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Adherence to cancer prevention guidelines and cancer risk in low-income and African American populations

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Abstract

Background—The American Cancer Society (ACS) publishes behavioral guidelines for cancer prevention, including standards on body weight, physical activity, nutrition, alcohol, and tobacco use. The impact of these guidelines has been rarely studied in low-income and African American populations.

Methods—The study included 61,098 racially diverse, mainly low-income adults who participated in the Southern Community Cohort Study and were followed for a median of 6 years. Cox models were used to estimate hazard ratios (HRs) for cancer incidence associated with behaviors and with an ACS physical activity/nutrition 0-to-4 compliance score indicating the number of body weight, physical activity, healthy eating, and alcohol guidelines met.

Results—During the study period, 2,240 incident cancers were identified. Significantly lower cancer incidence was found among never smokers and non/moderate alcohol drinkers, but not among those meeting guidelines for obesity, physical activity, and diet. The ACS compliance score was inversely associated with cancer risk among the 25,509 participants without baseline chronic disease. HRs for cancer incidence among those without baseline chronic diseases and who met one, two, three, or four guidelines vs. zero guideline were 0.93 (95% confidence interval: 0.71–1.21), 0.85 (0.65–1.12), 0.70 (0.51–0.97), and 0.55 (0.31–0.99), respectively. Associations were consistent in analyses stratified by sex, race, household income, and smoking status.

Conclusions—Meeting the ACS smoking and body weight/physical activity/dietary/alcohol guidelines for cancer prevention is associated with reductions in cancer incidence in low-income and African American populations.

Impact—This study provides strong evidence supporting lifestyle modification to lower cancer incidence in these underserved populations.

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Keywords

cancer prevention guidelines; smoking; alcohol intake; diet; physical activity

Introduction

The American Cancer Society (ACS) publishes behavioral guidelines recommended to decrease cancer risk, including standards on body weight, physical activity, nutrition, and tobacco use. These guidelines are updated approximately every five years and are intended to address the most common modifiable risk factors for cancer. “Stay away from tobacco” has been a consistent ACS recommendation (1). In addition, the ACS has issued Guidelines on Nutrition and Physical Activity for Cancer Prevention focused on body weight throughout the life course, physical activity, diet, and alcohol consumption (2). Previous studies find compliance with ACS cancer prevention guidelines and similar public health guidelines are associated with lower cancer risk (3–8). For example, a recent Women’s Health Initiative Observational Study (WHI-OS) publication found an ACS physical activity/nutrition compliance score (created to represent guidelines met for healthy diet, physical activity, normal weight body mass index (BMI), and abstaining from alcohol intake), was associated with a linear decreased risk of all cancers, with strong associations for breast and colorectal cancers (4). Most previous studies, however, were conducted in middle and upper income non-Hispanic whites.

The impact of cancer prevention guidelines on cancer incidence has been studied less frequently in African American or low-income samples. The aforementioned Women’s Health Initiative study showed that African Americans met fewer cancer prevention guidelines in comparison to non-Hispanic whites. However, in stratified analyses, the magnitude of the inverse association between the ACS physical activity/nutrition compliance score and cancer risk was stronger for African Americans than non-Hispanic whites (4).

No previous study has explicitly assessed the association of adherence to cancer prevention guidelines with cancer risk in individuals of low socioeconomic status (SES). Cancer prevention guidelines may be less effective in preventing cancer in low-SES Americans for multiple reasons. Moreover, low-income Americans have fewer economic resources, have less access to medical care, and more often live in communities with built and social environments that make healthy choices more difficult (9–11). Low SES characterizes an inadequate access to health resources including financial means, insurance coverage with affordable cancer screening, and knowledge of best health practices (12). We evaluated associations between ACS cancer prevention guideline compliance, individually and by a score that represents overall adherence to ACS Nutrition and Physical Activity Cancer Prevention guidelines (2), and total cancer incidence in a cohort study with over representation of low-income Whites and African Americans.

Materials and Methods

Study population

Data available for analysis are from the Southern Community Cohort Study (SCCS), a previously-described prospective cohort study conducted in 12 southeastern US states that enrolled nearly 85,000 participants from 2002–2009 (13,14). Eligible participants were age 40–79 at enrollment and English-speaking. Participants were primarily recruited from community health centers (CHCs) (86%), which provide health services to medically underserved populations (15). Trained interviewers collected data on lifestyle factors and demographics including self-reported race. The remaining 14% of the cohort were enrolled using an identical mailed questionnaire sent to stratified random samples of residents in the same 12 states. The SCCS was approved by Institutional Review Boards at Vanderbilt University and Meharry Medical College. All participants provided written informed consent.

Cancer incidence ascertainment

Ascertainment of incident cancer diagnoses was carried out via linkage to the 12 state cancer registries in the study area (Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia) through December 31, 2011. We obtained data for all reportable neoplasms with ICD-O-3 behavior code 2 or 3. For our analysis, we included only invasive cancers for all primary sites with the exception of the bladder, for which, we included both invasive and in situ cancers.

Exposure ascertainment and ACS physical activity/nutrition compliance score

We evaluated whether following ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention (2) and the guideline to “Stay Away from Tobacco” (1) were associated with cancer incidence in the SCCS. Information on potential risk factors, such as height, weight, lifetime smoking history (including number of cigarettes smoked per day), average number of alcoholic drinks per day, diet during the previous year, and physical activity was obtained via study questionnaires.

Associations with cancer incidence were first assessed individually for BMI, physical activity, an ACS diet quality score, alcohol consumption and smoking status. BMI (kg/m^2) was calculated using the values for weight and height provided at baseline interview. Participants were classified as having met current physical activity recommendations via sports and exercise if they reported ≥150 min/week of moderate activity, ≥75 min/week of vigorous activity or ≥150 min/week of moderate and vigorous activity combined. Dietary intake was evaluated by an 89-item Food Frequency Questionnaire, developed and validated specifically for the diet in the Southeastern US (16,17). To assess diet quality we calculated an ACS diet quality score to represent meeting three sub-guidelines under the guideline to “Consume a healthy diet, with an emphasis on plant foods”, including “limit consumption of processed meat and read meat”, “choose whole grains instead of refined grain products”, and “eat at least 2.5 cups of vegetables and fruits each day” set forth in the ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention. The SCCS Food Frequency

Questionnaire data were converted to equivalent (ounce or cup) intakes by linkage to MyPyramid Equivalents Database variables (version 2.0) (18,19). We calculated sex-specific quartiles for the intake of red and processed meats and for the ratio of whole grains intake to whole and refined grains intake (total grain intake). Participants in the quartile for lowest red and processed meat intake or the quartile for the highest whole to total grain intake ratio were considered to have met the respective sub-guidelines. Participants who reported eating ≥2.5 cups of vegetables and fruits per day were considered to have met the sub-guideline of vegetables and fruits intake. The three dietary variables (each with a value of 0 or 1) were then summed to create the ACS diet quality score with values ranging from 0 to 3. Participants scoring ≥2 on the ACS diet quality score were considered to have met the diet quality guideline for cancer prevention. We classified nondrinkers and moderate alcohol drinkers as having met the cancer prevention guideline, where moderate drinking was classified as alcohol intake reported as >0 but ≤1 drink/day for women or ≤2 drink/day for men. Heavy drinking was considered >1 drink/day for women and >2 drinks/day for men. Never smokers were considered to have met the “Stay Away from Tobacco” guideline. Former smokers were defined as participants who had ever smoked and did not report cigarette smoking at baseline interview.

The ACS physical activity/nutrition compliance score was created by counting and summing (0–4) the number of ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention (2) the participant met upon entry into the cohort (assigning one point for each of: 18.5 ≤BMI< 25 kg/m^2, meeting physical activity guidelines, meeting ≥2 ACS diet quality sub-guidelines, and being a non or moderate alcohol drinker).

Population for analysis

To reduce the likelihood of reverse causation, where the outcome precedes and causes the exposure of interest, we excluded participants with <2 years of follow-up time (N=2,680), or who at baseline reported a prior diagnosis of cancer (N=9,304), coronary heart disease (N=5,882), stroke (N=5,440), or HIV/AIDS (N=1,282). Participants missing data on smoking status (N=2,089), alcohol intake (N=2,937), body mass index (N=2,381), or physical activity (N=3,180) were excluded from analysis. After these exclusions (not mutually exclusive), data from 61,098 SCCS participants were available for analysis.

Statistical analysis

Analyses were conducted among the total study population and, to help remove influences of prior morbidity, analyses were also conducted restricted to participants without baseline diagnoses of diabetes, hypertension, or chronic obstructive pulmonary disease (COPD). Frequency distributions of participant characteristics were tabulated for selected characteristics hypothesized to be associated with exposures and mortality. Hazard ratios (HRs) and 95% confidence intervals (CIs) were estimated using Cox proportional hazard models for the associations between adherence to ACS guidelines, the ACS physical activity/nutrition compliance score, and cancer incidence with age as the time scale. Entry time was defined as age at baseline interview and exit as age at cancer diagnosis, death, loss to follow-up, or December 31, 2011, whichever came first (20). Analyses also were conducted for the major cancers (lung, colorectal, breast, and prostate cancers, and all

cancers except lung cancer) to determine if trends were similar by anatomic site. Statistical models included the following variables selected *a priori* as potential confounders: enrollment source (CHC, general population), family history of cancer in a first degree relative (yes, no), health insurance status (yes, no), race (black, white, other), sex, education (<9 years, 9–11 years, high school, some college, college graduate and beyond), income (< $15,000, $15,000–24,999, $25,000–49,999, ≥$50,000), marital status (married, separated, divorced, single), neighborhood deprivation index (quartiles), total energy intake (kcal/day, continuous), and postmenopausal hormone use (women only: yes, no). The exposure variables of interest were body mass index (BMI: <18.5, 18.5–24.9, 25.0–29.9, 30.0–34.9, 35.0–39.9, ≥40.0 kg/m^2), physical activity (meets, does not meet the guideline), ACS diet quality score (0–3), alcohol intake (non or moderate-drinker, heavy-drinker), and smoking status (never, former, current smoker of <20 years or <20 cigarettes/day, current smoker of ≥20 years and ≥20 cigarettes/day), and the ACS physical activity/nutrition compliance score. The neighborhood deprivation index variable incorporates 11 census tract-level variables that capture: unemployment, high school graduation rates, occupations, ownership and type of housing, poverty and income measures, household makeup, and car ownership. (21) Missing covariate data were set to race- and sex-specific medians (mode for marital and insurance status). We evaluated the proportional hazards assumption graphically. *P*-values for trend tests were calculated by treating the ordinal ACS physical activity/nutrition compliance score variable as continuous in the model. We evaluated the associations between the ACS physical activity/nutrition compliance score and cancer incidence in subgroups defined by sex, race, and baseline household income. We chose to dichotomize household income as < or ≥ $15,000 because $15,000 is the approximate poverty guideline for a two-person adult household. Possible interactions between the ACS physical activity/nutrition compliance score and factors of interest were assessed by likelihood ratio tests to compare main effects models with and without the addition of cross-product terms. Statistical analyses were performed using SAS statistical software (version 9.3; SAS Institute Inc., Cary, NC).

Results

After a median follow-up time of 6 years (range: 2–10 years), there were 2,240 incident cancers diagnosed in the cohort. In comparison to the total analytic cohort, individuals diagnosed with cancer during the study period were more likely to be male, African American, and have a family history of cancer at baseline (Table 1).

Adherence to components of the ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention, as well as smoking, was evaluated by examining associations with cancer incidence for each of BMI, physical activity, diet, alcohol consumption and smoking (Table 2). In general, the large majority (81%) of SCCS participants adhered to the ACS guidelines for alcohol intake, but few met the guidelines for body weight (25%) or physical activity (21%), and 63% had smoked cigarettes. Underweight participants at baseline (<18.5 kg/m^2) were at increased cancer risk in comparison to participants with normal weight BMI, but being overweight or obese in this follow up was associated with no increased risk. Not meeting the ACS guideline for physical activity was associated with non-significantly increased cancer risk, where participants who were the most inactive were at the highest

cancer risk (HR = 1.10, 95% CI: 0.97–1.24), and this association was more apparent among participants without chronic disease at baseline (HR = 1.20, 95% CI: 1.00–1.46). Heavy alcohol consumption was associated with a 17% increased cancer incidence. Only 7.5% of the analytical cohort met all three sub-guidelines relating to diet quality; meeting fewer sub-guidelines was associated with a non-significant increase cancer risk that was most apparent among participants without chronic diseases. There was a 50% increased cancer risk with ever smoking, and the HR rose to 2.00 (95% CI: 1.74–2.30) among heavy smokers. The large magnitude of the association is mainly attributable to the number of lung cancer diagnoses in the cohort. HRs for the association between current heavy smokers and lung cancer risk were 18.14 (95%CI: 12.01–27.40) for the total analytic sample and 13.16 (95%CI: 6.98–24.83) for participants without baseline chronic diseases.

The ACS physical activity/nutrition compliance score was inversely, but non-significantly, associated with cancer incidence in the overall sample (Table 3). A significant inverse trend, however, was observed in participants without chronic disease at baseline. Analyses stratified by smoking status, household income, sex, or race (Figure 1) showed consistent associations between the ACS physical activity/nutrition compliance score and cancer risk (*P* for interaction for household income = 0.73, sex = 0.78, race = 0.82, smoking = 0.66). We also observed no evidence of effect modification of the association between the ACS physical activity/nutrition compliance score and cancer risk by insurance status (*P* for interaction = 0.27 total analytic cohort, and 0.23 for participants without chronic diseases).

The most commonly diagnosed cancers were lung (N=422), colorectal (N=243), breast (N=352), and prostate (N=319). The ACS compliance score was inversely associated with cancer risk in analyses that excluded lung cancer diagnoses, signifying that the association is not limited to the most commonly diagnosed cancer in the cohort (Table 3). Moreover, the ACS physical activity/nutrition compliance score showed an overall null association with lung cancer (Supplementary Table 1). Sample sizes were limited to evaluate associations between the ACS physical activity/nutrition compliance score and site-specific cancer incidences. The ACS physical activity/nutrition compliance score was not associated with colorectal cancer incidence. In analysis restricted to participants without chronic disease at baseline, the ACS physical activity/nutrition compliance score showed evidence of a non-significant inverse association with breast cancer risk. The ACS physical activity/nutrition compliance score showed moderate evidence (*P* = 0.01) of an inverse association with prostate cancer risk among participants without baseline chronic disease, but not among the total analytic cohort (*P* = 0.15).

Discussion

In this cohort of predominantly African American and low-SES individuals, adherence to ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention was weakly associated with lower overall cancer risk, and adherence to the ACS guideline to “Stay Away from Tobacco” was strongly associated with lower cancer risk. The ACS physical activity/nutrition compliance score, created to represent meeting the four ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention: body weight, physical activity, diet, and alcohol intake, was significantly associated with decreased cancer incidence only among

individuals who had no major chronic diseases at cohort enrollment. These data provide support for the promotion of healthful behaviors, especially smoking cessation and avoidance of heavy alcohol consumption, as cancer prevention measures. Previous studies have also found ACS guideline scores to be associated with cancer risk. For instance, a recent paper by Kabat et al using NIH-AARP Diet and Health Study data, reported inverse associations between an overall ACS guidelines adherence score with overall cancer incidence and several site-specific cancers (8). The authors also found a significant inverse association between an ACS dietary quality score and overall cancer risk. Similarly, we observed a modest, albeit non-significant, inverse association between diet quality and overall cancer incidence. In a study conducted using data from the WHI-OS, individuals who met the most ACS Nutrition and Physical Activity guidelines were at a decreased cancer risk with no variation in the association by smoking status (4). The World Cancer Research Fund/American Institute for Cancer Research (WCRF/AICR) recommendations for cancer prevention (22) also have been evaluated for association with cancer risk (5–7,23). WCRF/AICR recommendations for cancer prevention are similar to ACS cancer prevention guidelines in that both groups advise individuals to maintain a healthy weight, be physically active, limit alcohol consumption, and eat a diet with an emphasis on plant origins. Analogous to ACS guidelines, meeting more of the eight WCRF/AICR recommendations has been consistently associated with lower cancer risk, including risk of colorectal, lung, breast, and endometrial cancers (5–8,23). The results of this study and others suggest that a healthy lifestyle, beyond nonsmoking, is important in reducing cancer risk (3–6,8).

Associations between our ACS physical activity/nutrition compliance score and cancer incidence did not vary by race or sex in this cohort that consists of mostly low-income individuals. The previously mentioned WHI-OS study found significant interaction (*P* for interaction=0.05) between their ACS compliance score by race with HRs for the associations between the ACS guidelines score and overall cancer incidence further from unity in African Americans, Asians and Hispanics in comparisons to non-Hispanic whites (4). A strength of the SCCS study design allows for racial disparities to be evaluated among participants of similar SES. White and African American participants have comparably low education and income levels. We may have found consistency in the associations between meeting ACS guidelines and cancer risk by race because the SCCS includes a large number of African Americans and the study design allows for more sufficient control of confounding by SES.

Our study has a number of strengths. The SCCS is a large, prospective, cohort study with comprehensive information on lifestyle factors, and complete follow-up to identify incident cancer cases. However, our study has certain limitations. Our assessment of physical activity was limited to activity performed during sports and exercise because of the construction of the SCCS baseline questionnaire. We used the activity performed during sports and exercise as a surrogate measure of total physical activity, which includes physical activity done during sports/exercise, leisure, home, and occupational activities. We likely underestimated some participants' physical activity. Due to the study's relatively short follow-up (median follow-up time of 6 years) we could not assess long-term associations between the ACS physical activity and nutrition variables with cancer risk. We also lacked power to thoroughly assess associations between meeting to ACS guidelines and risk of cancer by

specific anatomical sites. With longer follow up we will be better able to evaluate the associations between our ACS physical activity/nutrition compliance score and specific-anatomical cancer sites, particularly breast and colorectal cancer risk as these cancers have been consistently found to be inversely associated with ACS cancer prevention guidelines in other studies (4,7,23).

Initial analyses that included the full analytic cohort found weak and null associations between adherence to the individual ACS cancer prevention guidelines, and our ACS compliance score with cancer risk. Participants diagnosed with a chronic illness, such as diabetes or COPD may change their lifestyle in order to improve their health and subsequently better adhere to cancer prevention guidelines. In particular, they may improve their diet and quit smoking. Because our study questionnaire obtained information on recent diet and physical activity, the questionnaire responses may not be representative of long-term diet, physical activity, BMI, and alcohol intake exposures before illness or diagnosis of a chronic disease. To address potential reverse causation, we excluded the first two years of follow up. To address potential exposure misclassification, we conducted sensitivity analyses excluding participants with chronic diseases at baseline, including heart attack, stroke, HIV/AIDS, diabetes, hypertension, and COPD, who may have altered their lifestyles because of their diagnosis. An inverse association between adherence to ACS guidelines and cancer risk became more apparent in analyses that excluded participants with baseline diagnoses. Given an extended study follow-up, associations between the ACS cancer prevention guidelines and cancer risk may become more evident in this cohort. Additionally, the health guidelines recommended by the ACS and other organizations are most likely not restricted to cancer prevention, as body weight, physical activity, diet, alcohol intake, and smoking are also risk factors for heart disease and other causes of death and disability.

Conclusions

This study found that meeting ACS cancer prevention guidelines, especially regarding tobacco and alcohol consumption, was associated with a lower cancer risk in African American and low-income individuals, extending previous findings in middle and upper income non-Hispanic whites to these under-served populations. Smoking cessation is associated with reduced risks of many cancer types and should be a priority for individuals who currently smoke. Our results suggest that adherence to public health guidelines can lower total cancer risk, even in individuals who currently smoke. Public health campaigns and societal interventions to make adherence to ACS and other health guidelines easier are warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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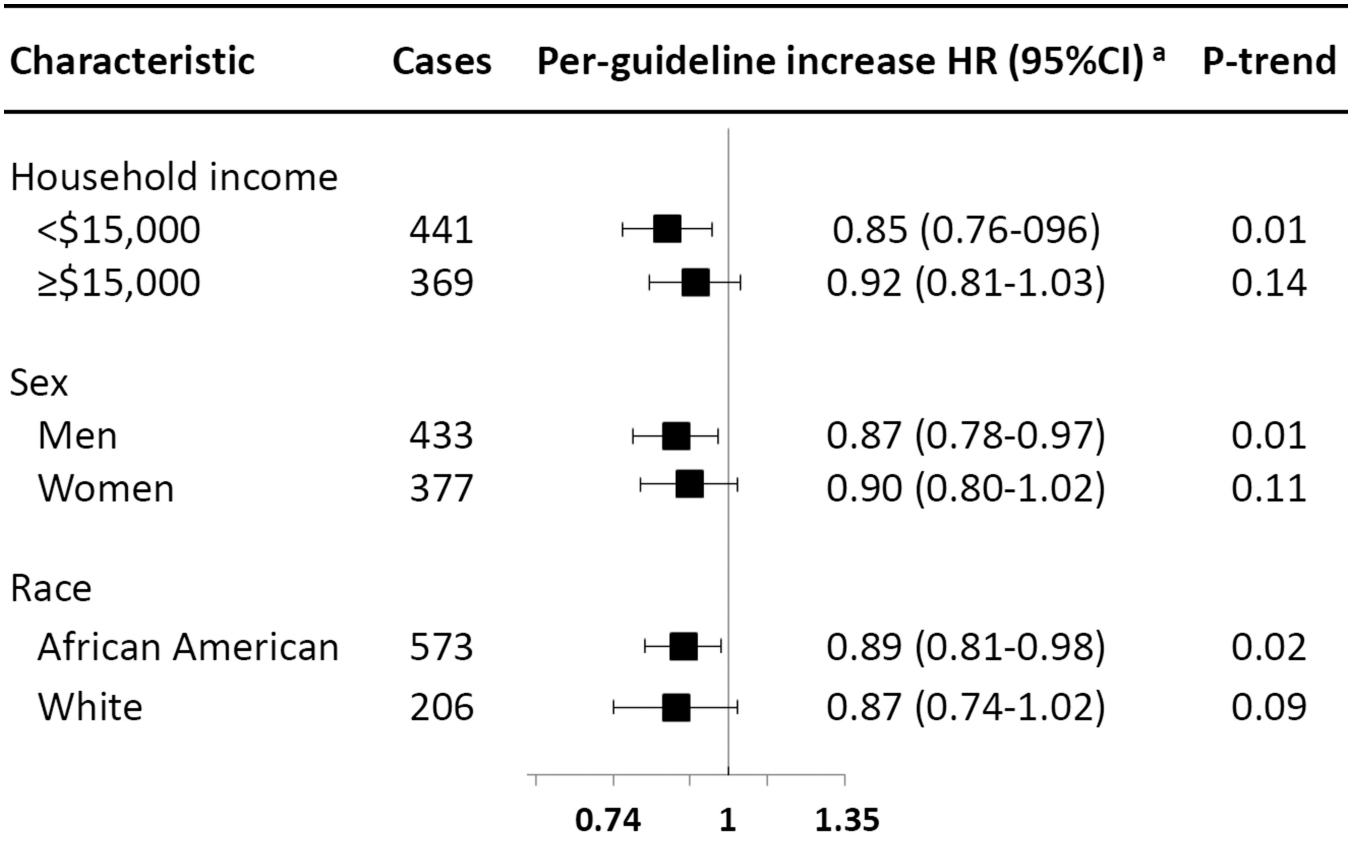

[a] Adjusted for sex, race, enrollment source, family history of cancer, insurance coverage, education, income, marital status, neighborhood deprivation index, smoking status, total energy intake, and postmenopausal hormone use (women only).
HR indicates hazard ratio; CI, confidence interval.

Figure 1. The associations between the ACS guidelines score and cancer incidence by selected characteristics among participants without chronic disease at baseline

Associations are displayed for the relationship between the ACS guidelines score and cancer incidence by potential effect modifiers. *P* for interactions between ACS guidelines score and potential effect modifiers in association with cancer incidence are as follows: household income= 0.73, sex=0.78, race=0.82, smoking=0.66. Hazard ratios are adjusted for sex, race, enrollment source, family history of cancer, insurance coverage, education, income, marital status, neighborhood deprivation index, smoking status, total energy intake, and postmenopausal hormone use (women only).

Participants without chronic disease at baseline include participants without a diagnosis of diabetes, hypertension, or chronic obstructive pulmonary disease.

Abbreviations: HR, hazard ratio; CI, confidence interval.

Table 1

Characteristics of study subjects by health status.

Characteristic (No. %)	Total analytic population		Participants without chronic disease at baseline[a]	
	Cohort (N=61,098)	Incident cancer cases (N=2,240)	Cohort (N=25,509)	Incident cancer cases (N=810)
Age (median, IQR, years)	50 (11)	54 (11)	47 (10)	52 (10)
Male sex	24,613 (40.3)	1,018 (45.4)	12,044 (47.2)	433 (53.5)
Race				
White	16,502 (27.0)	529 (23.6)	7,641 (30.0)	206 (25.4)
African American	42,149 (69.0)	1,645 (73.4)	16,753 (65.7)	573 (70.7)
Other[b]	2,447 (4.0)	66 (2.9)	1,115 (4.4)	31 (3.8)
Enrollment source				
Community Health Center	52,855 (89.8)	2,005 (89.5)	22,377 (87.7)	701 (86.5)
General population	6,003 (10.2)	235 (10.5)	3,132 (12.3)	109 (13.5)
Family history of cancer [c]	28,413 (46.5)	1,148 (51.3)	11,374 (44.6)	419 (51.7)
Health insured	34,841 (57.0)	1,381 (61.7)	13,353 (52.3)	450 (55.6)
Education				
<High school	16,987 (27.8)	740 (33.0)	5,981 (23.4)	220 (27.2)
High school	20,716 (33.9)	713 (31.8)	8,790 (34.5)	267 (33.0)
>High school	23,215 (38.0)	778 (34.7)	10,653 (41.8)	318 (39.3)
Income ($)				
<15,000	32,927 (53.9)	1,317 (58.8)	12,727 (49.9)	437 (54.0)
15,000–49,999	21,894 (35.8)	718 (32.1)	9,445 (37.0)	273 (33.7)
≥50,000	5,535 (9.1)	180 (8.0)	3,030 (11.9)	90 (11.1)
Marital Status				
Married	20,960 (34.3)	767 (34.2)	8,820 (34.6)	278 (34.3)
Divorced	20,513 (33.6)	780 (34.8)	8,403 (32.9)	279 (34.4)
Widowed	5,303 (8.7)	275 (12.3)	1,391 (5.5)	79 (9.8)
Single	14,039 (23.0)	406 (18.1)	6,763 (26.5)	170 (21.0)
Postmenopausal therapy use [d]	10,071 (27.6)	341 (27.9)	3,169 (23.5)	98 (26.0)
COPD diagnosis at baseline	4,684 (7.7)	213 (9.5)	--	--
Diabetes diagnosis at baseline	11,472 (18.8)	444 (19.8)	--	--
Hypertension diagnosis at baseline	31,200 (51.1)	1,252 (55.9)	--	--

[a] Includes participants without a diagnosis of COPD, diabetes, or hypertension at baseline.

[b] Other race includes participants who did not self-identify as non-Hispanic African American or non-Hispanic white.

[c] Participants reported their mother, father, sister or brother was diagnosed with cancer before baseline.

[d] Frequency among women.

Subjects with missing data not included in this analysis.

Abbreviations: IQR, Interquartile range; COPD, Chronic obstructive pulmonary disease.

Table 2

The associations between adherence to components of the ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention and Nonsmoking[a] with cancer incidence by baseline health status.

	Total analytic population			Participants without chronic disease at baseline		
Guidelines	**Cohort**	**Cases**	**HR (95%CI) [b]**	**Cohort**	**Cases**	**HR (95%CI) [b]**
Achieve and maintain a healthy weight throughout life.						
Body mass index (kg/m^2) at baseline						
<18.5	718	54	1.78 (1.35–2.35)	394	23	1.75 (1.14–2.68)
18.5–24.9	15,028	631	1 (Ref.)	9,186	306	1 (Ref.)
25.0–29.9	18,259	646	0.86 (0.77–0.96)	8,452	269	1.02 (0.87–1.21)
30.0–34.9	13,155	445	0.87 (0.77–0.99)	4,429	130	1.05 (0.85–1.30)
35.0–39.9	7,210	252	0.95 (0.81–1.10)	1,742	44	0.96 (0.69–1.33)
≥40.0	6,728	212	0.99 (0.84–1.17)	1,306	38	1.26 (0.89–1.79)
Adopt a physically active lifestyle.						
Physical activity guideline [c]						
Meets	12,571	389	1 (Ref.)	6,765	182	1 (Ref.)
Does not meet	48,527	1,851	1.05 (0.94–1.18)	18,744	628	1.08 (0.91–1.29)
Somewhat active	24,179	811	1.01 (0.89–1.14)	10,350	298	0.99 (0.82–1.19)
Inactive	24,348	1040	1.10 (0.97–1.24)	8,394	330	1.20 (1.00–1.46)
Consume a healthy diet, with an emphasis on plant foods.						
Diet quality score (number of recommendation met) [d]						
3	4,583	165	1 (Ref.)	1,786	49	1 (Ref.)
2	11,897	454	1.10 (0.92–1.32)	4,528	152	1.28 (0.93–1.78)
1	34,028	1,256	1.17 (0.99–1.39)	14,640	474	1.33 (0.97–1.81)
0	10,590	365	1.16 (0.96–1.40)	4,555	135	1.27 (0.90–1.78)
If you drink alcoholic beverages, limit consumption.						
Alcohol consumption [e]						
Non and Moderate	49,588	1,763	1 (Ref.)	19,405	570	1 (Ref.)
Heavy	11,510	477	1.17 (1.05–1.32)	6,104	240	1.35 (1.14–1.60)
“Stay away from tobacco.”						

Guidelines	Total analytic population			Participants without chronic disease at baseline		
	Cohort	Cases	HR (95%CI) [b]	Cohort	Cases	HR (95%CI) [b]
Smoking status [f]						
Never	22,802	647	1 (Ref.)	8,706	225	1 (Ref.)
Ever	38,296	1,593	1.49 (1.35–1.64)	16,803	585	1.30 (1.11–1.54)
Former	12,667	508	1.25 (1.11–1.40)	4,298	134	1.04 (0.83–1.29)
Current - Light	17,237	686	1.64 (1.45–1.85)	8,585	285	1.38 (1.14–1.69)
Current - Heavy	8,392	399	2.00 (1.74–2.30)	3,920	166	1.81 (1.44–2.27)

[a] American Cancer Society recommendations found at: www.cancer.org and in Kushi et al.(2)

[b] Adjusted for enrollment source, race, family history of cancer, insurance coverage, education, income, marital status, neighborhood deprivation index, total energy intake, postmenopausal hormone use (women only), and the individual exposures included in the table.

[c] Participants met current aerobic physical activity recommendations via sports and exercise if they reported ≥150 min/week of moderate activity, ≥75 min/week of vigorous activity or ≥150 min/week of moderate and vigorous activity combined. Participants who did not meet the physical activity guideline were classified into two groups of “somewhat active” and “inactive” based on whether they were above or below the median for total activity (in MET-hrs).

[d] Diet quality score created by summing number of nutrition-related ACS sub-guidelines met (0–3) related to consumption of grains, red and processed meats, and fruits and vegetables.

[e] Moderate alcohol consumption is defined as >0 but ≤1 drink/day for women or ≤2 drink/day for men.

[f] Light current smoking is defined as smoking for <20 years or <20 cigarettes/day. Heavy current smoking is defined as smoking ≥20 cigarettes/day and for ≥20 years.

Participants without chronic disease at baseline include participants without a diagnosis of diabetes, hypertension, or chronic obstructive pulmonary disease.

Abbreviations: ACS, American Cancer Society; HR, hazard ratio; CI, confidence interval; Ref., reference.

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Table 3

The associations between ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention compliance score and cancer incidence by baseline health and smoking status.

	Total analytic population			Participants without chronic disease at baseline				
	All incident cancers			All incident cancers			Incident cancers excluding lung cancer	
ACS Score (# Guidelines met)	Cohort	Cases	HR (95%CI) [a]	Cohort	Cases	HR (95%CI) [a]	Cases	HR (95%CI) [a]
0	4,427	151	1 (Ref.)	1,949	67	1 (Ref.)	55	1 (Ref.)
1	28,059	1,047	1.05 (0.88–1.24)	10,281	346	0.93 (0.71–1.21)	274	0.85 (0.64–1.15)
2	21,218	803	1.01 (0.84–1.20)	9,152	292	0.85 (0.65–1.12)	238	0.79 (0.58–1.06)
3	6,404	207	0.88 (0.71–1.09)	3,423	91	0.70 (0.51–0.97)	72	0.60 (0.42–0.87)
4	990	32	0.96 (0.65–1.42)	704	14	0.55 (0.31–0.99)	11	0.44 (0.23–0.86)
P-trend			0.09			0.003		0.001
Current smokers								
0	2,926	114	1 (Ref.)	1,353	52	1 (Ref.)	40	1 (Ref.)
1	11,717	518	1.00 (0.82–1.23)	5,144	202	0.95 (0.70–1.29)	139	0.86 (0.61–1.23)
2	8,412	350	0.94 (0.75–1.16)	4,455	151	0.83 (0.60–1.14)	108	0.77 (0.53–1.11)
3	2,286	87	0.84 (0.63–1.11)	1,351	40	0.69 (0.46–1.06)	28	0.61 (0.38–1.00)
4	288	16	1.40 (0.83–2.38)	202	6	0.73 (0.31–1.71)	4	0.60 (0.21–1.68)
P-trend			0.31			0.03		0.03
Never and former smokers								
0	1,501	37	1 (Ref.)	596	15	1 (Ref.)	15	1 (Ref.)
1	16,342	529	1.18 (0.84–1.65)	5137	144	0.96 (0.56–1.65)	135	0.88 (0.51–1.52)
2	12,806	453	1.16 (0.83–1.64)	4697	141	0.93 (0.54–1.61)	130	0.84 (0.49–1.45)
3	4,118	120	0.98 (0.67–1.42)	2072	51	0.73 (0.40–1.32)	44	0.60 (0.33–1.10)
4	702	16	0.80 (0.44–1.45)	502	8	0.47 (0.19–1.12)	7	0.38 (0.15–0.96)
P-trend			0.16			0.03		0.007

[a]Adjusted for sex, race, enrollment source, family history of cancer, insurance coverage, education, income, marital status, neighborhood deprivation index, smoking status, total energy intake, and postmenopausal hormone use (women only).

The ACS score was created by counting and summing (0–4) the number of ACS Guidelines on Nutrition and Physical Activity for Cancer Prevention the participant met upon entry into the cohort (assigning one point for each of: 18.5 ≤BMI< 25 kg/m^2, meeting physical activity guidelines, meeting ≥2 sub-guidelines for the ACS diet quality score, and being a non or moderate alcohol drinker). Participants without chronic disease at baseline include participants without a diagnosis of diabetes, hypertension, or chronic obstructive pulmonary disease.

Abbreviations: ACS, American Cancer Society; HR, hazard ratio; CI, confidence interval; Ref, reference.