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Association of the American heart association's new "life's essential 8" cardiovascular health with all-cause and cardiovascular mortality in adults with and without cancer: a retrospective cohort study

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Abstract

Background The American Heart Association released an updated algorithm used to assess cardiovascular health (CVH)-the Life's Essential 8 (LE8) score. Our objective was to quantify the association between CVH levels estimated by the LE8 score and all-cause and cardiovascular mortality in adults with and without cancer.

Methods In this retrospective cohort study, 29,352 adults were included from the National Health and Nutrition Examination Survey (NHANES) 2005–2018 at baseline linked to the 2019 National Death Index records. Cox regression models and Restricted cubic spline were used to evaluate the associations between CVH with cardiovascular mortality and all-cause mortality.

Results In this study, 14.8% of adults achieved a high total CVH score, compared to 20.3% with low scores. The adjusted HR (95% CI) for all-cause mortality in adults without cancer with a moderate or high CVH total scores compared with low scores was 0.71 (0.64, 0.79) and 0.46 (0.35, 0.60), respectively. The corresponding adjusted HR (95% CI) for cardiovascular disease (CVD) mortality was 0.58 (0.47, 0.72) and 0.30 (0.16, 0.57), respectively. And all 8 CVH indicators in CVD mortality were protective factors. The adjusted HRs (95% CI) for all-cause mortality in adults with cancer with moderate or high scores were 0.73 (0.58, 0.92) and 0.75 (0.48, 1.18), respectively.

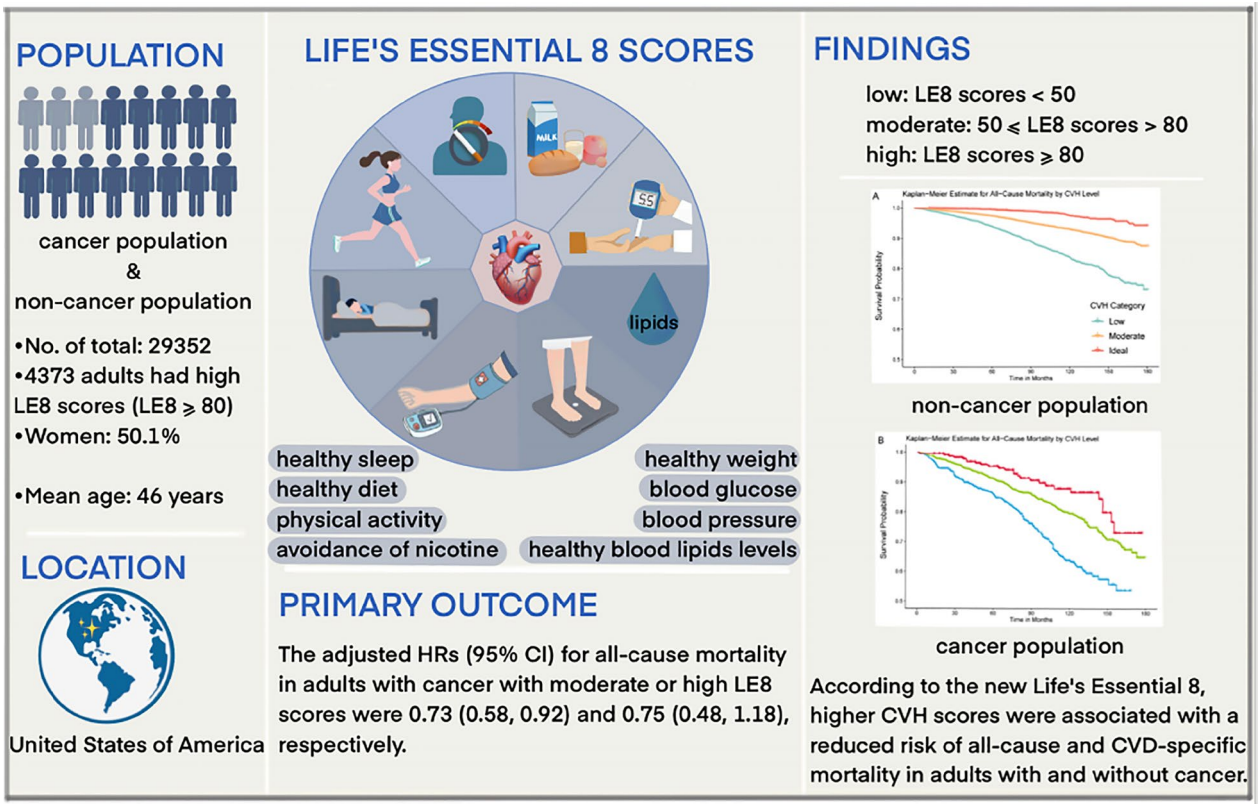
Conclusion According to the new LE8, higher CVH scores were associated with a reduced risk of all-cause and CVD-specific mortality in adults with and without cancer.

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Graphical Abstract



Keywords Cancer, Cardiovascular health, Life's essential 8, Mortality

Introduction

Cardiovascular disease (CVD), the leading cause of disability and death worldwide [1]. In an effort to further improve overall population and individual health, the American Heart Association (AHA) has broadened the strategy's goal to include not only addressing CVD, but also on those aspects that can directly contribute to population and individual health [2]. Cardiovascular health (CVH) emphasizes the integrity of health rather than just disease. the AHA developed this definition using existing relevant data and emerging concepts of prevention and is committed to improving CVH for all. Using the updated CVH assessment methodology allows for better evaluation of other metrics, quantification of raw metrics, and assessment of the potential value of other data sources [3].

The AHA has introduced an important component to the updated and enhanced CVH measure, sleep, now known as "Life's Essential 8"(LE8), which includes the 8 components of CVH: healthy weight, avoidance of nicotine, blood glucose, healthy sleep, healthy diet, participation in physical activity, healthy levels of blood lipids, and blood pressure [4]. This updated and enhanced measure of CVH provides a more comprehensive view of quantifying CVH and provides impetus for improving individual and population health [5].

Individuals diagnosed with specific cancer types often face an elevated risk of cardiovascular disease. Notably, during their post-treatment recovery phase, these individuals may also exhibit heightened cardiovascular or all-cause mortality rates. Given this amplified cardiovascular risk among cancer patients, it is imperative for healthcare professionals to rigorously monitor cardiac function, blood pressure, lipid levels, and glucose metrics. Providing tailored CVH strategies can mitigate the onset of cardiovascular events and enhance overall life quality for this vulnerable population [5]. Numerous behaviors and factors associated with CVH, such as a nutritious diet and engagement in physical activity, are believed to be closely associated with cancer prevention [5]. Studies have shown that adopting a healthy lifestyle, such as consuming an abundance of fruits and vegetables, limiting the intake of processed foods and red meat can reduce the risk of stomach, breast, colon and prostate cancers [6–8]. Optimal CVH can influence the prognosis of cancer patients. In particular, standard cancer treatments such as chemotherapy and surgery often have an inherent

cardiovascular impact [9, 10]. Reducing CVH risk factors and maintaining a state of cardiovascular fitness reduces the risk of cardiac complications and improves a patient's ability to tolerate treatment while undergoing therapy.

Therefore, we hypothesized that higher LE8 scores would be associated with reduced all-cause and cardiovascular mortality in adults with and without cancer. To test this hypothesis, we aimed to estimate the correlation between CVH and all-cause and cardiovascular mortality using data from the National Health and Nutrition Examination Surveys (NHANES).

Methods

This is a retrospective cohort study using NHANES data from 2005 to 2018 linked to the 2019 National Death Index (NDI) records for mortality follow-up. In this study, "mortality record" refers to the linkage with the NDI to determine the mortality status of participants. The study encompasses 29,352 adults and boasts a median follow-up time of 7.58 years, accumulating a total of 223,965.7 person-years. The study protocol was approved by the Institutional Review Board of the National Center for Health Statistics, and informed consent was submitted by each participant. All guidelines on data and analytical methods are available from the National Center for Health Statistics of the United States Centers for Disease Control and Prevention (https://www.cdc.gov/nchs/nhanes).

Study design and study population

The National Health and Nutrition Examination Survey (NHANES) is a nationally representative cross-sectional survey that evaluates the health and nutritional status of adults and children in the United States. We used data associated all-cause and heart-cause mortality files for adults with and without cancer to correlate participant death records. Data from the NHANES Associated Mortality Files encompassed 7 cycles from 2005 to 2018, covering a total of more than 30,000 participants aged 20 to 79 years, and provided usable mortality records. In the sample, 29,352 participants who were eligible to participate in the study were included in the analyses, and effects of pregnant women, minors, and missing values on individual components were excluded.

Covariates

Covariate assessment information such as gender, age, race and ethnicity, household income, and educational attainment was self-reported and collected through standardized questionnaires [11]. Such standardized questionnaires and instruments help ensure data consistency and reduce the potential for recall bias. Additionally, the data collection process was designed to collect information in a structured manner, minimizing reliance on participants' long term memory. Race and ethnicity were categorized as Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, and Other Race. Household income was categorized as Low, Medium, and High. Educational attainment was categorized as Some college or above, High school and less than high school.

Inclusion and exclusion criteria

Inclusion criteria: (1) patients in the NHANES database with ICD codes I00 through I09, I11, I20, I13 through I51, and I60 through I69 (definition of cardiovascular death); (2) Patients who were able to undergo CVH assessment ($n = 42022$).

Exclusion criteria (1) patients who were younger than 20 ($n = 1011$); (2) patients who were older than 80 ($n = 1936$); (3) patients who were pregnant ($n = 803$); (4) patients who were missing mortality record ($n = 297$).

Assessments of CVH

We used the LE8 score to evaluate the CVH [4]. "LE8", which includes the 8 components of CVH: healthy weight, avoidance of nicotine, blood glucose, healthy sleep, healthy diet, participation in physical activity, healthy levels of blood lipids, and blood pressure. Based on the recommendations of the American Heart Association, we categorized overall CVH into 3 levels low: LE8 < 50, moderate: 50 ≤ LE8 < 80, and high: LE8 ≥ 80) [12]. The mean of each dietary component obtained from 2 nonconsecutive 24-hour dietary reviews at baseline was used to calculate the dietary scores. By using standardized questionnaires [11], we gathered data on tobacco/nicotine exposure (combustible tobacco use or exposure to secondhand smoke), hours of sleep, and self-reported minutes of physical activity per week. At the screening facility, measurements of weight, standing height, blood pressure, and blood glucose were made. The average of the available blood pressure readings (97% of participants had three readings) was used to estimate the systolic and diastolic blood pressure. By deducting HDL cholesterol from total cholesterol, non-HDL cholesterol was calculated. An enzymatic approach was used to measure the serum cholesterol. By means of high-performance liquid chromatography, glycated hemoglobin was determined. Total CVH scores range from 0 to 100.

Statistical analysis

To ensure nationally representative estimates, sampling weights were considered in all analyses to account for oversampling of certain subgroups and complex sample designs. The student's t-test (continuous variables) or chi-square test (categoric variables) were utilized to compare differences in baseline characteristics between three levels of CVH estimated by the LE8 score. Cox proportional hazards regression models were employed to examine the associations of combined and single CVH metric scores (low level as the reference) with all-cause and CVD-specific

mortality with adjustment for sex, age, race/ethnicity (Adjusted I Model), and full covariates (Adjusted II Model) (i.e., age, gender, race, PIR, education, CVD, and diabetes). When the association between each CVH metric and mortality was evaluated, this metric was excluded from adjustment. We evaluated the PH assumption of the Cox proportional hazards regression model via Schoenfeld residuals. The global test and individual covariate tests indicated no significant violations (global test $p = 0.73$; all individual covariate tests $p > 0.05$), confirming the model's validity. Restricted cubic spline models with three knots (10th, 50th, and 90th percentiles) were conducted to estimate the dose–response association of total CVH metric score with all-cause and CVD-specific mortality, with 50 points of CVH score as the reference. Kaplan-Meier survival curves were generated for the calculation of cumulative mortality using three score categories of CVH metrics (low, intermediate, high), compared using the log-rank test.

R (version 4.3.0) and Python (version 3.12.0) were used for all statistical methods. All statistical tests were two-sided, and $P < 0.05$ was deemed statistically significant.

Results

Basic characteristics

Table 1 (A, B) lists the characteristics and weighted population size of the sample. The participant flow diagram is

Table 1 Participants' baseline characteristics by various levels of CVH as estimated by the "LE8" score (Demographic and socioeconomic Factors)

Characteristic	Total cohort	Low (LE8 < 50)	Moderate (50≤ LE8 < 80)	High (LE8 ≥ 80)	*P* value
A					
Prevalence, % (weight N, in millions)	182	30.7	117.8	33.9	
No. of participants in sample	29,352	5960	19,019	4373	
AGE, y (SD)	46.34 (15.71)	51.49 (19.43)	46.60 (15.82)	40.77 (15.09)	< 0.001
Race and ethnicity, % (weighted N, in millions)					< 0.001
Mexican American	15.7 (8.6)	2.7 (8.8)	10.7 (9.1)	2.2 (6.7)	
Other Hispanic	10.2 (5.6)	1.5 (4.9)	6.7 (5.8)	1.9 (5.6)	
Non-Hispanic White	123.8 (67.9)	20.1 (65.6)	79.3 (67.3)	24.3 (72.0)	
Non-Hispanic Black	19.4 (10.6)	4.7 (15.4)	12.7 (10.8)	1.9 (5.7)	
Other Race	13.3 (7.3)	1.6 (5.3)	8.2 (7.0)	3.4 (10.0)	
Women, % (weight N, in millions)	91.3 (50.1)	14.5 (47.4)	56.5 (48.0)	20.19 (59.6)	< 0.001
Educational level, % (weighted N, in millions)					< 0.001
Less than high school	27.5 (15.1)	9.1 (31.7)	17.7 (15.0)	19.7 (5.8)	
High school	42.3 (23.2)	9.5 (33.2)	28.5 (24.2)	39.8 (11.8)	
Some college or above	112.5 (61.7)	10.1 (35.1)	71.5 (60.7)	27.9 (82.4)	
Family income, % (weighted N, in millions)					< 0.001
Low	34.9 (20.4)	9.1 (31.7)	21.7 (19.8)	4.0 (12.5)	
Intermediate	47.9 (28.0)	9.5 (33.2)	31.5 (28.6)	6.8 (21.4)	
High	88.2 (51.6)	10.1 (35.1)	56.8 (51.6)	21.2 (66.1)	
B					
Cardiovascular Disease, % (weighted N, in millions)	12.3 (6.7)	4.4 (14.4)	6.9 (5.9)	0.9 (2.7)	< 0.001
Diabetes, % (weighted N, in millions)	25.9 (14.2)	10.8 (35.4)	14.2 (12.1)	0.8 (2.6)	< 0.001
Cancer, % (weighted N, in millions)	16.4 (9.0)	3.1 (10.1)	11.1 (9.5)	2.2 (6.6)	< 0.001
Cardiovascular Disease Death, % (weighted N, in millions)	2.2 (1.2)	0.94 (3.1)	1.1 (1.0)	0.07 (0.2)	< 0.001
All-cause Death, % (weighted N, in millions)	10.3 (5.7)	3.5 (11.1)	6.1 (5.3)	0.61 (1.8)	< 0.001
AHA LE8 score (SD)					< 0.001
Mean DASH diet score	42.81 (32.12)	23.82 (25.34)	41.16 (30.77)	65.75 (28.59)	
Mean physical activity score	49.23 (46.09)	9.63 (26.23)	48.10 (45.41)	89.12 (25.01)	
Mean tobacco/nicotine exposure score	68.38 (37.40)	43.51 (38.61)	68.50 (36.82)	90.55 (20.35)	
Mean sleep health score	83.19 (24.35)	69.20 (30.56)	83.99 (23.14)	93.12 (14.34)	
Mean body mass index score	60.00 (33.85)	34.25 (29.91)	59.17 (32.32)	86.25 (20.76)	
Mean body lipid score	64.50 (30.87)	44.80 (29.83)	63.96 (29.59)	84.28 (23.10)	
Mean body glucose score	85.01 (24.42)	64.47 (30.31)	86.83 (22.27)	97.34 (10.38)	
Mean body pressure score	67.54 (31.20)	45.01 (29.59)	67.32 (30.08)	88.61 (19.87)	

Abbreviations: CVH Cardiovascular health

Data are mean (SE) or percentages (weighted N, millions, or hundred thousand). CVH was categorized into 3 levels (low: LE8 score < 50, moderate: 50 ≤ LE8 score < 80, high: LE8 score ≥ 80). CVH, cardiovascular health; LE8, Life's Essential 8; PIR, poverty income ratio; CVD, cardiovascular disease

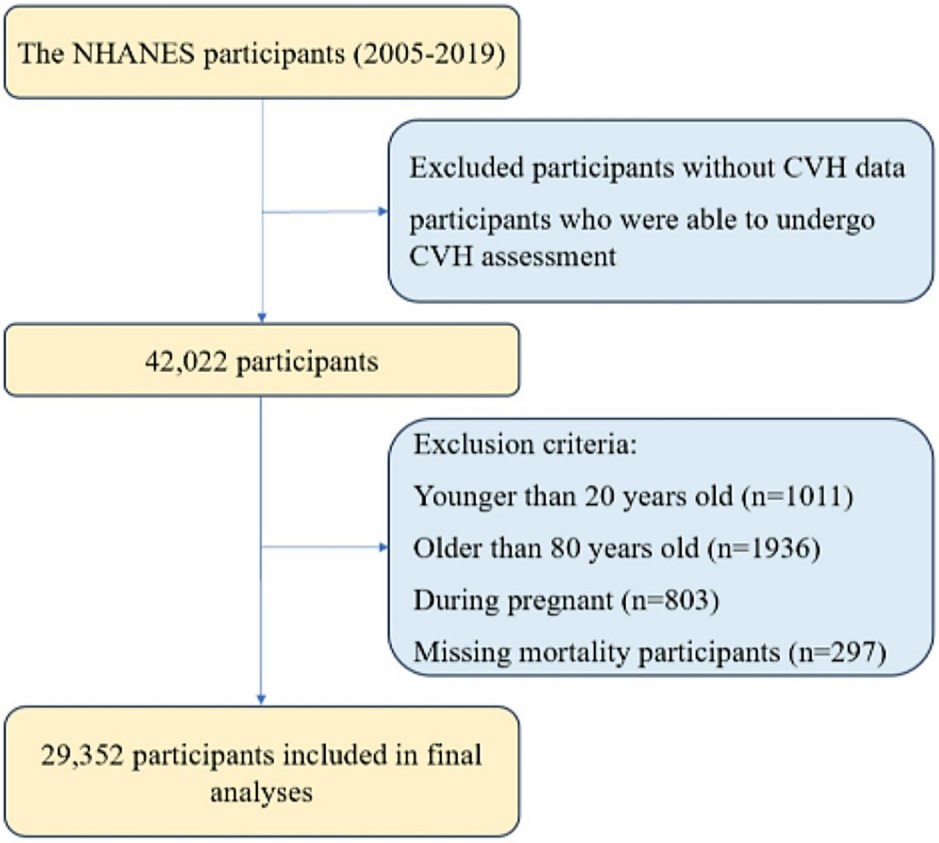


Fig. 1 Flowchart of patient selection

depicted in Fig. 1. There were 29,352 adults, representing 182 million U.S. adults. Table 1 (A, B) objectively lists the baseline characteristics, comorbidities, and Lifes'8 scores for this group. Based on guidance from previous studies, we categorized the LE8 scores into three hierarchical groups. Comparing the baseline data among the three groups, we found statistically significant differences ($P<0.05$) in all variables between levels. 5960 individuals (representing 30.7 million U.S. adults) had low LE8 scores (LE8 < 50), 19,019 adults had moderate LE8 scores (50 ≤ LE8 < 80), and 4373 adults had high LE8 scores (LE8 ≥ 80). Participants with high CVH at baseline were younger and more likely to have greater levels of family income. Those with high scores had a lower proportion of deaths than other groups, and those with high scores had the lowest proportion of all-cause and CVD deaths (Table 1A, B). Figure 2 shows distribution of CVH Scores Among Patients With and Without Cancer. We discovered several distinctions between the cancer and non-cancer groups. Physical activity, lipids, blood glucose levels, body mass index, blood pressure levels, and total CVH scores, for example, were lower in the non-cancer group than in the cancer group. The cancer group had higher dietary ratings, but nicotine exposure and sleep health did not differ substantially between cancer and non-cancer individuals. These findings may give some explanations for the disparities in LE8 scores between the two groups. Detailed baseline characteristics of cancer patients are summarized in Table S1 in the Supplementary Materials.

Association of the LE8 score and risk of all-cause mortality and CVD mortality in adults with and without cancer

A total of 10.3 million all-cause deaths were found to occur after weighting, of which 2.2 million were cardiac-caused deaths. Table 2 shows the results of regression models adjusted for different covariates to assess the association between individual LE8 score and the risk of CVD mortality and all-cause mortality (Table 2).

In the unadjusted model, we found that among adults without cancer, all eight metrics except the DASH diet were associated with the risk of CVD death. We found that the results for physical activity, nicotine exposure, diet, body mass index, body pressure, and CVH remained robust and statistically significant.

In Model II, the study found significant associations between various health metrics and the risk of cardiac cause of death and all-cause mortality among adults with and without cancer. Specifically, among adults with cancer, sleep fitness and cardiovascular fitness were the only metrics associated with the risk of cardiac cause of death, while

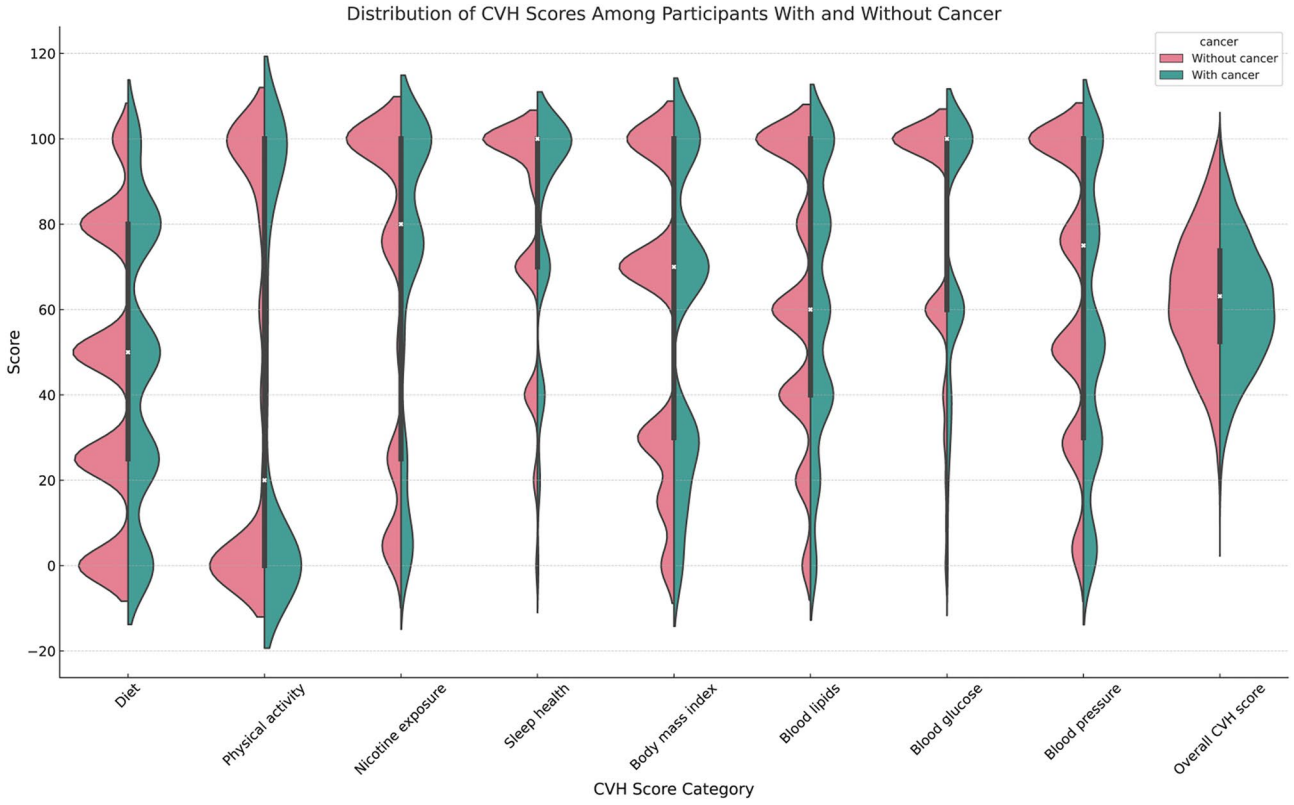


Fig. 2 Distribution of CVH scores among patients with and without cancer. Violin plots, which show both the distribution and density of the data. The width of each "violin" indicates the density of the data at that value, the black bar in the centre indicates the interquartile range, and the white dot indicates the median

physical activity, nicotine exposure, diet, sleep fitness, body mass index, and cardiovascular fitness were significantly associated with the risk of all-cause mortality. Among adults without cancer, physical activity, body mass index, nicotine exposure, diet, and CVH were associated with the risk of CVD death, and all eight metrics (excluding BMI) were associated with all-cause mortality. The study also revealed that adults without cancer with lower CVH scores had a higher risk of all-cause and CVD mortality.

Adults without cancer in the Moderate and High groups had significantly lower CVD and all-cause mortality rates compared to the Low group, with hazard ratios and 95% confidence intervals of 0.58 (0.47, 0.72) and 0.30 (0.16, 0.57) for CVD mortality, and 0.71 (0.64, 0.79) and 0.46 (0.35, 0.60) for all-cause mortality, respectively. In adults with cancer, higher CVH scores were still associated with a decreased risk of CVD and all-cause mortality. Implementing interventions to improve these health metrics in clinical practice may contribute to better outcomes and reduced mortality rates in both populations.

Results of the nonlinear relationship between mortality and CVH

Figure 3 shows a nonlinear connection between cardiac and all-cause mortality and CVH scores. Cancer patients with lower CVH scores had higher mortality rates. The relationship between CVH and cardiac mortality and all-cause mortality in both non-cancer and cancer populations showed a clear nonlinear trend, i.e., the lower the CVH score, the higher the cardiac mortality and all-cause mortality

Patients' survival status based on their cardiovascular health levels

We categorized patients' CVH scores into three groups: low, medium, and high, and plotted KM curves based on the CVH scores of adults without cancer (Fig. 4A) and adults with cancer (Fig. 4B) to compare the differences in all-cause mortality between the groups. The results of the research showed that patients in low CVH subgroup had worse survival and adults without cancer had shorter survival compared with the other groups (Fig. 4A). In the timeline, the survival time of patients in each group at any given time point was Idea Group (High) > Moderate > Low, and the results showed that as the level of CVH score decreased, the survival rate of patients decreased. In addition, in adults with cancer (Fig. 4B), the effects of the three CVH scores on all-cause mortality were consistent with the results in adults without cancer. Although the effects of CVH scores on mortality were consistent in

Table 2 CVD death and all-cause death HRs (95% CIs) in adults with and without cancer for various "LE8" groups

	Non-cancer participants			Cancer participants		
	Non-adjusted	**Adjusted I**	**Adjusted II**	**Non-adjusted**	**Adjusted I**	**Adjusted II**
CVD death						
DASH diet	0.98 (0.96, 1.02) 0.3188	0.93 (0.90, 0.96) < 0.0001	0.94 (0.91, 0.97) 0.0004	0.98 (0.91, 1.05) 0.5127	0.94 (0.87, 1.01) 0.0827	0.99 (0.91, 1.07) 0.7633
Physical activity	0.90 (0.87, 0.92) < 0.0001	0.92 (0.90, 0.95) < 0.0001	0.95 (0.92, 0.97) < 0.0001	0.90 (0.85, 0.96) 0.0012	0.90 (0.85, 0.96) 0.0010	0.95 (0.89, 1.01) 0.0847
Nicotine exposure	0.95 (0.93, 0.97) < 0.0001	0.92 (0.90, 0.94) < 0.0001	0.94 (0.92, 0.97) < 0.0001	0.95 (0.89, 1.01) 0.0843	0.88 (0.82, 0.94) 0.0004	0.93 (0.86, 1.01) 0.0714
Sleep health	0.94 (0.91, 0.97) 0.0003	0.94 (0.90, 0.97) 0.0002	0.97 (0.94, 1.01) 0.1271	0.91 (0.84, 0.99) 0.0210	0.87 (0.80, 0.95) 0.0010	0.91 (0.84, 1.00) 0.0413
Body mass index	0.92 (0.90, 0.95) < 0.0001	0.93 (0.90, 0.96) < 0.0001	0.96 (0.93, 0.99) 0.0069	0.97 (0.90, 1.04) 0.3415	0.96 (0.89, 1.03) 0.2371	1.02 (0.94, 1.11) 0.5630
Body lipid	0.97 (0.94, 1.00) 0.0248	0.99 (0.96, 1.03) 0.7293	0.99 (0.95, 1.02) 0.4255	1.05 (0.97, 1.13) 0.2582	1.03 (0.95, 1.12) 0.4834	1.02 (0.94, 1.11) 0.6403
Body glucose	0.82 (0.79, 0.84) < 0.0001	0.91 (0.88, 0.94) < 0.0001	0.97 (0.93, 1.02) 0.2583	0.84 (0.78, 0.91) < 0.0001	0.87 (0.80, 0.95) 0.0013	0.94 (0.84, 1.05) 0.2768
Body pressure	0.81 (0.78, 0.83) < 0.0001	0.94 (0.91, 0.97) 0.0003	0.96 (0.93, 0.99) 0.0212	0.86 (0.79, 0.92) < 0.0001	0.92 (0.85, 1.00) 0.0539	0.96 (0.88, 1.04) 0.2879
Cardiovascular health	0.61 (0.57, 0.65) < 0.0001	0.68 (0.64, 0.73) < 0.0001	0.77 (0.72, 0.84) < 0.0001	0.67 (0.57, 0.79) < 0.0001	0.63 (0.52, 0.75) < 0.0001	0.78 (0.63, 0.97) 0.0241
All-cause death						
DASH diet	1.00 (0.98, 1.01) 0.5924	0.94 (0.93, 0.95) < 0.0001	0.96 (0.95, 0.98) < 0.0001	0.95 (0.93, 0.98) 0.0017	0.92 (0.90, 0.95) < 0.0001	0.96 (0.93, 0.99) 0.0160
Physical activity	0.91 (0.90, 0.92) < 0.0001	0.94 (0.93, 0.95) < 0.0001	0.96 (0.95, 0.98) < 0.0001	0.92 (0.90, 0.94) < 0.0001	0.92 (0.90, 0.94) < 0.0001	0.95 (0.92, 0.97) < 0.0001
Nicotine exposure	0.93 (0.92, 0.94) < 0.0001	0.90 (0.89, 0.91) < 0.0001	0.92 (0.91, 0.93) < 0.0001	0.95 (0.92, 0.97) < 0.0001	0.90 (0.87, 0.92) < 0.0001	0.93 (0.91, 0.96) < 0.0001
Sleep health	0.95 (0.94, 0.97) < 0.0001	0.95 (0.93, 0.96) < 0.0001	0.98 (0.96, 1.00) 0.0149	0.93 (0.90, 0.97) < 0.0001	0.91 (0.88, 0.94) < 0.0001	0.94 (0.90, 0.97) 0.0003
Body mass index	0.97 (0.96, 0.99) 0.0001	0.99 (0.97, 1.00) 0.0665	1.01 (0.99, 1.03) 0.2302	1.01 (0.98, 1.03) 0.6882	1.00 (0.97, 1.03) 0.9081	1.04 (1.00, 1.07) 0.0257
Body lipid	0.99 (0.97, 1.00) 0.1506	1.03 (1.01, 1.04) 0.0017	1.02 (1.00, 1.04) 0.0263	1.03 (1.00, 1.06) 0.0747	1.02 (0.99, 1.05) 0.2409	1.02 (0.99, 1.06) 0.2255
Body glucose	0.84 (0.83, 0.85) < 0.0001	0.93 (0.91, 0.94) < 0.0001	0.97 (0.95, 1.00) 0.0194	0.93 (0.90, 0.96) < 0.0001	0.97 (0.94, 1.01) 0.1282	1.03 (0.99, 1.08) 0.1780
Body pressure	0.83 (0.82, 0.84) < 0.0001	0.96 (0.94, 0.97) < 0.0001	0.97 (0.96, 0.99) 0.0011	0.92 (0.90, 0.95) < 0.0001	0.99 (0.96, 1.02) 0.6307	1.00 (0.97, 1.04) 0.7963
Cardiovascular health	0.67 (0.65, 0.70) < 0.0001	0.75 (0.73, 0.78) < 0.0001	0.84 (0.81, 0.88) < 0.0001	0.76 (0.71, 0.82) < 0.0001	0.75 (0.70, 0.80) < 0.0001	0.86 (0.80, 0.94) 0.0004
CVD death (CVH Score)						
Low (LE8 < 50)	Ref	Ref	Ref	Ref	Ref	Ref
Moderate (50–79)	0.33 (0.27, 0.41) < 0.0001	0.44 (0.36, 0.54) < 0.0001	0.58 (0.47, 0.72) < 0.0001	0.41 (0.26, 0.66) 0.0002	0.37 (0.23, 0.60) < 0.0001	0.61 (0.35, 1.06) 0.0807
High (≥ 80)	0.08 (0.05, 0.15) < 0.0001	0.18 (0.10, 0.33) < 0.0001	0.30 (0.16, 0.57) 0.0002	0.06 (0.01, 0.47) 0.0069	0.06 (0.01, 0.45) 0.0060	0.16 (0.02, 1.22) 0.0767
All-cause death (CVH Score)						
Low (LE8 < 50)	Ref	Ref	Ref	Ref	Ref	Ref

Table 2 (continued)

	Non-cancer participants			Cancer participants		
	Non-adjusted	**Adjusted I**	**Adjusted II**	**Non-adjusted**	**Adjusted I**	**Adjusted II**
Moderate (50–79)	0.43 (0.39, 0.47) < 0.0001	0.55 (0.50, 0.61) < 0.0001	0.71 (0.64, 0.79) < 0.0001	0.56 (0.45, 0.68) < 0.0001	0.53 (0.43, 0.65) < 0.0001	0.73 (0.58, 0.92) 0.0073
High (≥ 80)	0.14 (0.11, 0.18) < 0.0001	0.29 (0.23, 0.37) < 0.0001	0.46 (0.35, 0.60) < 0.0001	0.35 (0.23, 0.52) < 0.0001	0.36 (0.23, 0.55) < 0.0001	0.75 (0.48, 1.18) 0.2106

Abbreviations: CVH Cardiovascular health; CVD Cardiovascular disease

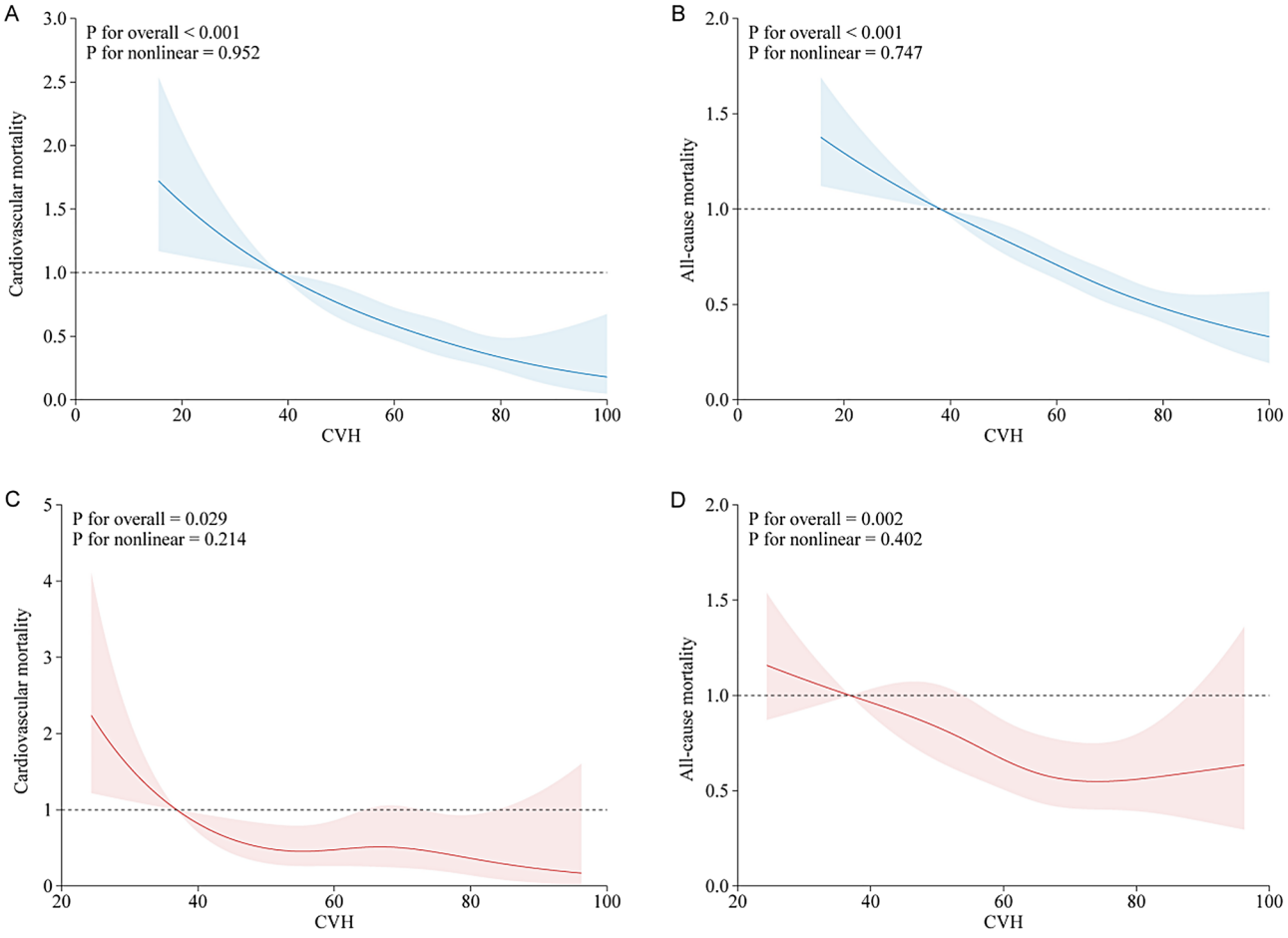


Fig. 3 Association between CVH levels estimated by the LE8 score and all-cause and cardiac cause mortality in a nationally representative sample of U.S. adults with and without cancer. **A B** represents the non-cancer population and **C D** represents the cancer population. Solid lines indicate the smoothing curves that best fit these variables. The background color indicates the fitted 95% confidence interval

both groups, adults with cancer patients with low CVH scores had significantly lower survival rates and significantly shorter survival periods compared with adults without cancer.

Discussion

To elucidate the relationship between CVH and risks of cardiovascular and all-cause mortality among participants with and without cancer, we conducted a cross-sectional analysis of 29,352 participants from the NHANES cohort. Our findings revealed an inverse association between CVH and the risks of both all-cause and cardiovascular mortality in adults, irrespective of their cancer status. Notably, this inverse relationship was more pronounced among participants with cancer. This underscores the heightened significance of optimizing the LE8 score and maintaining superior CVH in individuals with cancer compared to the general population to mitigate mortality risks.

In recent years, the concept of CVH has gained increasing attention as a comprehensive approach to promoting overall health and reducing the burden of CVD [13]. In

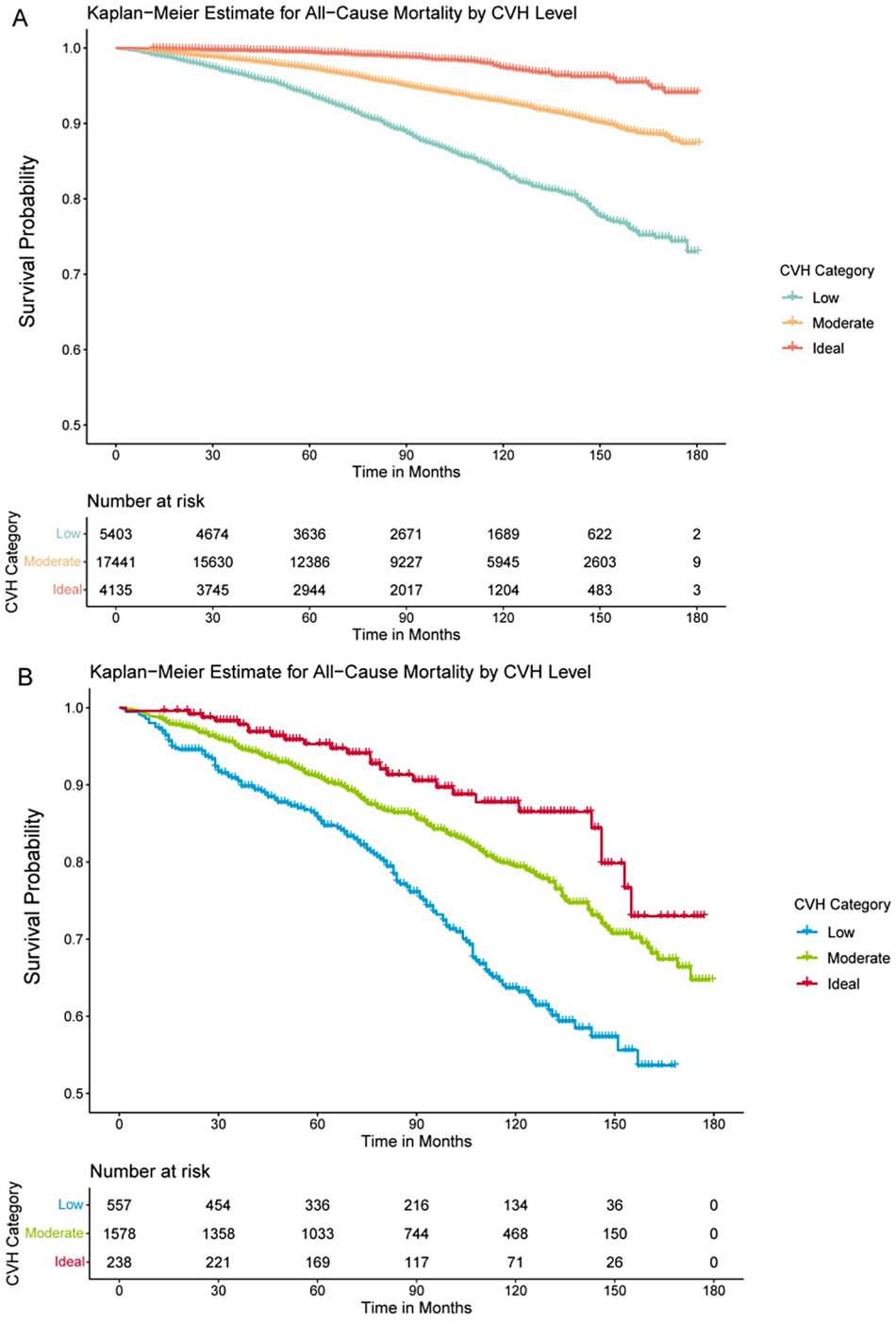


Fig. 4 Kaplan–Meier survival curves demonstrating differences in all-cause mortality by CVH level. **A** represents the non-cancer population and **B** represents the cancer population

this research, we explored the relationship between CVH and prognosis in adults with and without cancer, emphasizing the potential benefits of maintaining good CVH for both cancer and non-cancer populations. "The LE8" score includes eight components of CVH that provide a comprehensive framework for assessing and monitoring CVH.

The key variables involved in the "LE8" score affect prognosis in cancer populations was confirmed in our study. A large cohort study enrolling 710,000 patients found that 18% of patients with cancer had concomitant CVD risk factors or had CVD. The most common risk factor was hypertension (10.8%), followed by dyslipidemia (1.2%) and diabetes (5.3%). The cardiovascular

diseases with the highest prevalence were coronary heart disease (1.7%), stroke (2.7%), and heart failure (0.6%). After adjusting for covariates, patients with malignancies and heart failure had the poorest prognosis, with a 79% rise in all-cause mortality, followed by myocardial infarction, which had a 50% increase in all-cause mortality [14].

Participants with low CVH (LE8 score 50) had a life expectancy of 27.3 years (95% CI, 26.1–28.4), those with intermediate CVH (50 LE8 score 80) had a life expectancy of 32.9 years (95% CI, 32.3–33.4), and those with high CVH (LE8 score 80) had a life expectancy of 36.2 years (95% CI, 34.2–38.2). Participants with greater CVH had 8.9 (95% CI, 6.2–11.5) more years of life expectancy at age 50 compared to those with lower CVH [12]. Jiahong Sun et al.'s prospective cohort research corroborated similar findings. Adults with moderate or high total CVH scores had a 40% (HR 0.60, 95% CI 0.51–0.71) and 58% (HR 0.42, 95% CI 0.32–0.56) lower risk of all-cause death compared to those with low total CVH scores [15].

Unlike previous studies, we conducted further validation in patients from the cancer population. Cancer treatment itself may burden the cardiovascular system. For example, chemotherapeutic agents and radiotherapy may have direct or indirect adverse effects on cardiovascular function, including cardiotoxicity, atherosclerosis, and thrombosis. In addition, tumors may also adversely affect the cardiovascular system through mechanisms that contribute to inflammatory responses in the body, platelet activation and impairment of vascular endothelial function [15]. The strong link between CVH and cancer highlights the fact that cancer treatment often involves chemotherapy, radiotherapy, and surgery, all of which have an impact on the cardiovascular system. The treatment of malignant tumors has entered the "era of precision medicine". Novel targeted drugs, capable of specifically killing tumor cells while minimizing damage to normal tissues, are becoming more widely used. However, these drugs will inevitably cause damage to the heart [16]. For example, trastuzumab, bevacizumab, apatinib, etc., will lead to increased blood pressure and decreased cardiac function. For breast cancer, prostate cancer, etc., hormonal drugs such as tamoxifen, letrozole, exemestane, etc., may affect the blood lipids and blood pressure of tumor patients, and then induce atherosclerosis and other diseases [17–20].

Food choices in tumor patients do correlate with disease progression [21]. A sensible and healthy diet rich in fruits and vegetables, grains, etc. can reduce the overall mortality rate of patients with breast cancer by 43% compared to regular consumption of refined grains, red and processed meats, high-fat and fried foods [22]. By reducing cardiovascular risk factors and maintaining a healthy cardiovascular status, the risk of cardiac complications during treatment can be minimized and the ability of patients to tolerate treatment can be improved. Additionally, strong CVH promotes immune system performance and the body's capacity to fight cancer, thereby improving patient prognosis. Ideal CVH is negatively associated with cancer incidence and mortality [23]. There is a nonlinear relationship between CVH and the risk of cardiovascular and all-cause mortality in adults with and without cancer. The lower the CVH score, the higher the mortality rate. The findings suggest that maintaining good CVH is essential for reducing the risk of mortality.

Several limitations of our study need to be considered. First, the study design was observational and therefore causality could not be inferred. Second, the study relied on self-reported data and did not account for variation in the level of measurement, which may introduce reporting bias. Our study may have error in targeting the smoking population because we calculated this score without information on e-cigarettes, as this information was not available until after 2013, which would lead to error in this score with respect to smoking. Third, the study focused on adults and the findings may not be applicable to other age groups and other populations. The generalizability of our results to populations outside the U.S. may be limited due to differences in healthcare systems, cultural factors, dietary patterns, and prevalence of cardiovascular risk factors. Fourth, the analysis of CVD mortality did not account for competing risks, particularly cancer-related deaths, which are a substantial competing event in this population. Standard Cox proportional hazards models treat non-CVD deaths as non-informative censoring, which may introduce bias in the estimation of CVD mortality risk. Future studies should incorporate competing risks analyses to better address this issue and enhance the clinical relevance of the findings.

Future studies should continue to explore the relationship between CVH and cancer prevention and prognosis in different populations. Longitudinal studies with extended follow-up may provide further insight into temporal trends and long-term effects of CVH on cancer prognosis. In addition, interventions aimed at improving CVH should be developed and tested to determine their effectiveness in reducing cancer risk and improving cancer prognosis. Our study emphasizes the importance of maintaining good CVH for cancer prevention and prognosis. By promoting CVH and adopting appropriate health behaviors and factors, individuals can reduce their risk of developing certain cancers and improve their prognosis after a cancer diagnosis. While our findings highlight the importance of CVH in reducing mortality risks among U.S. adults, further research is needed to confirm the external validity of these results in non-U.S. populations and across different age groups. Such efforts would strengthen the evidence base for the LE8 score as a global tool for promoting cardiovascular health

and improving outcomes in both cancer and non-cancer populations. Future research should aim to validate the LE8 score and its association with mortality in diverse international populations to better understand its global applicability. Assessing and improving CVH should be incorporated into routine medical screening and interventions. Healthcare professionals can promote healthy behaviors and factors, such as encouraging a nutritious diet, regular physical activity, smoking cessation, and adequate sleep, to improve CVH. Maintaining optimal levels of blood glucose, lipids and blood pressure through appropriate medical management can further improve CVH.

Conclusion

In both cancer patients and those without cancer, cardiovascular health (CVH) scores show an inverse association with the risk of all-cause and cardiovascular disease mortality. It is particularly important for people with cancer to maintain an optimal lifestyle and maintain CVH to reduce the risk of death.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-14464-7.

Supplementary Material 1

Author contributions

Shixuan Peng, Qisheng Chen and Qianzi Liu were in charge of the research's overall execution and manuscript writing, while Ruijie Xie was in charge of analyzing the data. Yongjun Wu played a significant role in the manuscript revision, providing expertise to address reviewer feedback and improve the manuscript.

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Data availability

The datasets generated and/or analysed during the current study are available in the NHANES repository, (https://www.cdc.gov/nchs/nhanes). The study protocol was approved by the Institutional Review Board of the National Center for Health Statistics, and informed consent was submitted by each participant. All guidelines on data and analytical methods are available from the National Center for Health Statistics of the United States Centers for Disease Control and Prevention (https://www.cdc.gov/nchs/nhanes/index.htm). The National Health and Nutrition Examination Survey (NHANES) is a nationally representative cross-sectional survey that evaluates the health and nutritional status of adults and children in the United States. We used data associated all-cause and heart-cause mortality files for adults with and without cancer to correlate participant death records. Data from the NHANES Associated Mortality Files encompassed 7 cycles from 2005 to 2018, covering a total of more than 30,000 participants aged 20 to 79 years, and provided usable mortality records. In the sample, 29,352 participants who were eligible to participate in the study were included in the analyses, and effects of pregnant women, minors, and missing values on individual components were excluded.

Declarations

Human ethics and consent to participate declarations

The National Health and Nutrition Examination Survey (NHANES) was approved by the National Center for Health Statistics Research Ethics Review Board, and consent from all participants was documented. All methods were performed in accordance with the relevant guidelines and regulations of NHANES.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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