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FULL RESEARCH PAPER
Physical Activity

Association of premature atherosclerotic cardiovascular disease with higher risk of cancer: a behavioral risk factor surveillance system study

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Aim The aim of this study was to investigate a possible association between atherosclerotic cardiovascular disease (ASCVD) and risk of cancer in young adults.

Methods We utilized data from the Behavioral Risk Factor Surveillance System, a nationally representative US telephone-based survey to identify participants in the age group of 18–55 years who reported a history of ASCVD. These patients were defined as having premature ASCVD. Weighted multivariable logistic regression models were used to study the association between premature ASCVD and cancer including various cancer subtypes.

Results Between 2016 and 2019, we identified 28 522 (3.3%) participants with a history of premature ASCVD. Compared with patients without premature ASCVD, individuals with premature ASCVD were more likely to be Black adults, have lower income, lower levels of education, reside in states without Medicaid expansion, have hypertension, diabetes mellitus, chronic kidney disease, obesity, and had delays in seeking medical care. Individuals with premature ASCVD were more likely to have been diagnosed with any form of cancer (13.7% vs 3.9%), and this association remained consistent in multivariable models (odds ratio, 95% confidence interval: 2.08 [1.72–2.50], $P < 0.01$); this association was significant for head and neck (21.08[4.86–91.43], $P < 0.01$), genitourinary (18.64 [3.69–94.24], $P < 0.01$), and breast cancer (3.96 [1.51–10.35], $P < 0.01$). Furthermore, this association was consistent when results were stratified based on gender and race, and in sensitivity analysis using propensity score matching.

Conclusion Premature ASCVD is associated with a higher risk of cancer. These data have important implications for the design of strategies to prevent ASCVD and cancer in young adults.

Keywords Premature • ASCVD • Cancer • Healthcare disparities • Prevention • Screening

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Introduction

Cardiovascular disease and cancer are the top two leading causes of mortality, globally and in the USA.[1] Data from the National Center for Health Statistics and the Centers for Disease Control and Prevention suggest that cancer- and heart disease-related deaths account for ~310 deaths per 100 000 population.[2] Although often considered as independent entities, there is growing scientific interest in a possible association between the two, largely driven by shared risk factors (such as tobacco use, obesity, diabetes) and pathogenic mechanisms (chronic inflammation, free radical pathways).[1,3] Current research in cardio-oncology has focused on the management of cardiovascular disease in cancer survivors and on the management of cancer therapy-related side effects and toxicity; however, increasing evidence supports a 'reverse cardio-oncology' linkage, i.e. higher risk of cancer in patients with cardiovascular disease.[3–5]

Atherosclerotic cardiovascular disease (ASCVD) in younger adults has emerged as a concerning public health challenge.[6] Younger individuals may be less aware of their cardiovascular risk factors and consequently may delay seeking primary prevention.[7–9] Given the potential economic burden stemming from the loss of productivity years and healthcare utilization that may be associated with these conditions,[10] it is essential to quantify the magnitude of the problem to help guide policy makers to counteract. The present study was designed to assess the association of premature ASCVD with an increased cancer risk in a large, nationally representative population.

Methods

The Behavioral Risk Factor Surveillance System (BRFSS) survey, established by the Centers for Disease Control and Prevention, is a nationwide telephone-based questionnaire of a random sample of US residents regarding health-related risk behaviours, chronic health conditions, and use of preventive services. BRFSS includes participants in all 50 states as well as the District of Columbia and 3 US territories, making it the largest telephone-based survey in the world. We used data from the 2016 to 2019 BRFSS survey ($n = 1,745,999$). The BRFSS allows population-level investigations on the association of behavioural risk factors with various diseases. As BRFSS is a deidentified dataset that is publicly available (http://www.cdc.gov/brfss), it was exempt from institutional review board approval. The estimates provided by the BRFSS have been previously validated against other established surveys such as the national health and nutrition examination survey and the national health interview survey.[11,12]

ASCVD status was ascertained by self-report based on the participant's responding to the question 'Have you ever had coronary heart disease or myocardial infarction or stroke?'. Premature ASCVD was defined as adults ≤55 years of age who responded with a yes to the above question. History of cancer and the type of cancer was self-reported based on participant's response to a series of questions: skin cancer status was identified based on the response to the question 'Have you ever been told that you have skin cancer?'; having any cancer other than skin cancer was identified based on the response to the question, 'have you ever been told you have any other type of cancer? (besides skin cancer)'; the specific sub-type of cancer was elicited based on the response to the question 'What type of cancer was it?'.

We analysed these cross-sectional data using survey weights for BRFSS provided by the CDC to account for the survey design, and ensure the representativeness of the data to the US population.[13] We first ascertained the distribution of health-related behavioural risk factors in the groups with and without premature ASCVD. We then used multivariable logistic regression models to study the association of premature ASCVD with cancer risk by first adjusting for traditional comorbidities such as age, race, sex, cigarette smoking, diabetes, hyperlipidaemia, hypertension, heavy alcohol use, and use of other tobacco products such as smokeless tobacco. Next, to assess the influence of social determinants of health and access to care, we additionally adjusted for level of education, having a primary care physician, income, delays in medical care for financial reasons, and residing in states that had Medicaid expansion. Results were also stratified by sex and race. We performed a secondary subgroup analysis to assess our hypothesis among individuals with very premature ASCVD (defined as adults ≤45 years of age with ASCVD). We performed sensitivity analyses by using 1:1 propensity matching to adjust for differences in baseline comorbidities and demographics between groups with and without premature ASCVD. We also performed an additional sensitivity analysis to assess the robustness of outcomes to unmeasured confounding using the *E*-value methodology described by VanderWeele and Ding.[14] This estimates what the relative risk would have to be for any unmeasured confounder to overcome the observed association of cancer with premature ASCVD in this study (seeSupplementary material online for details). All analyses were conducted using Stata version 16.1 (StataCorp, College Station, TX, USA) and R version 3.6.3 (R foundation).

Results

Our study population included 748, 090 participants between the ages of 18–55 years, of whom 28, 522 (3.3%) reported a history of ASCVD (i.e. premature ASCVD) and 719, 568 (96.7%) did not have ASCVD. The baseline characteristics of the participants with and without premature ASCVD are listed in *Table 1*. Notably, individuals with premature ASCVD were more often Black adults, had lower incomes and lower levels of education, resided in states without Medicaid expansion, had hypertension, diabetes, and chronic kidney disease, suffered from obesity more often, and were more likely to report delays in seeking medical care due to financial constraints compared with those without premature ASCVD.

Individuals with premature ASCVD were more likely to have been diagnosed with any form of cancer [13.7% vs 3.9%, OR, 95% confidence interval (CI): 3.86 [3.59–4.15], $P < 0.01$]. This association persisted with some attenuation of effect after adjusting for cardiovascular comorbidities and baseline demographics (OR, 95% CI: 2.30 [1.93–2.73], $P < 0.01$) as well as social determinants of health and variables related to access to health care (OR, 95% CI: 2.08 [1.72–2.50], $P < 0.01$) (*Table 2* and *Figure 1*). Consistent results were obtained across all gender and racial groups, in the subgroup analysis for the very premature ASCVD group (*Tables 2* and *3*), and in additional stratified analysis based on underlying comorbidities and access to healthcare (Supplementary material online, *Table S5*). Furthermore, this association was observed to be driven mostly by cancers of head and neck [OR (95% CI): 21.08 [4.86–91.43], $P < 0.01$], genitourinary (i.e. bladder, ureter and kidney) [OR (95% CI): 18.64 [3.69–94.24], $P < 0.01$] and breast cancer [OR (95% CI): 3.96 [1.51–10.35], $P = 0.05$] (*Table 4*). Additional details regarding the regression model are provided in Supplementary material online, *Table S3*.

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Table 1 Baseline and demographic characteristics of participants with and without premature atherosclerotic cardiovascular disease

	No premature ASCVD (*n* = 719 568, 96.67%)	Premature ASCVD (*n* = 28 522, 3.33%)	*P*-value
Female gender	376 996 (49.9%)	14 358 (47.0%)	0.01
Race			
White	479 479 (56.1%)	17 726 (54.9%)	0.01
Black	64 583 (12.7%)	3428 (16.3%)	
Hispanic	95 331 (21.2%)	3613 (20.4%)	
Others	67 038 (9.9%)	3078 (8.5%)	
Age distribution			
18–34 years	276 743 (48.7%)	3830 (19.7%)	
35–44 years	195 110 (26.0%)	6465 (26.2%)	
45–54 years	247 715 (25.3%)	18 227 (54.2%)	
Education status			
< High school	50 287 (12.3%)	4205 (24.4%)	0.01
High school-college	384 986 (58.8%)	17 716 (60.1%)	
> College	281 508 (28.8%)	6470 (15.5%)	
Income level			
<10k	30 455 (5.6%)	3451 (14.4%)	0.01
10–15k	23 105 (4.1%)	2544 (9.8%)	
15–20k	38 902 (6.9%)	3051 (12.3%)	
20–25k	48 863 (8.7%)	2871 (12.7%)	
25–35k	56 035 (9.6%)	2442 (10.7%)	
35–50k	78 069 (12.5%)	2526 (10.2%)	
50–75k	97 103 (14.8%)	2597 (10.1%)	
>75k	240 964 (37.9%)	4719 (19.9%)	
Relation to poverty line			
Below poverty line	92 164 (15.7%)	7627 (29.6%)	0.01
Within 100–200%	124 495 (18.3%)	6736 (23.6%)	
>200%	465 541 (66.0%)	12 685 (46.8%)	
Have healthcare coverage	620 561 (83.8%)	24 251 (82.9%)	0.04
Have PCP	518 606 (68.8%)	23 498 (79.7%)	0.01
Cigarette smoker			0.01
Never	438 736 (65.8%)	11 180 (43.2%)	
Former	127 087 (17.1%)	6762 (23.6%)	
Current	121 065 (17.2%)	9382 (33.2%)	
BMI			
Underweight	11 529 (2.1%)	514 (1.8%)	0.01
Normal weight	217 237 (35%)	5767 (23.5%)	
Overweight	219 746 (33.5%)	7784 (29.9%)	
Obese	203 872 (29.3%)	12 064 (44.8%)	
Hypertension or use of blood pressure medications	70 441 (17.9%)	7951 (58.0%)	0.01
Hyperlipidaemia or use of cholesterol medications	62 174 (18.5%)	6541 (61.8%)	0.01
Diabetes	37 553 (4.5%)	6978 (22.6%)	<0.001
CKD	10 183 (1.4%)	2654 (9.1%)	0.01
Current E-cig use	25 450 (8.0%)	1457 (11.0%)	0.01
Other tobacco products	33 805 (4.4%)	1781 (6.7%)	0.01
Marijuana use	14 949 (13.8%)	706 (14.1%)	0.70
Heavy alcohol Consumption	36 500 (7.06%)	1315 (6.81%)	0.46
Rural county resident	50 627 (19.2%)	2653 (23.2%)	0.01
Residing in a state with Medicaid Expansion	539 523 (69.0%)	20 018 (65.2%)	0.01
Self-reported quality of general health			
Excellent	150 757 (21.4%)	1588 (5.9%)	0.01

Continued

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Table 1 *Continued*

	No premature ASCVD (*n* = 719 568, 96.67%)	Premature ASCVD (*n* = 28 522, 3.33%)	*P*-value
Very good	253 253 (33.7%)	3840 (12.8%)	0.01
Good	222 667 (31.8%)	8319 (30.3%)	0.01
Fair	73 119 (10.6%)	8721 (31.1%)	0.01
Poor	18 594 (2.4%)	5957 (19.9%)	0.01
How often do you get emotional support when needed			0.01
Always	11 136 (53.2%)	278 (45.6%)	0.01
Usually	5598 (26.9%)	138 (21.4%)	0.01
Sometimes	2231 (12.8%)	115 (19.0%)	0.01
Rarely	621 (3.6%)	37 (6.4%)	0.01
Never	615 (3.4%)	53 (7.6%)	0.01
Satisfaction with life			
Very satisfied	9664 (45.8%)	189 (29.6%)	0.01
Satisfied	9610 (48.6%)	323 (52.9%)	0.01
Dissatisfied	806 (4.45%)	78 (12.89%)	0.01
Very dissatisfied	200 (1.1%)	33 (4.6%)	0.01
Do you think you are in good physical heath (yes)	468 093 (66.0%)	9735 (35.6%)	0.01
Unable to see a doctor due to cost	102 994 (15.5%)	8033 (30.0%)	0.01
Cost-related medication non-adherence	5773 (10.2%)	770 (28.9%)	0.01
Delay seeking care for any reason	14 006(23.6%)	1063 (43.8%)	0.01
Diagnosed with any cancer	36 613 (3.9%)	4397 (13.7%)	0.01
Diagnosed with skin cancer	16 013 (1.67%)	1567 (5.40%)	0.01

ASCVD, atherosclerotic cardiovascular disease; BMI, body mass index; CKD, chronic kidney disease; E-cig, electronic cigarette; LGBT, lesbian, gay, bisexual, and transgender; PCP, primary care physician.

Sensitivity analysis

Results of the sensitivity analysis are provided in the Supplementary material online . A 1:1 propensity score matched model showed similar results as that of our original cohort. The *E*-values for the point estimate and upper confidence bound for the odds of having cancer were 3.57 and 2.84, respectively (see Supplementary material online for details).

Discussion

The present study shows that individuals with premature ASCVD had a higher observed prevalence of cardiovascular comorbidities such as hypertension, diabetes, hyperlipidaemia and obesity. They were also more likely to be socioeconomically disadvantaged with delays in seeking primary prevention care. They were more likely to have been diagnosed with cancer. This association persisted with some attenuation of effect in models adjusting for cardiovascular comorbidities as well as social determinants of health and access to health care. On evaluation by cancer site, it was observed that this association was mainly driven by cancers of the head and neck, genitourinary tract, and breast (*Figure 2*). This association was consistent across all gender and racial groups, and in sensitivity analysis with propensity score matching to account for differences in baseline comorbidities and demographics. The robustness of the results to unmeasured confounders was further strengthened by the results of *E*-value analysis.

There has been a growing interest in the two-way interaction between cardiovascular disease and cancer. While a majority of the work has been done investigating the cardiovascular effects of cancer therapies, there have been studies suggesting a possible association of higher cancer risk in patients with preexisting cardiovascular disease.[3–5] There are a number of possible linkages between the two disease processes that have been proposed. Cancer and ASCVD share common etiologic risk factors, such as obesity, diabetes, tobacco use, and alcohol use.[1] Recent studies have shown an increase in the diagnostic burden of cardiovascular comorbidities such as hypertension, diabetes, dyslipidaemia and smoking among patients hospitalized with any form of cancer.[15] In our analysis, we found that individuals with premature ASCVD had a higher prevalence of obesity, diabetes, hypertension, hyperlipidaemia, smoking and alcohol use, which supports the notion of shared risk factors between cancer and ASCVD. Interestingly, adjusting for these risk factors lead to some attenuation in the risk of cancer, explaining their possible contribution to the disease process. Further attenuation in risk was seen when we adjusted for social determinants of health and variables associated with access to health care and health care delivery, such as level of education, income, having access to and delays in seeking primary care due to financial constraints. This may point towards the significant contribution of socioeconomic disparities and poor healthcare access. Previous studies have shown that despite having cardiac risk factors, a majority of young adults may not believe that they are at risk for heart disease such that they are less likely to discuss risk

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Table 2 Odds ratios for the risk of cancer in participants with premature atherosclerotic cardiovascular disease compared with patients without premature atherosclerotic cardiovascular disease

	Unadjusted		Adjusted for comorbidities		Adjusted for comorbidities, social determinants of health, and variables associated with care delivery	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Any cancer (overall cohort)	3.86 [3.59–4.15]	<0.01	2.30 [1.93–2.73]	<0.01	2.08 [1.72–2.50]	<0.01
Based on gender						
Among males	4.37 [3.84–4.97]	<0.01	2.28 [1.70–3.06]	<0.01	2.21 [1.64–2.97]	<0.01
Among females	3.68 [3.37–4.02]	<0.01	2.31 [1.87–2.85]	<0.01	2.00 [1.58–2.53]	<0.01
Based on race						
Among whites	3.51 [3.23–3.81]	<0.01	2.03 [1.65–2.50]	<0.01	1.80 [1.44–2.24]	<0.01
Among blacks	4.09 [3.29–5.09]	<0.01	2.00[1.21–3.29]	<0.01	1.62 [0.91–2.86]	0.10
Among Hispanic	4.97 [4.02–6.13]	<0.01	3.26 [1.89–5.62]	<0.01	3.41 [1.82–6.41]	0.03

Results were stratified based on gender and race. Models adjusted for comorbidities refer to models that were adjusted for age, race, gender, cigarette smoking, diabetes, hyperlipidaemia, hypertension, heavy alcohol use, and use of other tobacco products such as smokeless tobacco. Models that were adjusted for comorbidities and social determinants of health were additionally adjusted for level of education, having a primary care physician, income, delay in medical care for financial reasons, and residing in states that had Medicaid expansion.

ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CNS, central nervous system; OR, odds ratios.

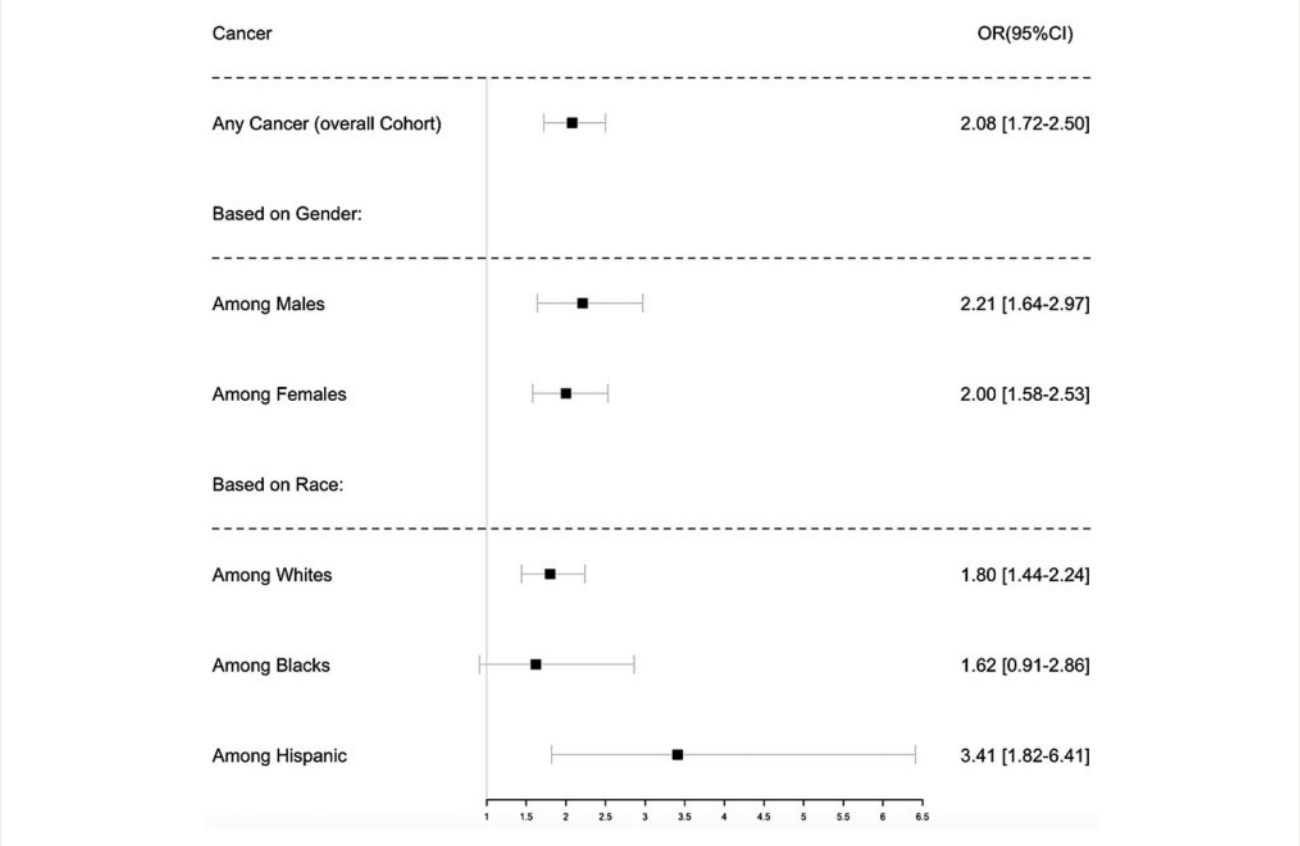

Figure 1 Summary of forest plot showing the odds ratios (95% confidence intervals) for the presence of cancer among individuals with versus without premature atherosclerotic cardiovascular disease.

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Table 3 Odds ratios for the risk of cancer in participants with very premature atherosclerotic cardiovascular disease compared with patients without very premature atherosclerotic cardiovascular disease

	Unadjusted		Adjusted for comorbidities		Adjusted for comorbidities, social determinants of health, and variables associated with care delivery	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Any cancer (overall cohort)	5.16 [4.52–5.90]	<0.01	3.40 [2.53–4.58]	<0.01	2.98 [2.15–4.12]	<0.01
Based on gender						
Among males	5.90 [4.46–7.79]	<0.01	4.22 [2.59–6.86]	<0.01	4.56 [2.72–7.65]	<0.01
Among females	4.72 [4.14 –5.38]	<0.01	3.21 [2.21–4.66]	<0.01	2.66 [1.77–3.98]	<0.01
Based on race						
Among whites	4.71 [4.09 –5.41]	<0.01	2.79 [1.90–4.10]	<0.01	2.49 [1.66–3.74]	<0.01
Among blacks	4.58 [3.25 –6.46]	<0.01	2.66 [1.07–6.65]	0.035	2.47 [0.98–6.24]	0.055
Among Hispanic	6.33 [4.76 –8.43]	<0.01	5.99 [2.90–12.37]	<0.01	5.75 [2.39–13.80]	<0.01

Results were stratified based on gender and race. Models adjusted for comorbidities refer to models that were adjusted for age, race, gender, cigarette smoking, diabetes, hyperlipidaemia, hypertension, heavy alcohol use, and use of other tobacco products such as smokeless tobacco. Models that were adjusted for comorbidities and social determinants of health were additionally adjusted for level of education, having a primary care physician, income, delay in medical care for financial reasons, and residing in states that had Medicaid expansion.
ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CNS, central nervous system; OR, odds ratios.

Table 4 Odds ratios for the risk of cancer in participants with premature atherosclerotic cardiovascular disease compared with patients without premature atherosclerotic cardiovascular disease based on cancer site

Based on cancer type:	Unadjusted		Adjusted for comorbidities		Adjusted for comorbidities and social determinants of health	
	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value	OR (95% CI)	*P*-value
Breast cancer	3.23 [1.85–5.62]	<0.01	3.83 [1.72–8.52]	<0.01	3.96 [1.51–10.35]	0.05
Female genital tract	4.29 [2.91–6.35]	<0.01	1.13 [0.32–3.95]	0.85	0.76 [0.20–2.91]	0.69
Head and neck	9.59 [4.24–21.67]	<0.01	23.83 [5.21–108.9]	<0.01	21.08 [4.86–91.43]	<0.01
Gastrointestinal	4.81 [2.13–10.84]	<0.01	2.52 [0.62–10.3]	0.19	1.32 [0.24–7.33]	0.75
Lymphomas	1.57 [0.79–3.14]	0.19	0.48 [0.1–2.3]	0.36	0.47 [0.095–2.35]	0.36
Male genital tract	1.47 [0.27–7.97]	0.65	1.38 [0.14–13.9]	0.78	1.28 [0.097–16.8]	0.84
Melanoma and other skin	2.93 [1.96–4.37]	<0.01	1.92 [0.90–4.1]	0.09	1.75 [0.85–3.60]	0.13
Lung	19.40 [6.06–62.06]	<0.01	2.23 [0.34–14.21]	0.39	2.06 [0.35–11.63]	0.43
Genitourinary	20.88 [8.31–52.44]	<0.01	35.89 [3.99–322.65]	<0.01	18.64 [3.69–94.24]	<0.01
CNS	4.11 [1.07– 15.76]	0.04	7.02 [1.39– 35.24]	<0.05	2.02 [0.65–6.31]	0.23
Other cancers	3.90 [2.11–7.12]	<0.01	1.75 [0.61–4.98]	0.29	1.54 [0.56–4.22]	0.40

Models adjusted for comorbidities refer to models that were adjusted for age, race, gender, cigarette smoking, diabetes, hyperlipidaemia, hypertension, heavy alcohol use, and use of other tobacco products such as smokeless tobacco. Models that were adjusted for comorbidities and social determinants of health were additionally adjusted for level of education, having a primary care physician, income, delay in medical care for financial reasons, and residing in states that had Medicaid expansion.
ASCVD, atherosclerotic cardiovascular disease; CI, confidence interval; CNS, central nervous system; OR, odds ratios.

factor modification and lifestyle changes with their primary care providers, with the issue being more pronounced in young women.[8,16] Similar to heart disease, lack of healthcare access, education, poverty, and belonging to a minority racial group have been predictors of poor prognosis among cancer patients as well.[17] Taken together, these findings point towards a need to improve measures of primordial prevention among young adults with a focus on socioeconomically disadvantaged groups to curb the dual epidemic of ASCVD and cancer.

In our analysis, we observed that the risk of cancer remained elevated in adults with premature ASCVD even after accounting for traditional risk factors and social determinants of health and access to health care. The finding of consistent result across all gender and racial groups indicate a possibility that these factors may not be playing a strong role in these observed associations. This may point towards other underlying factors that could not be accounted for in our study. Notably, the two disease processes share overlapping pathophysiologic mechanisms that may play a role. Inflammatory pathways have

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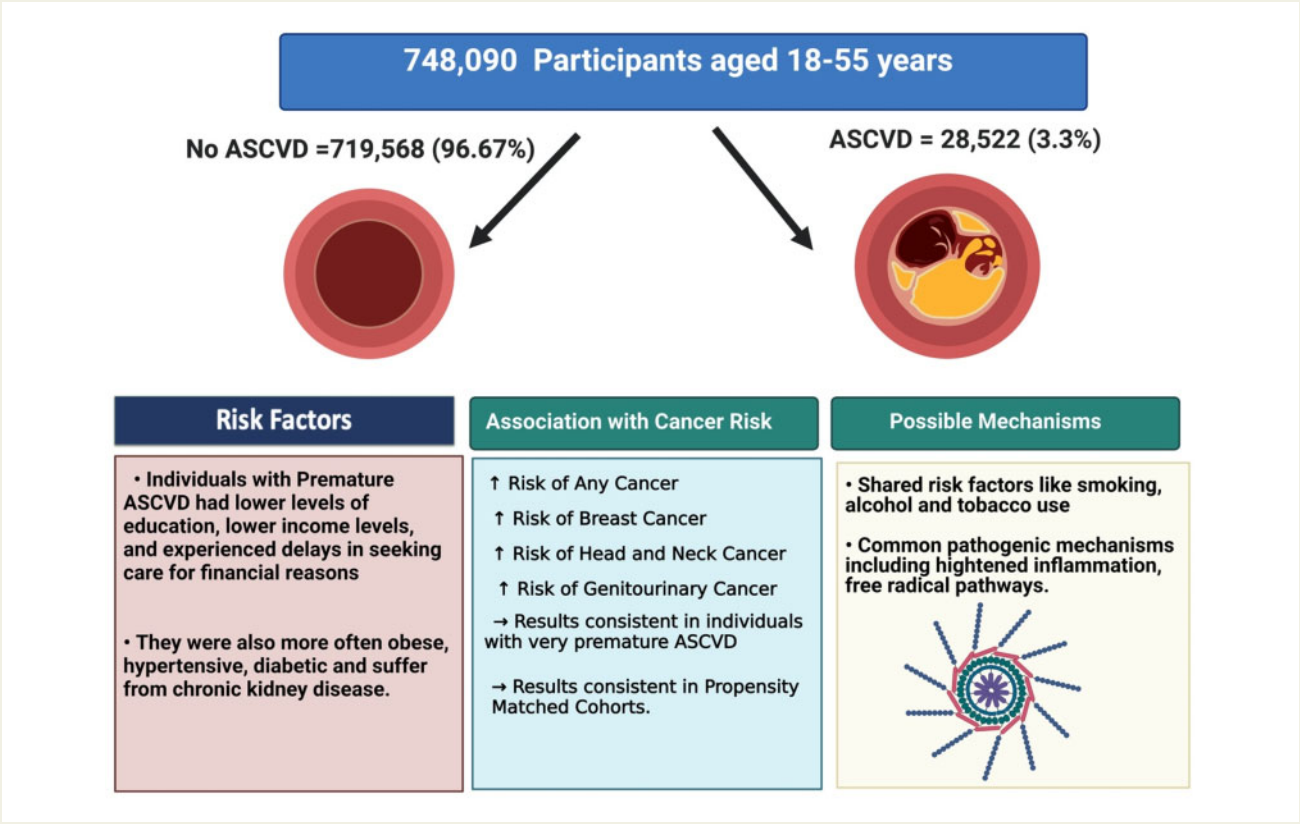

Figure 2 Figure summarizing the key findings of the study.

been known to play a key role in pathophysiologic processes that lead to the initiation and progression of cancer and ASCVD.[18] Studies have shown that inflammatory mediators, particularly interleukin-1, play an important role in the epithelial–mesenchymal transition of malignant cells, a key step in the neoplastic transformation of cells.[18–20] A recent sub-analysis of the CANTOS (Canakinumab Anti-inflammatory Thrombosis Outcomes Study) trial looking at the impact of anti-inflammatory therapy with canakinumab on incident lung cancer and its associated mortality found that compared with placebo, patients treated with canakinumab had significantly lower levels of inflammatory markers (high-sensitivity C-reactive protein and interleukin 6). Canakinumab in patients with myocardial infarction not only reduced the future risk of adverse cardiovascular outcomes compared to placebo, it also reduced incident lung-cancer diagnosis rates and lung cancer-associated mortality in a dose–response fashion.[21] Besides inflammatory pathways, cellular level signalling of pro-carcinogenic genes by mediators such as hypoxia-inducible factor 1 and vascular endothelial growth factor has also been recognized as potential linkage points in the association of cancer and ASCVD.[22,23]

The findings of the present study are consistent with existing data that have been presented in prior observational studies and a small number of meta-analyses.[24–26] The SHIP (Sakakibara Health Integrative Profile) cohort study that enrolled over 320 000 participants prospectively analysed the risk of developing cancer in patients with ASCVD. The study found that the prevalence of cancer was approximately twofold fold higher in individuals with ASCVD compared with individuals with non-ASCVD (5% vs 2%). Specifically, the observation of higher risk of head and neck cancer that was seen in our study was similar to the findings of a cohort study of 115 patients undergoing treatment for head and neck cancer.[4] In that study, the prevalence of coronary (15%) and carotid (9%) artery disease was significantly higher than that seen in the general population with comparable demographics, which was attributed to suboptimal primary prevention care among cancer patients.[4] Our study extends these findings to show that this association is present even in patients with premature ASCVD.

Our findings have significant public health and health policy implications. The age group of 18–55 years forms the economic backbone of a country. Consequently, risk preventive strategies aimed at increasing public awareness, providing adequate primary care resources, and collaborative effort between PCPs, cardiologists and oncologists focused at comprehensive screening and behavioural modification are needed. The annual cumulative cost of ASCVD and cancer care in the United States is an estimated $844.4 billion dollars, which is projected to double by 2030.[10] Efforts are needed to raise awareness regarding shared risk factors for cancer and ASCVD among young individuals, with increased resource allocation for primordial and primary prevention. In doing so, a focus on marginalized groups is needed. Unfortunately, the majority of the adults who suffer

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from these conditions have lower education levels and fewer resources at their disposal as shown in our analyses. Health policy decisions specifically aimed at health promotion in these populations need to be prioritized.[10]

Future work in cardio-oncology should be aimed at better understanding the underlying pathophysiologic mechanism of a possible increased cancer risk in patients with premature ASCVD. A reconsideration of the screening strategies for cancer as well as ASCVD in young adults is warranted. Additional therapeutic modalities along the lines of canakinumab need to be developed and investigated in such populations for the dual treatment of ASCVD and cancer. Similarly, further efforts are needed to fully understand the impact of primordial prevention with ideal cardiovascular health on premature ASCVD and cancer.

Limitations

Our results must be interpreted in the context of important limitations. This was a cross-sectional study and therefore causality and directionality cannot be inferred, i.e. whether these were cancer patients who had ASCVD events or patients with ASCVD who were diagnosed with cancer cannot be inferred. However, the strength of association between the two disease processes shown in the present study and in prior literature should be considered while designing future prospective studies that are better suited to ascertain causality. In any epidemiologic study, there is a possibility of residual confounding. However, we have tried to address this confounding by using multiple approaches such as subgroup analysis in the very premature ASCVD group, propensity score matching and *E*-value analysis. As information was self-reported, it is subject to measurement error and response bias. Due to the inherent limitation of BRFSS, details regarding cancer stage, medication use and treatment were not available. It is also important to note that our cohort of adults with premature ASCVD did not include females in the age group 55–64 years.

Conclusion

Premature ASCVD is associated with a higher risk of cancer. This association appears to be driven by a higher risk of head and neck, genitourinary, and breast cancer. These data have important implications for the design of strategies to prevent ASCVD and cancer in young adults. Understanding that ASCVD confers an increased risk of cancer may provide insight into identifying young adults at greatest risk, tailoring earlier intervention, and optimizing appropriate monitoring and follow-up.

Supplementary material

Supplementary material is available at *European Heart Journal – Cardiovascular Pharmacotherapy* online.

Conflict of interest: All authors declare that they have no conflicts of interest pertaining to this work.

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