Favorable Modifiable Cardiovascular Risk Profile Is Associated With Lower Healthcare Costs Among Cancer Patients: The 2012–2013 Medical Expenditure Panel Survey

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Background—Atherosclerotic cardiovascular disease (ASCVD) and cancer are among the leading causes of economic burden, morbidity, and mortality in the United States. We aimed to quantify the overall impact of cardiovascular modifiable risk factor (CRF) profile on healthcare expenditures among those with and without ASCVD and/or cancer.

Methods and Results—The 2012–2013 Medical Expenditure Panel Survey, a nationally representative adult sample (≥40 years), was utilized for the study. Variables included ASCVD, CRF (hypertension, diabetes mellitus, hypercholesterolemia, smoking, physical activity and/or obesity), and cancer (all). Two-part econometric models analyzed cost data. Medical Expenditure Panel Survey participants (n=27 275, 59±9 years, 52% female) were studied and 14% had cancer, translating to 25.6 million US adults over 40 years of age. A higher prevalence of ASCVD was noted in those with versus without cancer (25% versus 14%). Absence of ASCVD and a more favorable CRF profile were associated with significantly lower expenditures across the spectrum of cancer diagnosis. Among cancer patients, the adjusted mean annual cost for those with and without ASCVD were $10 852 (95% confidence interval [8917, 12 788]) and $6436 (95% confidence interval [5531, 7342]). Among cancer patients without ASCVD, adjusted annual healthcare expenditures among those with optimal versus poor CRF profile were $4782 and $7256.

Conclusions—In a nationally representative US adult population, absence of ASCVD and a favorable CRF profile were associated with significantly lower medical expenditure among cancer patients. This provides estimates to continue better cardiovascular management and prevention practices, while contextualizing the burden of cancer. (*J Am Heart Assoc*. 2018;7:e007874. DOI: 10.1161/JAHA.117.007874.)

Key Words: cancer • cardiovascular disease risk factors • cost

Atherosclerotic cardiovascular disease (ASCVD) and cancer are among the leading causes of economic burden, morbidity, and mortality in the United States.[1] Nearly half of all deaths in the United States can be attributed to either cancer or ASCVD. The annual direct and indirect cost of ASCVD and cancer in the United States is an estimated

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Clinical Perspective

What Is New?

- In this study, we noted a higher prevalence of atherosclerotic cardiovascular disease as well as poor cardiovascular disease risk profile among cancer survivors.
- Absence of atherosclerotic cardiovascular disease and presence of optimal cardiovascular risk profile among cancer survivors was associated with a significantly lower overall medical expenditure and resource utilization, including prescription medications, hospitalizations, emergency department, and outpatient visits.

What Are the Clinical Implications?

- These results support population healthcare models emphasizing prevention of atherosclerotic cardiovascular disease and improvement of cardiovascular risk factor profiles to favorably impact the rising burden of healthcare expenditures among cancer survivors.

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$844.4 billion dollars, which is projected to double by 2030.[2–4] In addition to an aging population, a growing number of cancer survivors are expected to increase from 15.5 to 20 million over the next decade, and in whom ASCVD is one of the most common causes of non–cancer-related deaths.[5,6]

An emerging paradigm, which continues to evolve, is the inextricable link between ASCVD and cancer through common modifiable risk factors such as tobacco use, obesity, diabetes mellitus, diet quality, and physical activity. A scientific statement from 2004 endorsed by the American Heart Association, American Cancer Society, and American Diabetes Association called for more collaborative and effective preventive healthcare strategies by targeting these shared risk factors.[7] Cancer survivorship begins at the time of diagnosis, and many face increased healthcare expenditures compared with individuals without a history of cancer, which can lead to a reduced use of preventive services and preventive medications.[8–10] Although there are some reports highlighting optimal cardiovascular risk factor (CRF) profile in middle age being associated with reduced cardiovascular costs later in life, the impact of ASCVD and global CRF on healthcare costs and resource utilization among cancer survivors is not well described.[11,12]

The goal of this study was to detail the healthcare costs for cancer patients across the spectrum of ASCVD status and varying modifiable CRF profiles in a nationally representative population. We hypothesized that a favorable CRF profile will be associated with significantly lower direct healthcare expenditure and resource utilization in cancer survivors.

Methods

Design

The Medical Expenditure Panel Survey (MEPS) data sets and codebooks used for this study are available to the public, and can be accessed on the Agency for Healthcare Research and Quality website at: https://meps.ahrq.gov/mepsweb/.[13] We conducted a retrospective study that utilized data from the MEPS, 2012 and 2013. The MEPS, led by the Agency for Healthcare Research and Quality, is a set of large-scale, national survey about individuals and families, their medical providers, and their employers. The Household Component of the MEPS collects data about health services used, their frequency and cost, charges, source of payment, income, employment, as well as ample data on insurance used by and available to US workers.[13] The MEPS respondents are enrolled for 2 years of data collection, with a new panel beginning each year. The sampling frame for the MEPS-Household Component is drawn from respondents to the National Health Interview Survey and the design of the MEPS-Household Component survey includes sampling weights, stratification, and clustering. The MEPS sampling weights incorporate adjustment for the complex sample design and reflect survey nonresponse and population totals from the Current Population Survey.[13]

In order to increase the study's population, we merged 2012 and 2013 data, and used (from the MEPS Household Component) the full-year consolidated data files and medical conditions files. The full-year consolidated data files include most demographics on a person-level, while the medical conditions files include each diagnosis a person has, which after being transcribed verbatim at each survey, are translated into *International Classification of Diseases, 9th Edition, Clinical Modification* (*ICD-9-CM*) by professional coders. MEPS also allows categorization by Clinical Classification Software, a tool from Healthcare Cost and Utilization Project that groups *ICD-9-CM* codes into meaningful clinical categories.[14] All files were linked together in order to determine accurate results for each individual. Since MEPS information is publically available, de-identified data-files, it was exempt from institutional review board review.[15]

Participants

Initially, 75 402 individuals were surveyed between 2012 and 2013. We limited our study population to US adults ≥40 years of age (because of the low prevalence of established ASCVD among adults aged 18–39 years), who had a positive sampling weight (to best estimate nationally representative results), and a body mass index≥18.5 kg/m^2 (given that they often represent a sicker patient population), reaching a study population of 25 275 noninstitutionalized individuals.

Study Variables

Individuals in the study population were classified into our outcome variables based on presence of either a prior diagnosis (ascertained by *ICD-9-CM* or Clinical Classification Software codes, Table S1), or self-report for any of the following: ASCVD (coronary artery disease, cerebrovascular disease, or peripheral artery disease), any cancer, and CRFs (hypertension, diabetes mellitus, hypercholesterolemia, lack of physical exercise [defined as not participating in moderate-vigorous physical activity, ≥30 minutes, ≥5 times per week], smoking and/or obesity [body mass index ≥30 kg/m^2, a constructed variable using self-reported weight and height]). For CRFs, based on the presence of the individual risk factors, survey participants were profiled as "Poor" (≥4 CRFs), "Average" (3–2 CRFs), or "Optimal" (0–1 CRFs).

Outcome variables: expenditures and resource utilization

Total annual direct medical expenditures were calculated for each person. Data for this variable included expenditures from all payer groups and out-of-pocket spending, including information from hospitalizations, prescribed medications, outpatient visits (hospital outpatient visits and office-based visits), emergency department (ED) visits, and other expenditures (dental visits, vision aid, home health care, and other medical supplies). In a similar fashion, resource utilization analysis assessed the total number of outpatient and ED visits, number of hospitalizations and number of prescription medications purchases/refills each surveyed individual incurred. All expenditures were adjusted to 2013 US dollars by use of the gross domestic product .[16]

Covariates

Other variables included in the study were age (grouped in 40–54, 55–64, 65–74, and ≥75), sex, family income (grouped in Poor/Near poor [<125% of the 2012 federal poverty level], Low/Middle Income [125% to <400% federal poverty level], and High Income [≥400% federal poverty level]), race/ethnicity, employment, insurance type, education, geographical region, and modified Charlson Comorbidity Index (without cardiovascular components).

Statistical Analysis

For comparison of demographic characteristics in our sample, χ^2 tests were performed.[17] Because of the right-skewedness of expenditures data (i.e. most expenditures are seen in only a small proportion of the population), 2-part models were utilized to study expenditures.[18] Two-part models are often used to model healthcare expenditures, and are the product of (1) the probability that any given individual had any

expenditures; and (2) their mean expenditures.[19] The first part of the model consists of a probabilistic regression model (*probit*), which estimates the probability of zero versus positive expenditures. Contingent upon having a positive annual healthcare expenditure, a generalized linear model (*glm*) with gamma distribution and a logarithmic-link function estimates the average expenditure per capita[19,20]; we determined the distribution of the *glm* using the modified Park Test.[21] For resource utilization, unadjusted and adjusted logistic regression models were utilized. Unadjusted means and proportions were calculated, adjusting for the survey design and sampling weight. For all statistical analyses, *P*<0.05 was considered statistically significant. All analyses were carried out using Stata®, version 13.1 (StataCorp, LP, College Station, TX). Total and Marginal expenditures were estimated using the "margins" command after the 2-part models.[19] All analyses took into consideration the MEPS complex survey design.

Results

Population Characteristics

The final study population consisted of 27 275 participants ≥40 years of age (59±9 years, 52% female), which translates to ≈141.6 million US adults; demographic information is presented in Table 1. Overall, 14% had cancer, translating to 25.6 million of the noninstitutionalized adult population in the United States. Those with cancer were more likely to be older, female, have ASCVD, have poor CRF profile, and a higher burden of comorbid conditions. In the total study population with cancer, 1434 (26.7%) had optimal, 2361 (50.6%) had average, and 1126 (22.7%) had poor CRF profile, translating to 6.8, 12.9, and 5.8 million individuals in the United States, respectively.

Healthcare Expenditures

Average per-capita healthcare expenditures estimated using univariate and multivariate models by CRF profile, cancer, and ASCVD status are shown in Table 2. Presence of cancer was associated with increased overall healthcare expenditures compared with those without cancer across the spectrum of ASCVD status and CRF profile. Cancer participants without ASCVD and a poor CRF profile had a mean annual expenditure of $11 191 compared with $8116 among those with an optimal CRF profile (Table 2, model 1). Additional adjustments for covariates including demographics, socioeconomic factors, insurance, and comorbid conditions continued to show a robust association with $7256 (95% confidence interval [CI], 5245–9266) versus $4782 (95% CI, 3764–5800) mean annual expenditure of cancer participants without ASCVD and with

Table 1. Baseline Characteristics From Adults ≥40 Years of Age, With and Without Cancer, From the MEPS Survey 2012–2013

	All	Cancer	No Cancer	P Value
Sample (N)	27 275	3951	23 324	
Weighted sample	141 619 336	25 610 059	116 009 277	
Age strata, n (weighted %) (y)				<0.001
40–54	14 418 (42.4)	963 (18.2)	13 455 (47.7)	
55–64	8152 (27.2)	1076 (24.8)	7076 (27.7)	
65–74	4937 (17.6)	1203 (28.5)	3734 (15.2)	
≥75	3366 (12.8)	1157 (28.4)	2209 (9.4)	
Sex, n (weighted %)				<0.001
Female	39 365 (52.2)	2913 (54.9)	36 452 (51.6)	
Male	36 037 (47.8)	2008 (45.1)	34 029 (48.4)	
Race/ethnicity, n (weighted %)				<0.001
Non-Hispanic white	27 747 (70.9)	3390 (87.3)	24 357 (67.2)	
Non-Hispanic black	15 646 (10.9)	690 (5.5)	14 956 (12.1)	
Non-Hispanic Asian	5410 (4.9)	151 (1.5)	5259 (5.6)	
Non-Hispanic other/multiple	2219 (1.9)	74 (1.1)	2145 (2.1)	
Hispanic	24 380 (11.5)	616 (4.6)	23 764 (13.0)	
Atherosclerotic cardiovascular disease, n (weighted %)				<0.001
Non-ASCVD	70 395 (84.3)	3738 (74.9)	66 657 (86.4)	
ASCVD	5007 (15.7)	1183 (25.1)	3824 (13.6)	
CRF profile, n (weighted %)				<0.001
Optimal	48 893 (36.0)	1434 (26.7)	47 459 (38.0)	
Average	20 121 (45.8)	2361 (50.6)	17 760 (44.7)	
Poor	6388 (18.2)	1126 (22.7)	5262 (17.2)	
Education, n (weighted %)				<0.001
<High School	33 722 (13.9)	890 (11.9)	32 832 (14.3)	
GED or high school diploma	29 967 (56.0)	2683 (55.4)	27 284 (56.2)	
>College	11 550 (30.1)	1343 (32.8)	10 207 (29.5)	
Insurance status, n (weighted %)				<0.001
Private	37 641 (67.1)	2963 (66.7)	34 678 (67.2)	
Public only	24 128 (21.5)	1639 (29.1)	22 489 (19.8)	
Uninsured	13 633 (11.4)	319 (4.2)	13 314 (12.9)	
Region, n (weighted %)				<0.001
Northeast	12 254 (18.3)	796 (17.2)	11 458 (18.6)	
Midwest	13 810 (21.8)	1066 (23.3)	12 744 (21.5)	
South	28 178 (37.3)	1861 (36.9)	26 317 (37.4)	
West	21 160 (22.5)	1198 (22.6)	19 962 (22.5)	
Family income, n (weighted %)				<0.001
Poor	18 124 (10.3)	757 (8.3)	17 367 (10.7)	
Near poor	5033 (4.3)	285 (4.9)	4748 (4.2)	
Low income	13 111 (12.8)	722 (13.8)	12 389 (12.6)	
Middle income	20 719 (28.7)	1386 (26.5)	19 333 (29.1)	
High income	18 415 (44.0)	1771 (46.4)	16 644 (43.4)	

Table 1. Continued

	All	Cancer	No Cancer	P Value
Modified Charlson Comorbidity Index*, n (weighted %)				<0.001
0	67 098 (83.8)	2976 (62.1)	64 122 (88.6)	
1	6737 (10.9)	576 (11.5)	6161 (10.8)	
≥2	1567 (5.3)	1369 (26.4)	198 (0.6)	

ASCVD indicates atherosclerotic cardiovascular disease; CRF, cardiovascular risk factor; GED, general equivalency diploma; MEP, Medical Expenditure Panel.
*Charlson Comorbidity Index without Cardiovascular components.

poor CRF versus optimal CRF profiles, respectively (Table 2, model 3). Highest adjusted marginal total healthcare expenditure of $10 852 (95% CI, 8917–12 788) was observed in those with both cancer and ASCVD. In a sensitivity analysis, we additionally added an interaction between presence of cancer diagnosis and ASCVD/NON-ASCVD CRF Profiles, with it being nonsignificant (*P*>0.1), thus proving that a cancer diagnosis would not influence our results, and similar trends should be expected. Figure details levels of specific expenditures (hospitalizations, ED visits, prescription drugs, office-based visits, and other) according to CRF profile, ASCVD, and cancer status. Adjusting for covariates including demographics, insurance, socioeconomic status, as well as comorbid conditions, individuals with cancer in the absence of ASCVD and with a poor CRF profile spent an annual average of $2207 on hospitalizations and $1969 on prescription medications compared with $1194 and $624 for cancer individuals with optimal CRF profile, respectively.

Healthcare Resource Utilization

Table 3 summarizes healthcare utilization rates across cancer and ASCVD status as well as CRF profile categories. Overall, favorable CRF profile and the absence of ASCVD were associated with significantly less use of healthcare resources among individuals with cancer. Among cancer participants without ASCVD, those with optimal versus poor CRF profile were less likely to have an ED visit (10.3% versus 22.6%) or any hospitalization (7.3% versus 15.1%). After adjusting for key covariates, among individuals with cancer but without ASCVD, those with optimal CRF profile had 72% lower odds of being hospitalized (odds ratio, 0.28 [95% CI, 0.15–0.53]), 67% lower odds of having an ED visit (odds ratio, 0.33 [95% CI, 0.27–0.41]), 61% lower odds of outpatient visit (odds ratio, 0.39 [95% CI, 0.17–0.89]), and 89% lower odds of purchasing/refilling a prescription medication (odds ratio, 0.11 [95% CI, 0.09–0.12]) compared with those with poor CRF profile.

Table 2. Total Costs by Cancer, ASCVD, and CRF Profile

		No ASCVD		
		CRF Profile		
	ASCVD	Poor	Average	Optimal
	Expenditure (95% CI)	Expenditure (95% CI)	Expenditure (95% CI)	Expenditure (95% CI)
Model 1				
Cancer	$15 906 (14 335, 17 477)	$11 191 (9137, 13 244)	$9129 (8087, 10 171)	$8116 (5608, 10 623)
No cancer	$11 556 (10 608, 12 503)	$7842 (7039, 8644)	$4413 (4123, 4703)	$2697 (2477, 2918)
Model 2				
Cancer	$14 001 (11 773, 16 228)	$9639 (7486, 11 793)	$6712 (5849, 7574)	$6309 (4380, 8238)
No cancer	$9972 (8630, 11 313)	$7034 (6132, 7936)	$3698 (3447, 3948)	$2446 (2237, 2655)
Model 3				
Cancer	$10 852 (8917, 12 788)	$7256 (5245, 9266)	$5306 (4715, 5896)	$4782 (3764, 5800)
No cancer	$9443 (8316, 10 569)	$6790 (6009, 7572)	$3954 (3691, 4218)	$2841 (2542, 3140)

Model 1: unadjusted. Model 2: adjusted for age, sex, socioeconomic status, race/ethnicity, insurance type, and geographical region. Model 3: adjusted for "model 2" plus Modified Charlson Comorbidity Index (without cardiovascular components). ASCVD indicates atherosclerotic cardiovascular disease; CI, confidence interval; CRF, cardiovascular risk factor.
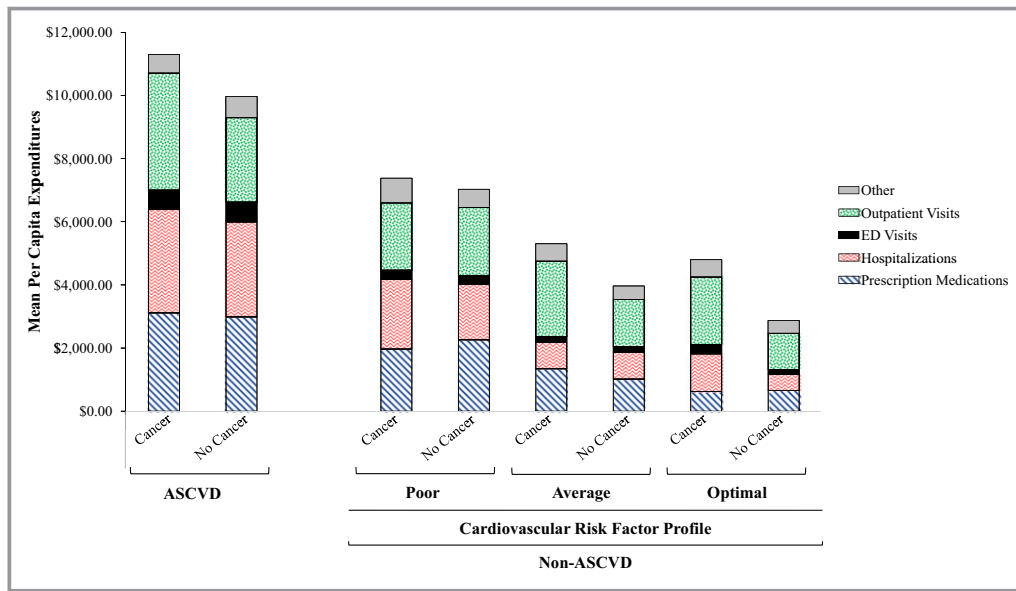
Figure. Mean per capita healthcare expenditures by ASCVD, cardiovascular risk factor profile, and cancer status. ASCVD indicates atherosclerotic cardiovascular disease; ED, emergency department. Weighted and adjusted for age, sex, socioeconomic status, race/ethnicity, insurance type, geographic region, modified Charlson Comorbidity Index (without Cardiovascular components), and modifiable risk factors (only ASCVD).

Discussion

Previous studies have evaluated the financial burden associated with cancer survivorship[4,8,10,22,23]; however, to the authors' knowledge, this is the first attempt to contextualize the economic impact of ASCVD and CRF profiles on cancer survivors in a contemporary national representative sample of the US population. We found a higher prevalence of ASCVD (25% versus 14%) and lower likelihood of an optimal CRF profile (27% versus 38%) among cancer survivors compared with those without cancer. Additionally, we found significantly reduced healthcare utilization and expenditures among cancer survivors without ASCVD, and especially among those with optimal CRF profile.

Our results are consistent with prior reports highlighting the increased burden of ASCVD and CRF in cancer survivors.[5,24–26] Several contributing factors to this observation include common risk factors, rapidly growing survivorship population with the majority over the age of 65, and potentially cardiotoxic effects from cancer therapies themselves.[6,24,27] Many of the major shared risk factors between cancer and ASCVD are incorporated into the American Heart Association's "Strategic Impact Goals for 2020," which introduced the Life's Simple 7 (smoking status, physical activity, eating pattern, body weight, blood cholesterol, blood glucose, and blood pressure) as a population-level health-promotion strategy that has been shown to improve overall cardiovascular outcomes.[28,29] Additionally, adherence to more components in American Heart Association's Life's Simple 7 appears to be associated with a lower risk of incident cancer even when smoking was removed

from the score.[30] In a large retrospective cohort, adherence to cancer guidelines for obesity, physical activity, and diet were associated with a reduction of cancer and ASCVD mortality.[31] Optimal management of cancer survivors involves increased awareness of worse oncological and cardiovascular outcomes in individuals with ASCVD and CRF, and early recognition and aggressive management of shared risk factors. As noted in our study (Figure), presence of ASCVD and poor risk profile in absence of ASCVD was not only associated with much higher subspecific absolute costs, but also a significant proportion of costs (30%) were related to hospitalizations. On the other hand, among cancer patients in absence of a diagnosis of ASCVD, among patients with average and optimal CRF, hospitalizations contributed to nearly 15% of overall expenditures, with a major proportion (≈40%) of all costs related to outpatient visits. These findings support the focus of current healthcare reforms for value-based health care, emphasizing an integrated population health on lowering overall healthcare costs by shifting care from hospital-based services to ambulatory. Our results provide cost estimates for potential cost savings by incorporating preventive strategies of modifiable CRF for cancer survivors to mitigate progression to ASCVD and reduce the associated comorbid cost burden.[32]

Study Limitations

Several limitations should be noted. First, we could not break down cost by type or stage of cancer, or whether active treatment for cancer was being delivered. Cancer survivors

Table 3. Resource Utilization Stratified by ASCVD, Cancer, and CRF Profile

| | | No ASCVD | | |
| | | CRF Profile | | |
	ASCVD	Poor	Average	Optimal
Hospitalizations				
Proportion with any hospitalization				
Cancer	0.2791	0.1509	0.1155	0.0731
No cancer	0.1991	0.1019	0.0593	0.025
Average hospitalizations				
Cancer	1.43	1.36	1.28	1.27
No cancer	1.42	1.4	1.19	1.15
OR for any hospitalization				
Cancer				
Unadjusted	*Ref*	0.46 (0.40, 0.53)	0.34 (0.29, 0.39)	0.20 (0.13, 0.32)
Adjusted*	*Ref*	0.53 (0.40, 0.70)	0.43 (0.42, 0.44)	0.28 (0.15, 0.53)
No cancer				
Unadjusted	*Ref*	0.46 (0.38, 0.55)	0.25 (0.17, 0.38)	0.10 (0.08, 0.14)
Adjusted*	*Ref*	0.53 (0.45, 0.64)	0.34 (0.23, 0.51)	0.16 (0.13, 0.20)
ED				
Proportion with any ED visits				
Cancer	0.3091	0.2257	0.1708	0.1027
No cancer	0.2634	0.1721	0.1215	0.0717
Average ED visits				
Cancer	1.66	1.31	1.44	1.5
No cancer	1.58	1.52	1.36	1.27
OR for any ED visits				
Cancer				
Unadjusted	*Ref*	0.65 (0.49, 0.87)	0.46 (0.20, 1.05)	0.26 (0.19, 0.34)
Adjusted	*Ref*	0.72 (0.51, 1.01)	0.55 (0.25, 1.20)	0.33 (0.27, 0.41)
No cancer				
Unadjusted	*Ref*	0.58 (0.42, 0.81)	0.39 (0.20, 0.73)	0.22 (0.16, 0.29)
Adjusted*	*Ref*	0.58 (0.45, 0.75)	0.44 (0.25, 0.77)	0.26 (0.20, 0.35)
Outpatient visits				
Proportion with any outpatient visits				
Cancer	0.9759	0.9588	0.9542	0.911
No cancer	0.9188	0.9026	0.7956	0.6837
Average outpatient visits				
Cancer	18.02	13.4	13.56	11.04
No cancer	12.7	10.53	8.13	6.95
OR for any outpatient visits				
Cancer				
Unadjusted	*Ref*	0.58 (0.16, 2.12)	0.52 (0.25, 1.08)	0.25 (0.14, 0.47)
Adjusted*	*Ref*	0.68 (0.11, 4.16)	0.70 (0.45, 1.09)	0.39 (0.17, 0.89)

Continued

Table 3. Continued

| | | No ASCVD | | |
| | | CRF Profile | | |
	ASCVD	Poor	Average	Optimal
No cancer				
Unadjusted	*Ref*	0.82 (0.79, 0.85)	0.34 (0.28, 0.42)	0.19 (0.17, 0.22)
Adjusted*	*Ref*	0.98 (0.76, 1.25)	0.45 (0.31, 0.66)	0.27 (0.22, 0.32)
Prescription medications				
Proportion with any purchase/refills				
Cancer	0.9792	0.9732	0.9473	0.7788
No cancer	0.9391	0.937	0.7734	0.5385
Average purchase/refills				
Cancer	42.22	40.18	23.85	13.55
No cancer	39.27	35.21	18.42	9.72
OR for any purchase/refills				
Cancer				
Unadjusted	*Ref*	0.77 (0.48, 1.24)	0.38 (0.18, 0.80)	0.07 (0.06, 0.09)
Adjusted*	*Ref*	0.92 (0.55, 1.54)	0.51 (0.25, 1.07)	0.11 (0.09, 0.12)
No cancer				
Unadjusted	*Ref*	0.97 (0.45, 2.06)	0.22 (0.17, 0.29)	0.08 (0.05, 0.11)
Adjusted*	*Ref*	1.27 (0.71, 2.27)	0.32 (0.26, 0.38)	0.12 (0.08, 0.18)

Odds ratios are presented as: OR (95% CI). ASCVD indicates atherosclerotic cardiovascular disease; CI, confidence interval; CRF, cardiovascular risk factor; ED, emergency department; OR, odds ratio.

*Adjusted for age, sex, socioeconomic status, race/ethnicity, insurance type, geographical region, and Modified Charlson Comorbidity Index (without cardiovascular components).

were defined as any individual who has ever been diagnosed with cancer regardless of duration as previously described.[6] Second, the MEPS data only capture a fraction of total national health expenditures for cancer patients. For example, nursing home expenditures attributable to cancer are excluded.[33] Cancer patients with advanced disease were likely not able to participate in the survey, further underestimating cancer costs. The true burden of cancer goes beyond medical costs and includes lost productivity, stress, mental health, costs for travel and child care, and costs incurred by caretakers.[34] Other analyses have reported an underestimation of total medical expenditures from MEPS data, which all suggest our results are a conservative estimate for the burden of modifiable CRF on cancer patients as well as the estimated savings from prevention strategies,[33,35,36] therefore strengthening our findings. Third, because cancer, ASCVD, and modifiable CRF were self-reported, there is likely an underrepresentation of the true national prevalence, as has previously been described.[37,38] The prevalence of ASCVD in this study was lower than previous national estimates (15.7% versus 36%), in part because we excluded hypertension, as it was included in the CRF profile.[2] Fourth, lack of information

on dietary habits did not allow us to include this important modifiable risk factor. Additionally, because of the lack of clinical factors (blood pressure, fasting blood glucose, and total cholesterol), we were not able to calculate American Heart Association's ideal health cardiovascular status (Life's Simple 7). Fifth, there is a risk of residual confounding from unmeasured characteristics that could affect our study outcomes, despite our best attempts to comprehensively control for the most importantly observed contributing variables. Lastly, the results only apply to the noninstitutionalized adult US population.

Conclusions

From a contemporary nationally representative population, we found that the absence of ASCVD and a favorable cardiovascular risk factor profile among cancer survivors was associated with significantly lower healthcare expenditure and resource utilization. These results provide robust estimates for potential healthcare savings as preemptive strategies continue to become integrated into new healthcare delivery models, for increased awareness and prevention of ASCVD,

and improvement in cardiovascular risk factor profiles among those with and without diagnosed cancer.

Disclosures

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SUPPLEMENTAL MATERIAL

Table S1. ICD-9-CM codes, MEPS 2012-2013.

Diagnosis	ICD-9-CM
ASCVD	
Acute Myocardial Infarction	410
Angina Pectoris	413
Other Chronic Ischemic Heart Disease	414
Cerebrovascular Disease	
Precerebral Artery Occlusion	433
Cerebral Artery Occlusion	434
Transient Cerebral Ischemia	435
Acute, But Ill-Defined, Cerebrovascular Disease	436
Other And Ill-Defined Cerebrovascular Disease	437
CRF	
Hypertension	401
Diabetes Mellitus	250
Disorders Of Lipoid Metabolism	272
Diagnosis	**CCS**
Cancer	11 - 44

ICD-9-CM, International Classification of Diseases, 9th Edition, Clinical Modification; ASCVD, atherosclerotic cardiovascular disease; CRF, cardiovascular risk factor; CCS, clinical classification software diagnoses.