)
Female	26,282	10,756,492	60.2 (59.3–61.2)
Race and Ethnicity			
Hispanic	1752	1,656,937	8.9 (8.5–10.1)
Non-Hispanic Black	2483	1,586,475	8.9 (8.3–9.5)
Non-Hispanic White	36,286	13,683,884	76.6 (75.7–77.6)
Other	2206	926,402	5.2 (4.6–5.7)
Annual Household Income			
< $25,000	9669	4,104,702	28.8 (27.8–29.8)
$25,000—$50,000	9040	3,513,941	24.7 (23.7–25.7)
≥ $50,000	15,283	6,610,778	46.5 (45.4–47.6)
Education			
Did Not Graduate High School	2953	2,293,450	12.9 (12.0–13.7)
Graduated High School	11,404	4,929,424	27.7 (26.8–28.5)
Attended Some College/Technical School	12,126	5,680,395	31.9 (31.0–32.8)
Graduated College/Technical School	16,106	4,898,880	27.5 (26.8–28.3)

BRFSS, Behavioral Risk Factor Surveillance System

Table 2 Weighted percentage (%) of health behaviors among cancer survivors, BRFSS 2019

Guideline	Unweighted Sample size	Weighted percentage, % (95%CI)
Fruit and vegetable consumption ≥ five times/day	37,063	15.1 (14.3–15.9)
BMI < 30 kg/m^2	39,723	66.8 (65.9–67.7)
Engaging in physical activity ≥ 150 min/week	38,064	51.1 (50.1–52.1)
Not currently smoking	41,217	84.9 (84.1–85.7)
Not drinking alcohol excessively	40,216	89.5 (88.8–90.3)

BMI, body mass index; BRFSS, Behavioral Risk Factor Surveillance System; CI, confidence intervals

and higher levels of education for all guidelines except for alcohol drinking in which the lowest weighted percentage was found in the highest income group (85.5%) and which had a similar weighted percentage (~ 90%) meeting the guideline across all education levels (Figs. 1d-e and Supplemental Table 1). Most differences between subgroups were statistically significant ($p < 0.05$), except for fruit and vegetable consumption by age group ($p = 0.08$), excessive alcohol drinking by race and ethnicity ($p = 0.59$), and excessive alcohol drinking by education ($p = 0.50$).

Most cancer survivors met at least three of the health behavior guidelines, with only 25.7% of the unweighted sample in the lowest score group of 0–2 for the overall health behavior score (Table 3). Cancer survivors over the age of 65 were most likely to be in the high score group, whereas survivors aged 18–64 were most likely to have a moderate adherence score of 3. Males (37.0%) were more likely than females (33.7%) to be in the high adherence group ($p = 0.001$). When stratified by race and ethnicity, a higher weighted percentage of cancer survivors who were non-Hispanic White (36.8%) or in the Other race and ethnicity group (35.2%) were in the highest adherence category of the health behavior score than non-Hispanic Black (27.7%) and Hispanic (26.6%) survivors ($p = 0.001$). Cancer survivors with the highest income or education level had significantly higher weighted percentage of meeting a health behavior
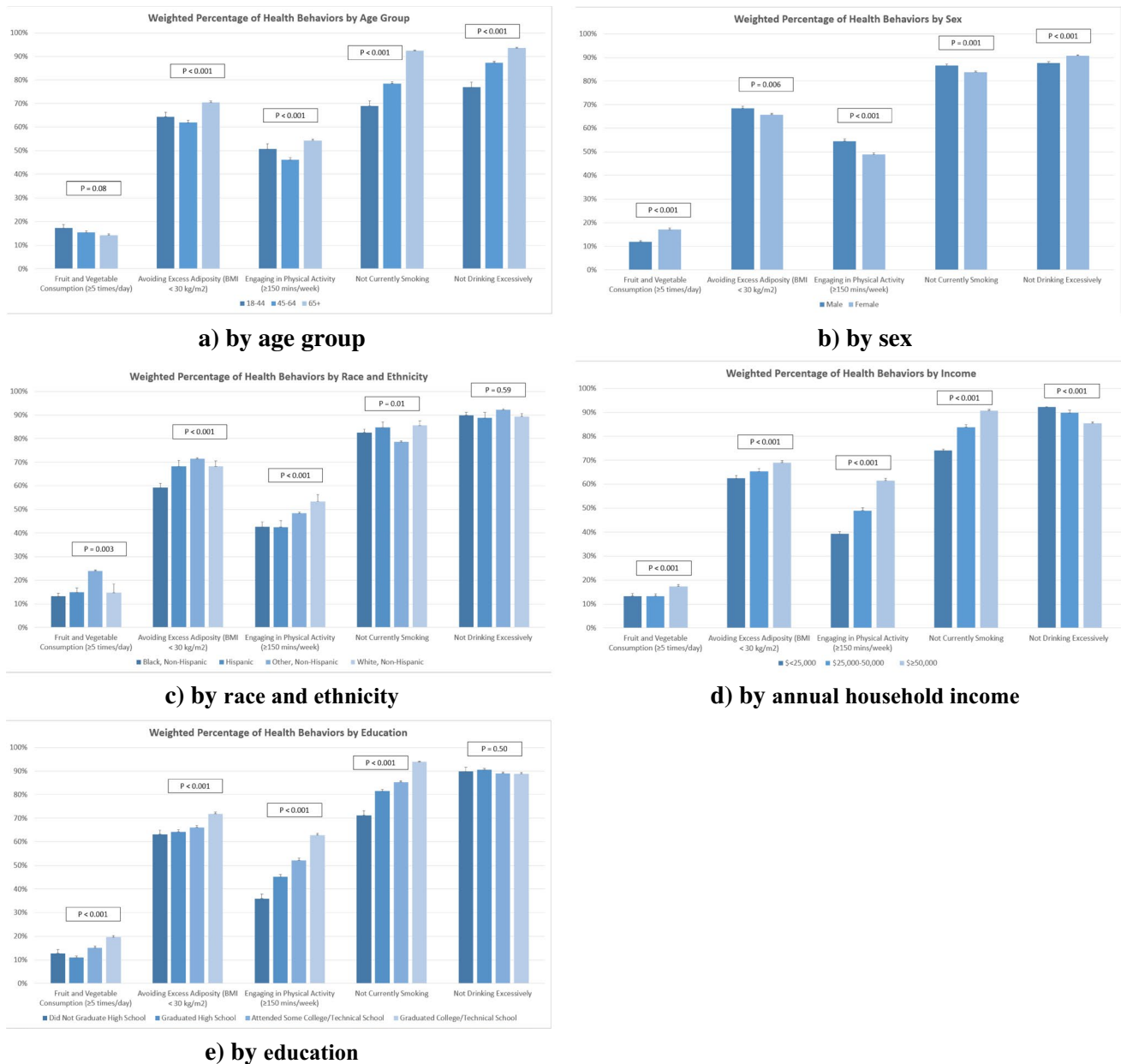
a) by age group

b) by sex

c) by race and ethnicity

d) by annual household income

e) by education

Fig. 1 Weighted percentage (%) of health behaviors by age, sex, race and ethnicity, income, and education, BRFSS 2019

overall (42.3% and 47.4%, respectively) than cancer survivors in the lowest income or levels of education (23.6% for income < $25,000/year and 21.6% for those who did not graduate high school; $p < 0.001$).

Discussion

We examined the prevalence of meeting health behavior guidelines among cancer survivors in the United States using data from the 2019 BRFSS. While the majority of cancer survivors met the guidelines for not smoking (~85%)

and limiting alcohol drinking (~90%), one-third had elevated BMI, almost half were not engaging in recommended physical activity levels, and a large majority (~85%) had inadequate fruit and vegetable intake. One-fourth of cancer survivors were meeting less than three total of the five health behavior guidelines. Higher overall health behavior scores were observed among older cancer survivors and those with higher income and education.

We focused on the ACS health behavior guidelines published in 2012 [4] and operationalized these similarly to previous studies in order to enhance comparability. However, it is notable that a more recent publication on ACS

Table 3 Weighted percentage of health behavior scores among cancer survivors stratified by selected characteristics, BRFSS 2019

	Low Adherence (Score 0–2) %, 95% Confidence Interval	Moderate Adherence (Score 3) %, 95% Confidence Interval	High Adherence (Score 4–5) %, 95% Confidence Interval	P-value*
Overall (unweighted number)	8405	11,932	12,338	
Age (years)				<0.001
18–44	36.4 (31.9–40.8)	40.2 (35.8–44.5)	23.5 (20.1–26.8)	
45–64	34.8 (33.0–36.6)	36.7 (34.8–38.6)	28.4 (26.7–30.2)	
≥65	20.8 (19.8–21.9)	37.5 (36.2–38.8)	41.7 (40.3–43.0)	
Sex				0.001
Male	25.4 (23.7–27.1)	37.6 (35.9–39.4)	37.0 (35.3–38.7)	
Female	28.8 (27.6–30.1)	37.5 (36.1–38.9)	33.7 (32.3–35.0)	
Race and Ethnicity				<0.001
Hispanic	30.8 (25.0–36.6)	42.6 (37.0–48.3)	26.6 (21.9–31.3)	
Non-Hispanic Black	35.8 (31.9–39.7)	36.5 (32.5–40.5)	27.7 (23.9–31.5)	
Non-Hispanic White	26.3 (25.3–27.3)	37.0 (35.9–38.1)	36.8 (35.7–37.8)	
Other	25.3 (20.5–30.0)	39.6 (33.4–45.7)	35.2 (28.2–42.1)	
Annual household income				<0.001
<$25,000	35.9 (33.8–38.0)	40.4 (38.1–42.7)	23.6 (21.6–25.7)	
$25,000-$50,000	31.0 (28.2–33.7)	37.6 (35.1–40.1)	31.4 (29.2–33.7)	
≥$50,000	21.5 (20.1–22.9)	36.1 (34.4–37.8)	42.3 (40.6–44.1)	
Education				<0.001
Did Not Graduate High School	40.4 (35.7–45.0)	38.1 (33.8–42.3)	21.6 (17.8–25.3)	
Graduated High School	33.2 (31.2–35.1)	39.4 (37.3–41.5)	27.4 (25.5–29.3)	
Attended Some College/Technical School	27.6 (25.9–29.3)	37.7 (35.8–39.7)	34.6 (32.7–36.6)	
Graduated College/Technical School	17.0 (15.8–18.2)	35.6 (33.9–37.2)	47.4 (45.8–49.1)	

BRFSS, Behavioral Risk Factor Surveillance System

*p-value determined by Chi-square test

guidelines for cancer survivors was published in 2022 [9] which updates the review of the evidence on health behaviors and cancer survivorship. The guidelines are very similar in both versions, but the 2022 publication provides increased consideration of changing needs between individuals including cancer type specific needs, barriers to nutrition and physical activity, and recommendations for counseling [9]. We focused on the 2012 guidelines due to availability at the initiation of our study, but our analysis likely would not have changed with use of the more recent guidelines, as the quantification of the guidelines is applicable to both versions.

In the systematic review of studies published prior to 2019, a pooled estimate of 34% of cancer survivors were meeting the fruit and vegetable intake guideline of ≥5 servings/day or ≥400 g/day based on 33 studies [12]. A study of only female breast cancer survivors in the 2009 BRFSS reported a similar proportion of 34% who were consuming recommended amounts of fruits and vegetables [15]. Compared to that study, among female survivors of all cancers in 2019, we found a much lower proportion meeting the guidelines for fruit and vegetable intake (17%). We did not

have data on type of cancer to be able to estimate weighted percentages among breast cancer survivors solely. Another more recent study using the 2017 BRFSS found that 11.5% of cancer survivors ate 5 or more servings of fruits and vegetables per day [16], a slightly lower weighted percentage than we found in the 2019 BRFSS (15.1% for all cancer survivors). Differences in fruit and vegetable intake reported across different years of BRFSS may reflect actual differences in intake across years, but also may be partially due to differences in wording of survey questions or the different choices by investigators of which fruits and vegetables to include in the total fruit and vegetable variable. For example, the 2017 and 2019 BRFSS inquired about frequency of intake of 100% fruit juice with no added sugar, while the 2009 BRFSS asked frequency of intake of any fruit drink. Fruit juice was not included in the total fruit and vegetable intake in the Zhu et al. publication on the 2017 BRFSS [16] but was included in the Zhao et al. publication from 2009 [15] and in our analyses. Regardless, the prevalence in the range of 11–34% of cancer survivors meeting the fruit and vegetable guideline across different studies is low and

deserves attention in future studies and interventions aimed at improving health of cancer survivors.

The weighted percentage of obesity among cancer survivors increased slightly from the 2009 BRFSS in which 28% had obesity [19] compared to 33% in 2019. In a systematic review of 27 studies, a similar 33% of cancer survivors had obesity [12]. The prevalence of obesity has risen in the last decade in the general United States adult population, increasing from 36% in 2009–2010 to around 42% in 2017–2020 (pre-pandemic) based on NHANES [23, 24], so the increase in weighted percentage of obesity during the past decade among cancer survivors mirrors that of the general population. The lower prevalence of obesity among cancer survivors as compared to the general population may be related to weight loss due to cancer treatment or pathogenesis, or a survival bias in that cancer survivors who had survived longer may have been healthier than others diagnosed with cancer who were not alive at the time of survey administration. We did not have data on time since diagnosis to be able to examine the weighted percentage of obesity stratified by more recent versus longer term cancer diagnosis to examine this possible explanation. However, one study among breast cancer survivors reported lower prevalence of obesity with increasing time since diagnosis [15], which supports the potential for survival bias as an explanation for the lower rates of obesity seen among cancer survivors compared to the general population.

In the 2009 BRFSS, approximately 31% of cancer survivors in the United States did not engage in leisure time physical activity in the past 30 days [19] and 46% of breast cancer survivors were not engaging in recommended levels of physical activity [15]. Another study of the 2009 BRFSS compared physical activity levels between cancer survivors and respondents without cancer [18]. Prostate cancer survivors reported 20 more minutes per week of moderate-to-intensity physical activity equivalent compared to males without cancer, and cervical and endometrial cancer survivors reported 10 fewer minutes per week of moderate-to-intensity physical activity equivalent compared to females without cancer [18]. We measured physical activity using a different set of questions defined by engaging in any type of physical activity for at least 150 min per week and found that almost half were not meeting the guideline, whereas the previous studies measured any leisure time physical activity. Therefore, a direct comparison of rates of physical activity between the two survey years is not possible. Interestingly, a study using the NHANES from 2007–2010 found that cancer survivors are more likely to report more moderate intensity physical activity but also were more likely to spend > 8 h per day in sedentary behavior than individuals without cancer [25].

The proportion of cancer survivors meeting smoking and excessive alcohol guidelines did not materially change during the last decade comparing our results to previous reports. Approximately 15% of cancer survivors were current smokers in both the 2009 [19] and 2019 BRFSS. A slightly smaller proportion of breast cancer survivors (10%) reported current smoking in 2009 [15]. Among breast cancer survivors, 7% reported excessive alcohol drinking in the 2009 BRFSS [15] which is comparable to the approximate 9% female breast cancer survivors who reported this in 2019. Prevalence estimates comparing cancer survivors to individuals without cancer have varied for smoking and alcohol. A study using the NHANES from 1999–2008 reported that individuals with cancer under age 40 are more likely to be current smokers than individuals without cancer, but in older age groups there was no significant difference in prevalence of current smokers between those with and without cancer [26]. A study using the 2012–2017 National Health Interview Study found that cancer survivors have a lower prevalence of binge drinking, defined as five or more drinks/day for men and 4 or more drinks/day for women at least once per month in the past year, than individuals without cancer [27].

We created an overall health behavior score by combining adherence to all five health behaviors and observed that around 25% of respondents adhered to less than three of the guidelines and approximately 38% were meeting four or five of the guidelines. In a systematic review and meta-analyses of 13 studies, the prevalence of cancer survivors adhering to multiple health behaviors (defined as adhering to at least two-thirds of the behaviors that were examined in the individual study) ranged from 7 – 40% and the pooled prevalence was 23% (95% CI: 17, 30%) [12]. In the review, prevalence of adhering to multiple behaviors was higher among cancer survivors diagnosed within the past 5 years as compared to > 5 years prior, those who were older than 60 years as compared to younger, and in studies that were published more recently (2015–2017 as compared to 2007–2010) suggesting that perhaps healthy behaviors are increasing over time [12]. As mentioned, we did not have information on time since cancer diagnosis, but observed a similar higher prevalence of adhering to multiple behaviors among older cancer survivors (≥ 65 years) compared to younger. We also noted higher prevalence of adhering to multiple behaviors among males, non-Hispanic White and Other race and ethnicity respondents, and those with higher income or education (at least some college) which also have been reported for individual health behaviors in previous studies [15–17].

As described in the 2022 ACS cancer survivorship guidelines, the epidemiologic evidence supports a benefit of following the five health behaviors not only for reducing risk of premature death but also improving quality of life [9]. Other systematic reviews and meta-analyses corroborate these conclusions. For example, intake of vegetables was

associated with a reduced risk of mortality among cancer survivors in a systematic review and meta-analyses of 21 studies [28]. A meta-analysis reported that even low levels of physical activity reduced mortality by 40% in cancer survivors [29], and in another review paper, more active breast cancer and colorectal cancer survivors had lower mortality rates from cancer and other causes compared to their less active counterparts [30]. Tobacco use after a cancer diagnosis has been shown to increase risk of recurrence and mortality [3, 31], and survivors may have a better quality of life after smoking cessation [32]. Alcohol intake has been associated with modest increased risk of mortality among cancer survivors in a systematic review [pooled risk ratio (RR) of 63 studies: 1.08, 95%CI: 1.02, 1.16] which strengthened among certain types of cancers such as head and neck cancers and non-Hodgkin lymphoma, but was attenuated when only post-diagnosis alcohol intake was assessed (RR: 0.94, 95%CI: 0.81, 1.11) [28]. An increased risk of cancer recurrence, however, was observed for studies of both pre- and post-diagnosis alcohol intake (RR: 1.17, 95%CI: 1.05, 1.31) as well only studies of post-diagnosis intake only (RR: 1.31, 95%CI: 1.04, 1.66) [28], highlighting the importance of alcohol reduction in cancer survivor guidelines.

Strengths and limitations

A strength of this study is the large sample size of cancer survivors representative of the United States population. We used a recent version of the BRFSS prior to the start of the COVID-19 pandemic (2019). We could not use the most recently available version of BRFSS (2020) because it did not include questionnaire modules for each health behavior. A limitation of the 2019 BRFSS survey is that data on cancer types and age at diagnosis were not collected in the majority of respondents, thus we could not examine whether prevalence of health behaviors differed by cancer type or time since diagnosis. The BRFSS is a self-administered survey that is not validated by objective measures of dietary intake or physical activity, medical records, or linkage with cancer registries, therefore our study is subject to possible measurement error due to self-report. Finally, we recognize that BMI is not a perfect measure of adiposity, and there may have been some misclassification of obesity status particularly among those with high muscle mass or those with metabolic obesity in the normal weight condition [33, 34].

Conclusion

In summary, we found that the majority of cancer survivors in the United States in 2019 were meeting guidelines for smoking and alcohol drinking, while one-third had elevated BMI, half

were not engaging in recommended physical activity, and a large majority reported inadequate fruit and vegetable intake. Adherence to the majority of guidelines was lowest among younger cancer survivors and those with lower income and education, suggesting these may be populations where future research and public health resources could be targeted to have the greatest impact.

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