Trends in Obesity Prevalence in Adults With a History of Cancer: Results From the US National Health Interview Survey, 1997 to 2014

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ABSTRACT

Purpose

Obesity after a diagnosis of specific cancers has been associated with worse prognosis. We examined the trend in obesity prevalence among cancer survivors in the United States in the past two decades and compared trends with those of adults without a history of cancer.

Patients and Methods

This was a population-based nationally representative sample of 538,969 noninstitutionalized US adults 18 to 85 years old with and without a history of cancer who participated in annual cross-sectional National Health Interview Surveys from 1997 to 2014. Obesity was defined as body mass index ≥ 30 kg/m² for non-Asians and body mass index ≥ 27.5 kg/m² for Asians.

Results

Among 32,447 cancer survivors identified, the most common cancer diagnoses were breast (n = 6,948), prostate (n = 3,984), and colorectal (n = 2,546). From 1997 to 2014, the prevalence of obesity increased from 22.4% to 31.7% in cancer survivors and from 20.9% to 29.5% in adults without a history of cancer (*P* for trend < .001, both groups). Over this period, the estimated rate of annual increase in obesity prevalence was higher in women and men with a history of cancer compared with those without a history of cancer (all *P* for interaction < .001). The estimated rate of annual increase in obesity prevalence was 3.1% in female and 3.7% in male colorectal cancer survivors, 3.0% in breast cancer survivors, and 2.1% in prostate cancer survivors (all *P* < .001). In subgroup analyses, populations with the highest rates of increasing obesity burden were colorectal cancer survivors, breast cancer survivors, and non-Hispanic blacks.

Conclusion

From 1997 to 2014, obesity increased more rapidly among adult cancer survivors compared with the general population. Colorectal and breast cancer survivors and non-Hispanic blacks were identified as being at the highest risk for obesity.

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INTRODUCTION

Obesity is a major public health issue associated with increased morbidity and mortality in the United States and globally.¹⁻³ According to the most recent US obesity trends analysis, the prevalence of obesity escalated from 1980 to 2000 and continued to increase among non-Hispanic black and Mexican-American women from 1999 to 2010.⁴ By 2030, the continued increase in obesity in the United States and the United Kingdom is projected to cause an additional 6 to 8.5 million new diagnoses of diabetes and 5.7 to 7.3 million new diagnoses of heart disease and stroke, and a loss of 26 to 55 million quality-adjusted life-years.⁵

Obesity has also been associated with cancer incidence, progression, and survival, especially in hormonally and metabolically driven cancers such as breast and colorectal cancer.⁶⁻⁹ The projected increases in population-based obesity rates likely pose additional health hazards for cancer survivors. For example, recent studies suggest that weight at the time of breast cancer diagnosis and weight gain after diagnosis are both associated with higher cancer mortality and all-cause mortality.¹⁰⁻¹² Although patients with cancer and cancer survivors are subject to similar energy-balance-related causes of weight gain as is the general population of the United States, they are also at risk for increased weight gain caused by specific cancer treatments, including chemotherapy, steroid medications, and

hormonal therapy.^{13,14} Several national organizations recommend weight control for cancer survivors,^{15,16} and a recent ASCO position statement encouraged oncology care providers to address weight management among their patients.⁹ Whether US cancer survivors have experienced different rates of changes in obesity burden compared with adults without a history of cancer has not been evaluated. Large population-based studies are needed to evaluate whether a distinct obesity pattern and trajectory exist in cancer survivors.

To better inform future research on obesity and cancer survival and to inform the planning and implementation of weight-loss interventions in cancer survivors,¹⁷ we compared trends from 1997 to 2014 in obesity prevalence in US adults with and without a history of cancer. We hypothesized that the prevalence of obesity would increase over time among adults both with and without a history of cancer, and that the amount of annual increase would be greater in adults with a history of cancer. To identify populations of cancer survivors at the highest risk for obesity, we examined trends in obesity prevalence among cancer survivors by cancer type, age, race/ethnicity, and time since diagnosis.

PATIENTS AND METHODS

Study Participants

The analysis used data from adult participants 18 to 85 years of age in the annual 1997 to 2014 waves of the National Health Interview Survey (NHIS). The NHIS is an ongoing cross-sectional survey of the health status, health care access, and behaviors of the US civilian non-institutionalized population conducted by the National Center for Health Statistics. Details on the NHIS sample design are published elsewhere.¹⁸ Briefly, each year, the NHIS uses multistage probability sampling to select 428 primary sampling units from approximately 1,900 geographically defined primary sampling units covering the 50 states and the District of Columbia. Approximately 41,000 households and 107,000 individuals are selected each year. The NHIS has used two sets of questionnaires since 1997: (1) a set of basic health and demographic items (ie, the Core questionnaire) for all individuals living in a house and (2) one or more sets of questions on current health topics (ie, the Supplements) for one adult and one child, each randomly selected from each house. The Cancer Screening questionnaire has been included as a supplement every year since 1997. The NHIS annual response rate is approximately 80%. In this analysis, we used data from adults who responded to both the Core questionnaire and the Cancer Screening supplement. All NHIS activities undergo human subject oversight, and participants provide informed consent.

Cancer History

Interviewers asked participants if a physician or other health professional had ever informed them that they had cancer, and if the answer was yes, in what year the cancer diagnosis occurred. Cancer survivors included individuals who reported a cancer diagnosis at any age and excluded those who reported only nonmelanoma skin cancers.

Obesity

Self-reported height and weight were used to compute body mass index (BMI, kg/m²). BMI was categorized as underweight (BMI < 18.5 kg/m²), normal weight (BMI, 18.5 to < 25 kg/m²), overweight (BMI, 25 to < 30 kg/m²), class I obesity (BMI, 30 to < 35 kg/m²), and class II/III obesity (BMI ≥ 35 kg/m²).¹⁹ For Asians, the WHO Asian cut points were applied for underweight (BMI

< 23 kg/m²), overweight (BMI, 23 to < 27.5 kg/m²), and obese (class I, BMI ≥ 27.5 kg/m² and class II/III, BMI ≥ 32.5 kg/m²) participants.²⁰ In analyses of obesity prevalence, we dichotomized BMI as nonobese and obese (BMI < 30 kg/m² v ≥ 30 kg/m² for non-Asians; BMI < 27.5 kg/m² v ≥ 27.5 kg/m² for Asians).

Demographic and Behavioral Information

Participants provided self-reported information on age, sex, race/ethnicity, education, employment, family income, health insurance coverage, nation of birth, current smoking behavior, current alcohol use, physical activity, and noncancer chronic conditions.

Statistical Analyses

NHIS-constructed survey weights were applied to account for the NHIS complex stratified sampling methods and to make estimates representative of the US civilian noninstitutionalized adult population.¹⁸ To compare population characteristics over time, survey participants were grouped into six consecutive 3-year samples (1997 to 1999, 2000 to 2002, 2003 to 2005, 2006 to 2008, 2009 to 2011, and 2012 to 2014). In descriptive analyses for each sample, Pearson's χ^2 tests were used to compare demographic and health characteristics of cancer survivors and cancer-free participants; a Bonferroni correction was used to account for multiple comparisons.²¹ To examine the differences in obesity prevalence between cancer survivors and cancer-free participants, the age-standardized prevalence of obesity was calculated for each sample using the 2000 US population for appropriate comparisons between the survey years.²² Cochran-Armitage trend tests were used to determine whether demographic and health characteristics of the population changed over time for each group. Changes from the first to the last survey were compared between the two groups using Z-tests. To visually illustrate changes in obesity prevalence over time, we calculated the age-standardized prevalence of obesity for each survey year by sex and cancer status and displayed the results as smoothed lines using locally weighted scatterplot smoothing.²³ The same method was used to display the prevalence of adults with one or more chronic condition(s) by cancer and BMI category.

Individual-level data on obesity status were aggregated by survey year, sex, age group, and cancer status, accounting for survey weights. These data included the estimated number of obese and nonobese adults by survey year, sex, age group, and cancer status. The aggregate data were used to analyze the prevalence of obesity over time, and the unit of analysis was the count of obese and nonobese individuals in the population for each year-sex-age-cancer group. Poisson regression was used to estimate the rate ratio because the distribution of the primary outcome (ie, the number of obese individuals in a specific population) is a discrete frequency distribution that counts the number of events occurring in a fixed period of time. We estimated the relative increase in obesity prevalence per year using Poisson regression adjusting for age, and fit models separately by sex and cancer type. We tested the interaction between year and cancer status to test for differential annual increases in obesity prevalence between all cancer survivors compared with participants without a history of cancer. We also separately tested the interaction between year and cancer status for survivors of each of the most common cancers, including colorectal, breast, and prostate cancer. Subgroup analyses were conducted by age group, race/ethnicity, and length of cancer survivorship.

All tests of significance were two tailed, with $\alpha = .05$. Analyses were performed using R (version 3.2.4; <https://cran.r-project.org/>). All analyses used the R survey package^{24,25} to apply the complex survey design.

RESULTS

Participant Characteristics

The characteristics of 32,447 adult cancer survivors and 506,522 adults without a history of cancer are summarized in

Table 1 by NHIS participation time period and cancer history status. Over the 18-year period, the proportion of US adults with a history of cancer increased steadily (5.1% between 1997 and 1999, 5.3% between 2000 and 2002, 5.5% between 2003 and 2005, 5.6% between 2006 and 2008, 6.2% between 2009 and 2011, and 6.2% between 2012 and 2014). In almost all periods, compared with adults without a history of cancer, cancer survivors were more likely to be female, non-Hispanic white, have been born in the United States, have higher education attainment, not currently employed, have lower incomes, have health insurance, be a heavy smoker, a light-to-moderate drinker, and have more than one chronic condition (all P values $< .001$).

Obesity Trends

The prevalence of obesity consistently increased from 22.4% in 1997 to 31.7% in 2014 in cancer survivors and from 20.9% to 29.5%, respectively, in adults without a history of cancer (P for trend $< .001$ for both groups; Fig 1; Table 1). Meanwhile, there was a decreasing prevalence of normal weight (BMI, 18.5 to < 25 kg/m²) and underweight (BMI < 18.5 kg/m²) individuals and no consistent change in overweight individuals in adults with and without a history of cancer (Fig 1; Table 1). Across the time periods, changes in obesity prevalence were similar in women (21.2% to 35.0% in cancer survivors v 19.2% to 29.4% in adults without a history of cancer) and men (17.0% to 34.9% in cancer survivors v 19.1% to 29.2% in adults without a history of cancer). Of particular note, among women, across all time periods, the prevalence of class I obesity was consistently higher in cancer survivors compared with women without a history of cancer (13.6% to 21.0% in female cancer survivors v 12.2% to 16.6% in women without a history of cancer), and the differences grew larger over time (Fig 1).

Over the study period, the prevalence of obesity was estimated to increase by 2.9% and 2.8% each year for women and men, respectively, with a history of cancer, and by 2.3% and 2.4%, respectively, for women and men without a history of cancer (Table 2; Fig 2). The annual increase in the rate of obesity was significantly greater in women and men with a history of cancer compared with those without a history of cancer (all P for interaction $< .001$). The elevated annual increase in rates of obesity was even higher in colorectal (3.1% in women and 3.7% in men) and breast (3.0%) cancer survivors compared with adults without a history of cancer but was lower in prostate (2.1%) cancer survivors (all P for interaction $< .001$).

Subgroup Analyses of Obesity Trends by Age, Race/Ethnicity, and Years Since Diagnosis, by Cancer Type

The prevalence of obesity among the most common cancers (colorectal, breast, and prostate) was examined by age, race/ethnicity, and years since diagnosis (Table 3). The prevalence of obesity grew more rapidly in nearly every subgroup of colorectal and breast cancer survivors compared with the corresponding groups of adults without a history of cancer (all P for interaction $< .001$). Among colorectal cancer survivors, women 18 to 44 years of age, non-Hispanic blacks, and those 2 to 9 years from diagnosis had the highest increasing rates of obesity. Among female breast cancer survivors, women 18 to 44 years of age, non-Hispanic whites, and those ≤ 1 year from diagnosis were the groups with the highest

increasing rates of obesity (all P for interaction $< .001$). The patterns were different among men. Among male colorectal cancer survivors, the increasing rates of obesity were highest among men 65 to 85 years of age, non-Hispanic blacks, and those ≥ 10 years from diagnosis. Among prostate cancer survivors, men 18 to 44 years of age, non-Hispanic whites, and those 2 to 9 years from diagnosis had the highest increasing rates of obesity (all P for interaction $< .001$).

Trends in Chronic Conditions

The percentages of adults with one or more noncancer chronic condition(s) increased over time independent of BMI and cancer history (Appendix Fig A1, online only). Within each BMI category, cancer survivors are systematically more likely to have one or more noncancer chronic condition(s) compared with adults without a history of cancer.

DISCUSSION

In a large, population-based, nationally representative sample, we observed a consistently increasing burden of obesity from 1997 to 2014 in US adults with and without a history of cancer. Across this time period, cancer survivors had a significantly faster increase in obesity prevalence compared with adults without a history of cancer. The faster increase in obesity prevalence was more pronounced in women, in breast and colorectal cancer survivors, and in non-Hispanic blacks. Our findings suggest that the trajectory of the US obesity burden will continue to increase, which will result in an increased burden of obesity in the general population and thus increase the number of obesity-related cancers, and also result in an increased burden of obesity among cancer survivors, including those cancers in which obesity is associated with poorer cancer outcomes.

On the basis of current trajectories, we identified population characteristics of cancer survivors at the highest risk of obesity, which are important patient populations in which oncology care providers should focus weight management efforts. In female colorectal cancer survivors, those who are young and non-Hispanic black and have been diagnosed within 2 to 9 years have the highest increasing rates of obesity. Similarly, among female breast cancer survivors, those who are young, were diagnosed within the past year, and are non-Hispanic white have the highest increasing obesity rate. Among male colorectal cancer survivors, the highest increases in obesity are among older men, non-Hispanic blacks, and those ≥ 10 years from diagnosis. In contrast, prostate cancer survivors with the highest increases in obesity burden are younger, non-Hispanic whites 2 to 9 years from diagnosis. Previous studies of weight change in prostate cancer showed similar patterns, which found younger age at diagnosis and lower baseline BMI to be predictors of weight gain after diagnosis.^{28,29} However, increased BMI was most likely to occur in the first year of therapy for prostate cancer survivors.³⁰

Given that breast and colorectal cancer are the two cancers most closely linked to obesity, our findings can be partially explained by the growing population of patients with breast and colorectal cancer in whom obesity may have been in the causal pathway for disease.³¹⁻³³ However, we have identified additional

Table 1. Sample Characteristics by Year

Characteristic	1997-1999 ^a		2000-2002		2003-2005		2006-2008		2009-2011		2012-2014		Difference Between 2012-2014 and 1997-1999 [95% CI] ^b	
	Cancer	Noncancer	Cancer	Noncancer	Cancer	Noncancer	Cancer	Noncancer	Cancer	Noncancer	Cancer	Noncancer	Cancer	Noncancer
Sample size	5,230	91,981	5,194	88,464	5,389	85,963	4,027	63,639	5,530	79,945	7,077	95,530		
Projected US population, 1,000s ^c	29,664	552,872	31,600	569,699	35,010	599,114	36,982	618,169	41,576	632,498	43,437	652,916		
Female, %	63.1	47.1	66.4	47.1	64.6	46.6	64.2	46.3	65.2	47.2	62.2	47.1	-0.92 (-0.95 to -0.90)	0.01 (0.01 to 0.02)
Race/ethnicity, %														
Non-Hispanic white	87.3	78.1	89.2	76.1	86.6	74.2	83.9	72.4	82.1	70.8	80.7	69.0	-6.56 (-6.57 to -6.54)	-9.12 (-9.12 to -9.11)
Non-Hispanic black	7.1	10.5	5.8	11.5	5.7	11.2	8.7	11.3	8.8	11.4	6.4	11.4	-0.60 (-0.62 to -0.59)	0.90 (0.90 to 0.90)
Hispanic	4.9	9.7	4.7	10.4	6.8	12.4	5.6	13.5	8.2	14.6	10.7	16.1	5.83 (5.82 to 5.85)	6.41 (6.41 to 6.41)
Asian	0.8	1.8	0.3	2.1	0.8	2.2	1.8	2.7	1.0	3.2	2.1	3.6	1.33 (1.33 to 1.34)	1.81 (1.81 to 1.81)
Education, %														
High school graduate or less	42.3	44.7	43.1	43.7	39.0	41.6	37.0	41.3	32.6	37.2	32.7	34.8	-9.52 (-9.54 to -9.49)	-9.89 (-9.89 to -9.88)
Associate's degree/some college	33.8	30.7	34.5	30.9	33.3	31.1	32.9	31.1	37.8	32.5	36.0	32.7	2.23 (2.21 to 2.26)	2.00 (2.00 to 2.01)
Bachelor's degree and above	24.0	24.7	22.5	25.4	27.8	27.3	30.1	27.7	29.6	30.3	31.2	32.6	7.28 (7.26 to 7.30)	7.89 (7.88 to 7.89)
Employment, %														
Unemployed	86.3	89.4	80.9	87.2	81.2	87.0	79.7	86.7	78.5	84.1	80.8	85.7	-5.50 (-5.52 to -5.48)	-3.67 (-3.67 to -3.67)
Employed	0.4	0.2	2.2	2.4	4.5	3.3	3.6	3.0	6.3	5.7	5.0	4.4	4.70 (4.69 to 4.71)	4.21 (4.21 to 4.21)
Not in labor force	13.4	10.4	16.9	10.4	14.3	9.7	16.7	10.3	15.2	10.1	14.2	9.9	0.81 (0.79 to 0.83)	-0.55 (-0.55 to -0.54)
Income < \$20,000, % ^d	50.9	45.5	49.5	41.0	41.8	37.6	42.3	35.9	41.2	35.3	37.6	33.3	-13.22 (-13.24 to -13.20)	-12.14 (-12.14 to -12.13)
No health insurance, % ^e	8.6	9.3	12.0	12.0	12.6	13.7	14.0	15.0	15.3	16.5	13.9	15.2	5.26 (5.25 to 5.28)	5.89 (5.88 to 5.89)
US born, %	95.0	89.2	94.9	87.6	93.9	85.7	94.5	85.3	91.6	83.9	91.4	82.4	-3.57 (-3.58 to -3.55)	-6.82 (-6.83 to -6.82)
Smoking history, % ^f														
Current, heavy smoking	23.1	20.5	28.0	20.0	23.8	18.0	24.3	17.7	19.3	15.8	17.1	13.8	-5.97 (-5.99 to -5.95)	-6.63 (-6.63 to -6.62)
Current, light-moderate smoking	3.1	4.5	4.8	4.2	5.8	4.4	3.9	4.5	3.2	4.7	4.4	4.0	1.30 (1.29 to 1.31)	-0.48 (-0.49 to -0.48)
Former smoker	29.4	24.5	23.4	23.7	26.8	22.3	27.7	21.8	26.8	21.7	26.1	21.9	-3.30 (-3.32 to -3.28)	-2.54 (-2.54 to -2.53)
Never-smoker	44.5	50.6	43.8	52.0	43.6	55.3	44.1	56.0	50.7	57.8	52.4	60.2	7.97 (7.94 to 7.99)	9.65 (9.64 to 9.65)
Alcohol use, % ^g														
Current, heavy drinking	19.4	23.4	20.0	22.3	21.0	22.8	25.0	25.0	21.2	26.4	27.2	28.3	7.75 (7.73 to 7.77)	4.89 (4.89 to 4.90)
Current, light-moderate drinking	49.5	45.6	45.8	45.5	48.1	45.3	47.4	44.5	49.0	45.7	47.0	44.0	-2.49 (-2.51 to -2.46)	-1.59 (-1.60 to -1.59)
Former drinker	17.7	13.9	18.5	14.0	14.6	13.0	14.7	13.5	16.4	12.3	15.7	11.5	-2.08 (-2.09 to -2.06)	-2.42 (-2.42 to -2.42)
Never-drinker	13.3	17.1	15.7	18.3	16.2	18.9	12.9	17.0	13.5	15.6	10.1	16.2	-3.19 (-3.21 to -3.18)	-0.89 (-0.89 to -0.88)
Meets physical activity guidelines, % ^h	31.5	30.1	29.8	31.4	29.0	30.3	29.2	30.6	37.7	35.3	36.1	38.3	4.60 (4.57 to 4.62)	8.12 (8.12 to 8.13)
No. chronic conditions ⁱ														
0	66.4	75.6	54.0	67.6	60.6	72.7	52.4	66.1	54.5	69.9	55.1	71.8	-11.33 (-11.36 to -11.31)	-3.81 (-3.81 to -3.80)
1	18.7	15.6	24.8	20.1	22.5	17.2	23.6	21.1	24.6	19.0	24.9	18.6	6.14 (6.13 to 6.16)	2.99 (2.98 to 2.99)
≥ 2	14.9	8.8	21.2	12.3	16.9	10.1	23.9	12.9	21.0	11.1	20.1	9.7	5.19 (5.17 to 5.20)	0.82 (0.82 to 0.82)
BMI (kg/m ²), %														
18.5	8.2	6.0	8.8	5.5	6.3	5.2	7.0	5.1	6.6	4.9	7.0	4.7	-1.14 (-1.15 to -1.13)	-1.36 (-1.36 to -1.36)
18.5-24.9	33.9	36.4	32.1	34.0	35.4	32.4	31.5	31.0	32.4	30.3	30.6	29.9	-3.31 (-3.33 to -3.29)	-6.56 (-6.56 to -6.55)
25-29.9	35.5	36.7	35.2	36.9	31.4	37.3	32.7	36.7	31.9	36.3	30.6	36.0	-4.90 (-4.92 to -4.87)	-0.68 (-0.68 to -0.67)
≥ 30	22.4	20.9	24.0	23.6	26.9	25.2	28.8	27.3	29.0	28.5	31.7	29.5	9.35 (9.33 to 9.37)	8.59 (8.58 to 8.59)

Abbreviation: BMI, body mass index.

^aPearson's χ^2 test results between adults with and without cancer within each period were statistically significant (all $P < .001$ after Bonferroni correction) for sex, race/ethnicity, education, employment, income, insurance, nativity, current smoking, and current drinking.

^bTrend test for proportions over time showed statistically significant trends in all sample characteristics (all $P < .001$ after Bonferroni correction). Z-tests were used to compare changes in characteristics between populations with and without cancer for the first (1997-1999) and last (2012-2014) periods; there were statistically significant differences for all characteristics (all $P < .001$ after Bonferroni correction), except for the proportion of employed adults.

^cThe projected size of populations with and without cancer were estimated using National Health Interview Survey complex survey design and cancer survey weights.

^dIndividuals' total incomes in the previous year, including hourly wages, salaries, tips, and commissions.

^eHealth insurance included self-reported Medicaid, Medicare, private insurance, insurance offered at workplace, military health care/Veterans Affairs insurance, Medi-Gap, and Indian Health Service insurance.

^fSmoking: current smoking was defined as self-reported smoking at the time of interview, heavy smoking was defined as smoking every day, and light-moderate smoking was defined as currently smoking less than every day.

^gAlcohol use: current alcohol use was defined as having at least 12 drinks of any type of alcoholic beverage in the past year, heavy drinking was defined as having at least 1 day with five or more drinks during the past year, and light-moderate drinking was defined as any current alcohol use that was less than heavy drinking.

^hPhysical activity: adults classified as partaking in regular leisure-time activity reported at least three sessions per week of vigorous leisure-time physical activity lasting at least 20 minutes in duration or at least five sessions per week of light/moderate physical activity lasting at least 30 minutes in duration.²⁶

ⁱSelf-reported noncancer chronic conditions included angina pectoris, coronary heart disease, noncongenital heart condition, heart attack, stroke, other heart condition, asthma, chronic bronchitis, emphysema, chronic obstructive pulmonary disease, asthma attack, arthritis, diabetes, hepatitis, liver condition, and weak/failing kidney. The number of chronic conditions other than cancer was categorized into 0, 1, and ≥ 2 .

Fig 1. Changes in BMI categories from 1997 to 2014 in US adults with and without a history of a cancer diagnosis. Survey-weighted and age-standardized prevalence of five BMI categories were estimated for men and women with and without a history of cancer at each survey year. BMI was categorized according to National Heart, Lung, and Blood Institute guidelines as underweight (BMI $< 18.5 \text{ kg/m}^2$), normal weight (BMI, 18.5 to $< 25 \text{ kg/m}^2$), overweight (BMI, 25 to $< 30 \text{ kg/m}^2$), class I obesity (BMI, 30 to $< 35 \text{ kg/m}^2$), and class II/III obesity (BMI $\geq 35 \text{ kg/m}^2$). For Asians, the WHO Asian cut points were applied for underweight (BMI $< 23 \text{ kg/m}^2$), overweight (BMI, 23 to $< 27.5 \text{ kg/m}^2$), and obesity (class I, BMI $\geq 27.5 \text{ kg/m}^2$ and class II/III, BMI $\geq 32.5 \text{ kg/m}^2$). Data were plotted as smoothed lines using locally weighted scatterplot smoothing. BMI, body mass index.

populations of cancer survivors at risk of obesity in whom the effects of obesity are not as well understood. In addition, it is important to consider obesity among cancer survivors not only in relation to cancer outcomes, but also in relation to other comorbid conditions. Although the association between increased BMI and recurrence and survival is not fully understood, it is well established that obesity can influence other medical conditions such as diabetes, heart disease, hypertension, and hypercholesterolemia, which may affect overall survival.^{1,2} In addition, specific chemotherapy agents have cardiac adverse effects that can be compounded by higher BMI.³⁴ Among breast and prostate cancer survivors, the majority will die as a result of cardiovascular disease and not cancer.^{35,36} Studies of breast, colon, and prostate cancer showed that comorbid conditions increase 5-year all-cause and cancer-specific mortality.^{37,38} Therefore, it is important to consider obesity among cancer survivors not only in relation to cancer outcomes, but also in relation to other comorbid diseases.

A major strength of this study is that it was based on a large and nationally representative sample, making our results generalizable to the US adult population. Our estimates of prevalent cancer cases were similar to estimates of the National Cancer Institute's SEER program. Using the NHIS data, we estimated that

there were 14,250,194 cancer survivors in 2012 and 14,673,007 in 2013. In comparison, SEER reported that there were an estimated 13,776,251 cancer survivors in 2012,³⁹ and the National Cancer Institute estimated that there were 14,483,830 cancer survivors in 2014.⁴⁰ Our estimates were slightly higher than the SEER estimates of total prevalent cases, likely because our sample came from the noninstitutionalized population in the US, who may have been healthier than institutionalized individuals. Another strength of the study is that the ascertainment of cancer history was uniform and consistent across geographic regions and survey years, which helped reduce ascertainment bias. From this population-based sample of US adults, we were able to identify a large number of cancer survivors of different ages and race/ethnicities and at different stages of cancer survivorship, allowing for statistically robust comparisons in each subgroup of survivors. Nevertheless, our results do have limitations. First, the secular trends in obesity prevalence were observed using cross-sectional data over time; therefore, the observed faster increase in cancer survivors would be overestimated if leaner cancer survivors are at greater risk of mortality. Conversely, weight loss associated with heavy smoking⁴¹ and cachexia⁴² in cancer survivors may have biased our estimates toward the null. Second, the NHIS uses respondents' self-reported

Table 2. Estimated Annual Increase Rates in Obesity Prevalence From 1997 to 2014 in US Adults With and Without a History of Cancer

Population	Women			Men		
	Annual Increase in Obesity Prevalence (%)*	95% CI	P for Interaction†	Annual Increase in Obesity Prevalence (%)*	95% CI	P for Interaction†
No history of cancer	2.31	2.31 to 2.31		2.38	2.38 to 2.38	
History of cancer						
All cancers	2.88	2.87 to 2.88	$< .001$	2.77	2.77 to 2.78	$< .001$
Colorectal cancer	3.09	3.07 to 3.12	$< .001$	3.70	3.68 to 3.73	$< .001$
Breast cancer	3.01	3.00 to 3.02	$< .001$	—	—	—
Prostate cancer	—	—	—	2.06	2.04 to 2.07	$< .001$

*Annual increases were estimated using Poisson regressions adjusted for age and stratified by sex and cancer type.

†P value for the interaction term between cancer status (yes/no) and time.

Fig 2. Trends in obesity prevalence in US adults from 1997 to 2014, by sex, cancer history and race/ethnicity. (A) Obesity trends by sex and cancer history. Obesity (defined as body mass index ≥ 30 kg/m²) prevalence was estimated for men and women with a history of any cancer, colorectal, breast, and prostate cancers, and those without a history of cancer. Separate Poisson regression models were fit for each group to estimate the annual increase rates in obesity prevalence during this period. Each line represents the trend of predicted obesity prevalence over the specific period. Tests of differential increased rates showed that the increased rates were significantly higher among female cancer survivors compared with women without a history of cancer, and significantly higher among survivors of all cancer and colorectal cancer in men (all *P* for interaction $< .001$). (B) Obesity trends by race/ethnicity. Subgroup analyses by sex and race/ethnicity were conducted for all cancer survivors. The difference in increased rates of obesity prevalence was greater in non-Hispanic blacks compared with non-Hispanic whites and Hispanics.

height and weight to calculate BMI, which may introduce information bias because obesity awareness has changed over time. It has been shown that self-reported weight and height data underestimate the prevalence of overweight and obesity.^{4,43} Our estimate of obesity prevalence in 2013 (29.6%) was comparable with findings from another self-reported national survey, the Behavioral Risk Factor Surveillance System, which reported the obesity prevalence for US adults 18 years of age and older as 28.9% in 2013.⁴⁴ However, estimates of obesity prevalence from the National Health and Nutrition Examination Survey, which uses clinical measurements of height and weight, were slightly higher. The National Health and Nutrition Examination Survey results

from 2011 to 2012 reported a 34.9% obesity prevalence for adults 20 years of age and older,⁴⁵ as compared with the 29.6% estimate reported here. Third, because of the ecologic nature of this study, our findings may have limited inference on individual level obesity risk. Fourth, income may not be a good measure of socioeconomic status because it may reflect retirement income for older populations. Therefore, we examined additional socioeconomic factors, including education, employment, and health insurance coverage. Finally, we were unable to assess factors contributing to obesity because we lacked data on cancer stage, cancer treatment received, and detailed lifestyle behaviors, all of which can affect weight and cancer survival.

Table 3. Annual Percent Changes in Obesity Prevalence From 1997 to 2014 in US Adults, by History of Breast, Colorectal, and Prostate Cancer

Population Characteristic	History of Cancer		No History of Cancer	
	Annual Change in Obesity Prevalence (%)*	95% CI	Annual Change in Obesity Prevalence (%)*	95% CI
Colorectal cancer, women				
Age at survey, years				
18-44	7.95	7.84 to 8.06	2.65	2.65 to 2.65
45-64	1.44	1.40 to 1.49	1.72	1.71 to 1.72
65-85	3.12	3.09 to 3.16	2.33	2.32 to 2.33
Race/ethnicity				
Non-Hispanic white	3.00	2.97 to 3.04	2.39	2.39 to 2.39
Black	3.85	3.79 to 3.92	1.72	1.72 to 1.73
Hispanic	-3.29	-3.39 to -3.18	2.31	2.30 to 2.31
Years since diagnosis†				
Never			2.31	2.31 to 2.32
≤ 1	2.98	2.89 to 3.08		
2-9	3.32	3.29 to 3.36		
≥ 10	1.48	1.43 to 1.53		
Breast cancer, women				
Age at survey, years				
18-44	5.31	5.26 to 5.35	2.65	2.65 to 2.65
45-64	2.18	2.16 to 2.20	1.72	1.71 to 1.72
65-85	3.09	3.08 to 3.11	2.33	2.32 to 2.33
Race/ethnicity				
Non-Hispanic white	3.13	3.12 to 3.14	2.39	2.39 to 2.39
Black	2.06	2.03 to 2.10	1.72	1.72 to 1.73
Hispanic	0.29	0.25 to 0.33	2.31	2.30 to 2.31
Years since diagnosis†				
Never			2.31	2.31 to 2.32
≤ 1	5.86	5.82 to 5.91		
2-9	2.71	2.69 to 2.73		
≥ 10	3.28	3.26 to 3.30		
Colorectal cancer, men				
Age at survey, years				
18-44	0.70	0.60 to 0.80	2.36	2.35 to 2.36
45-64	3.09	3.05 to 3.13	2.14	2.14 to 2.15
65-85	3.78	3.75 to 3.81	3.06	3.05 to 3.07
Race/ethnicity				
Non-Hispanic white	3.37	3.34 to 3.40	2.49	2.49 to 2.49
Black	8.44	8.33 to 8.54	1.92	1.92 to 1.93
Hispanic	-2.25	-2.36 to -2.14	2.54	2.53 to 2.54
Years since diagnosis†				
Never			2.38	2.38 to 2.39
≤ 1	-0.18	-0.26 to -0.11		
2-9	4.88	4.85 to 4.92		
≥ 10	5.33	5.28 to 5.38		
Prostate cancer, men				
Age at survey, years				
18-44	8.21	7.86 to 8.56	2.36	2.35 to 2.36
45-64	0.74	0.71 to 0.77	2.14	2.14 to 2.15
65-85	2.56	2.54 to 2.58	3.06	3.05 to 3.07
Race/ethnicity				
Non-Hispanic white	2.36	2.35 to 2.38	2.49	2.49 to 2.49
Black	1.00	0.96 to 1.03	1.92	1.92 to 1.93
Hispanic	0.25	0.19 to 0.32	2.54	2.53 to 2.54
Years since diagnosis†				
Never			2.38	2.38 to 2.39
≤ 1	-0.07	-0.11 to -0.02		
2-9	2.64	2.63 to 2.66		
≥ 10	1.56	1.52 to 1.60		

*Annual percent changes were estimated on the basis of obesity rates by year, sex, and age group using Poisson regressions. *P*values for the interaction term between cancer status (yes/no) and time were all < .001.

†Annual percent changes were compared with all cancer-free adults (the "Never" group).

Our findings suggest that obesity is a growing public health burden for cancer survivors, which requires attention. Although it is well known that unfavorable lifestyle factors may contribute to the overall increase in obesity, future research should identify and act on

modifiable risk factors that may be responsible for the steeper obesity trends in cancer survivors. Moreover, we have identified subgroups of cancer survivors who may be at the greatest risk of obesity and who may benefit from effective, targeted interventions

by oncology care providers. These findings call for public health planning of effective and scalable weight management and control programs for cancer survivors, especially for breast and colorectal cancer survivors and for non-Hispanic blacks.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Disclosures provided by the authors are available with this article at www.jco.org.

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AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Trends in Obesity Prevalence in Adults With a History of Cancer: Results From the US National Health Interview Survey, 1997 to 2014

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Appendix

Fig A1. The percentages of adults with one or more noncancer chronic condition(s) increased over time independent of body mass index and cancer history.