Social Risk Profile, Planetary Health Diet, and Mortality Risk in Individuals with Metabolic Dysfunction–Associated Steatotic Liver Disease: A Population-Based Study

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ABSTRACT

Background/Aims: *The individual and combined associations of social vulnerability and diet quality with long-term health outcomes in metabolic dysfunction–associated steatotic liver disease (MASLD) remain unclear. The authors aimed to examine the independent and cumulative associations of diet quality and social vulnerability with all-cause and cardiovascular disease (CVD) mortality among US adults with MASLD.*

Materials and Methods: *The authors included 13 518 adults with MASLD from the 1999-2018 National Health and Nutrition Examination Survey, with mortality follow-up through 2019. Diet quality was assessed using the planetary health diet index (PHDI) based on 24-hour dietary recalls. Social vulnerability was evaluated using a composite social risk profile (SRP) score. Cox proportional hazards models were used to derive hazard ratios (HRs) with 95% CIs.*

Results: *Over a median follow-up of 104 months, 1875 deaths, including 643 from CVD, were recorded. Lower PHDI and SRP scores were each associated with significantly higher risks of all-cause and CVD mortality (all P < .05). In the joint analysis, participants with both the lowest PHDI tertile and an SRP score of 0-2 had the highest hazards for all-cause (HR = 3.86, 95% CI: 2.86-5.20) and CVD mortality (HR = 4.94, 95% CI: 2.97-8.20) compared with those with the highest PHDI tertile and an SRP score of 6-8. Subgroup analysis revealed that the associations of SRP score and PHDI with all-cause mortality were stronger among adults younger than 65 years (P for interaction < .001).*

Conclusion: *Poor diet quality and social disadvantage were independently and jointly associated with increased mortality risk among US adults with MASLD, particularly those younger than 65 years.*

Keywords: *Cardiovascular diseases, diet quality, metabolic dysfunction–associated steatotic liver disease, mortality, social deprivation*

INTRODUCTION

Metabolic dysfunction–associated steatotic liver disease (MASLD) is defined by the presence of hepatic steatosis in individuals with at least 1 cardiometabolic risk factor and in the absence of other causes of steatosis.[1]Epidemiological data indicate that MASLD affects 38% of the global population, 36.91% of Asian adults, and 27.7% of US adults.[2-4] Although most individuals with MASLD do not develop advanced liver disease, the condition is associated with a substantially increased risk of cardiovascular disease (CVD) mortality. Several factors associated with mortality in MASLD have been identified, including advanced age, a family history of premature CVD mortality, smoking, elevated low-density lipoprotein cholesterol levels, sedentary behavior, obesity, diabetes, and hypertension.[5]

Given that diet is a potentially modifiable lifestyle factor, there has been growing interest in how healthy eating patterns influence long-term outcomes in MASLD. For instance, previous research has indicated that a diet with a high dietary inflammatory index is associated with increased mortality risk,[6] whereas adherence to a Korean Mediterranean-style diet or a gut microbiota-promoting diet is associated with lower mortality risk in individuals with MASLD.[7,8]Nevertheless, evidence regarding the association between adherence to the planetary health diet (PHD) and mortality risk among individuals with MASLD remains limited.

The EAT–Lancet Commission introduced the PHD in 2019 as a dietary pattern designed to promote mutually

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beneficial outcomes for human health and environmental sustainability.[9] The PHD is assessed using the PHD index (PHDI), with higher scores reflecting lower consumption of meat and dairy products and greater consumption of vegetables, fruits, nuts, and legumes. Adherence to the PHD pattern has been consistently associated with a lower risk of various chronic diseases, such as respiratory diseases and cardiovascular diseases.[10,11] More importantly, most previous studies have suggested that adherence to the PHD pattern is associated with lower all-cause, CVD, and cancer mortality in both the general population and specific populations, including individuals with chronic kidney disease, depression, or a history of cancer and Black women.[12-16] However, some studies have reported contradictory findings. For instance, no significant associations between PHD adherence and cancer or CVD incidence and mortality have been reported.[17] These inconsistencies may limit the broader adoption of the PHD and highlight the need for further research into the association between PHD adherence and mortality risk in individuals with MASLD.

Social risk profile (SRP) is a multidimensional measure of an individual's cumulative social disadvantage that extends beyond socioeconomic status. It is recognized as a key determinant of health outcomes through its effects on healthcare access, educational opportunities, diet quality, physical activity, and other adaptive resources. For example, a recent cross-sectional study found an inverse association between family income and the prevalence of MASLD and liver fibrosis.[18] A study by Dansero et al[19] showed that lower socioeconomic status could amplify the risk of cancer mortality associated with MASLD. In contrast, a Swedish nationwide study reported that socioeconomic factors such as educational attainment and relationship status were significantly associated with major adverse liver outcomes in MASLD in unadjusted analyses; however, these associations were no longer significant after adjustment for confounders.[20] Furthermore, SRP also plays a crucial role in shaping dietary habits, because individuals with lower incomes tend to consume greater amounts of energy-dense, nutrient-poor foods and fewer fresh fruits and vegetables. Therefore, further studies are needed to investigate the association between SRP and outcomes in MASLD.

To the authors' knowledge, the interplay among adherence to the PHD, SRP, and mortality risk among patients with MASLD has not been investigated. To address this gap, the current study used nationally representative data to assess the associations of PHDI and SRP with all-cause and CVD mortality among US adults with MASLD.

Main Points

- *Poor diet quality is independently associated with increased risks of all-cause and cardiovascular mortality among patients with metabolic dysfunction–associated steatotic liver disease (MASLD).*
- *Social disadvantage is independently associated with increased risks of all-cause and cardiovascular mortality among patients with MASLD.*
- *Low diet quality and high social disadvantage were cumulatively associated with increased mortality risk.*
- *The associations of poor diet quality and social disadvantage with all-cause mortality were more pronounced among individuals younger than 65 years.*

MATERIALS AND METHODS

Data Source and Subjects

The data analyzed in the present retrospective cohort study were pooled from 10 discrete 2-year cycles (1999-2000 to 2017-2018) of the National Health and Nutrition Examination Survey (NHANES), an ongoing, nationwide, cross-sectional survey that collects data on the health status of the US population. All participants provided written informed consent, and the study protocol was approved by the National Center for Health Statistics Ethics Review Board. Because NHANES is a publicly available, deidentified database, this analysis was exempt from further ethical review and did not require additional informed consent. This study did not use AI and/or LLM tools in the preparation of this manuscript.

The authors initially included 18 619 adults aged ≥20 with MASLD. Participants were excluded if they had no 24-hour dietary assessment (n = 688), missing SRP data (n = 2403), unknown death status (n = 9), missing covariate data (n = 672), or implausible dietary energy intake (n = 879). Implausible energy intake was defined using sex-specific cutoffs: <800 or >4200 kcal/day for men and <600 or >3500 kcal/day for women.[21] Figure 1 illustrates the participant inclusion and exclusion process.

Diagnosis of Metabolic Dysfunction–Associated Steatotic Liver Disease

Operationally, MASLD was defined by the presence of hepatic steatosis and at least 1 cardiometabolic risk factor after exclusion of alternative causes, such as autoimmune hepatitis, viral hepatitis, or alcohol-associated liver disease. Alcohol consumption was defined as more than 2 standard drinks per day for men and more than 1

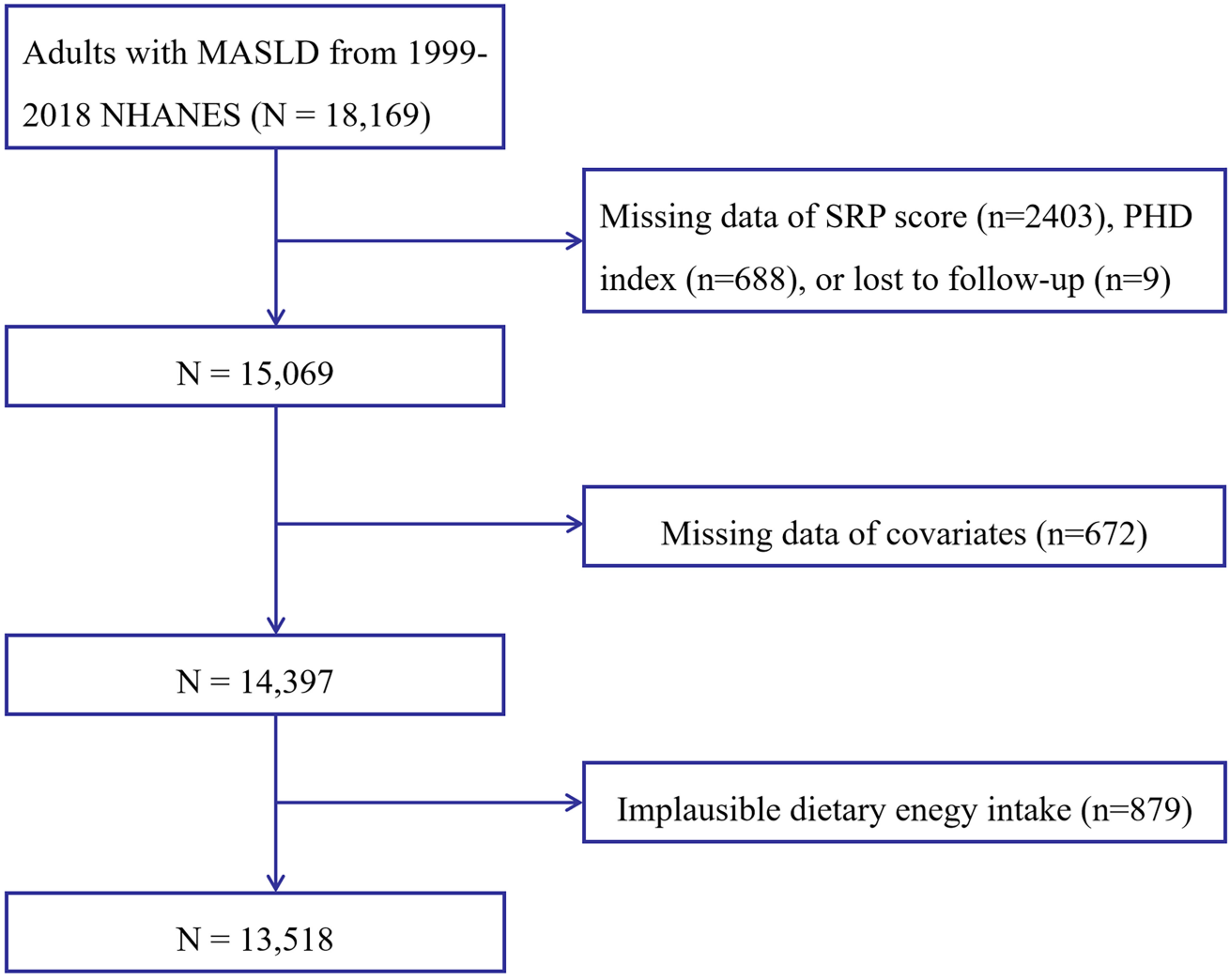

Figure 1. Selection of participants with MASLD from the 1999-2018 NHANES. MASLD, metabolic dysfunction–associated steatotic liver disease; NHANES, National Health and Nutrition Examination Survey; PHD, planetary health diet; SRP, social risk profile.

standard drink per day for women. Cardiometabolic risk factors included hypertension, prediabetes or diabetes, dyslipidemia, and overweight or obesity and were defined as follows:[22]

(1) Hypertension: self-reported diagnosis, current use of antihypertensive drugs, or an observed blood pressure of 130/85 mmHg or higher; (2) prediabetes or diabetes: self-reported history, use of glucose-lowering medications, fasting glucose level of ≥5.6 mmol/L, 2-hour post-challenge glucose level of ≥7.8 mmol/L, or HbA1c level of ≥5.7%; (3) dyslipidemia: total cholesterol level of ≥200 mg/dL, high-density lipoprotein cholesterol level of <40 mg/dL (men) or <50 mg/dL (women), low-density lipoprotein cholesterol level of ≥130 mg/dL, or current use of lipid-lowering therapy; or (4) overweight or obesity: body mass index (BMI) ≥23 kg/m^2 for Asian individuals or ≥25 kg/m^2 for non-Asian individuals or waist circumference of >94 cm for non-Asian men, >90 cm for Asian men, or >80 cm for women.

Because liver ultrasound and vibration-controlled transient elastography were not available for the 1999-2016 NHANES cycles, the authors used the fatty liver index (FLI) to identify liver steatosis. The FLI is a composite measure based on waist circumference, triglyceride level, BMI, and gamma-glutamyl transferase.[23] Based on previous validation studies, an FLI value of 60 or higher was

considered indicative of liver steatosis; this cutoff has demonstrated good to substantial agreement with imaging-defined steatosis.[23]

Assessment of Planetary Health Diet Adherence

The PHDI was derived from dietary intake data collected through 24-hour dietary recalls. For the 1999-2002 NHANES cycles, only 1 24-hour dietary recall was available; for the 2003-2018 cycles, the first and second 24-hour recalls were averaged to account for intraindividual variation. As described previously,[24] the PHDI comprised 14 food groups, including 6 adequacy components and 8 moderation components. Individual components were scored from 0 to 10, giving a maximum aggregate score of 140. For adequacy components, higher intakes were favored, with intakes at or above the recommended maximum threshold receiving the full 10 points. Conversely, for moderation components, lower intakes were favored, with consumption at or near zero receiving the maximum 10 points. After determining daily intake (in grams) of the various food and nutrient categories, the PHDI was calculated using the validated Dietaryindex R package.[25] Detailed scoring procedures are provided in Supplementary Table 1.

Social Risk Profile Characterization

Based on the Healthy People 2030 framework, the SRP score was derived from 8 indicators across 5 domains: (1) social and community context, reflected by marital status; (2) neighborhood and built environment, indicated by home ownership; (3) healthcare access and quality, assessed by access to medical care and type of health insurance coverage (private vs government); (4) education access and quality, measured by the highest level of education completed; and (5) economic stability, assessed by employment status, food security, and the poverty–income ratio. Each of the 8 indicators was dichotomized and assigned a score of 0 for an unfavorable SRP (i.e., social disadvantage present) and 1 for a favorable SRP (i.e., no social disadvantage). The total SRP score ranged from 0 to 8, with higher scores indicating less social disadvantage. This SRP construct has been previously validated for use with NHANES data and has been applied in epidemiological studies.[26] Detailed scoring algorithms are provided in Supplementary Table 2.

Covariates

The following variables were selected a priori as covariates: demographic characteristics (age, sex, and race/ethnicity); lifestyle factors (smoking, alcohol intake, physical activity, and BMI); medical comorbidities (history of cancer, CVD, diabetes, and hypertension); laboratory measurements (alanine transferase, aspartate transferase, glycated hemoglobin A1c, and high-density lipoprotein cholesterol); and total energy intake. Race/ethnicity was self-reported and categorized as non-Hispanic White, non-Hispanic Black, and other racial/ethnic groups (including Hispanic, other races, and multiracial). Smoking status was classified into 3 groups: never (fewer than 100 cigarettes smoked during the lifetime), former (at least 100 cigarettes smoked but none during the preceding month), and current (100 or more cigarettes smoked and currently smoking). Alcohol consumption was similarly categorized as never (fewer than 12 alcoholic drinks consumed during the lifetime), former (12 or more drinks consumed but none during the preceding year), and current (12 or more drinks and currently consuming alcohol). Moderate- and vigorous-intensity physical activity were defined as activities performed during a typical workweek for more than consecutive minutes that require moderate effort (causing a slight increase in respiration and pulse) or vigorous effort (causing a substantial increase), respectively. Hypertension and diabetes were defined according to the cardiometabolic risk factor criteria for MASLD. CVD was defined as a self-reported history of coronary artery disease, angina pectoris, congestive heart failure, heart attack, or stroke.

Mortality Assessment

The primary outcome was all-cause mortality, with CVD mortality serving as the secondary outcome. Mortality data were obtained by linking NHANES participants to the National Death Index, with follow-up through December 31, 2019. CVD deaths were identified using International Classification of Diseases, Tenth Revision (ICD-10) codes I00-I09, I11, I13, and I20-I51. For each participant, the observation period began at the Mobile Examination Center visit and continued until death or December 31, 2019, whichever occurred first.

Statistical Analysis

All statistical analyses accounted for the complex, multistage probability sampling design of NHANES by incorporating survey weights, stratification, and primary sampling units to generate nationally representative estimates. Participants were divided into 3 groups according to PHDI tertiles. Group comparisons were performed using the Rao–Scott chi-square test for categorical variables and the survey-weighted Wald test for continuous variables. Multivariable Cox proportional hazards models were used to estimate hazard ratios (HRs) and 95% CIs

for the associations of PHDI and SRP score with all-cause and CVD mortality. Schoenfeld residuals indicated that the proportional hazards assumption was satisfied. Three hierarchical Cox proportional hazards models were specified. The first model was crude (unadjusted). Model 1 was adjustment for demographic and lifestyle characteristics. Model 2 included all variables from Model 1, in addition to medical comorbidities, laboratory measurements, and total energy intake. Linear trends across tertiles were assessed using Cox proportional hazards models that incorporated the median value of each tertile as a continuous ordinal variable. To examine dose–response associations, restricted cubic spline curves were used, with knot locations determined according to the Akaike information criterion. Stratified analyses were conducted to assess whether the associations varied by age, sex, race/ethnicity, BMI, diabetes, hypertension, smoking status, and alcohol consumption. Several sensitivity analyses were also performed to assess the robustness of the findings. These included: (1) removing participants who died during the first 24 months of follow-up to limit reverse causation; (2) excluding participants with preexisting CVD; and (3) multiple imputation by chained equations for the 672 participants with missing covariate data. The Benjamini–Hochberg procedure was applied to control the false discovery rate at 0.05 for multiple comparisons. A 2-sided *P* value < .05 was considered statistically significant.

RESULTS

Participant Characteristics

Table 1 summarizes the baseline characteristics of the 13 518 included participants. The mean age was 50.24 years, 51.90% were male, and the mean SRP score was 5.47. Compared with participants in the lowest PHDI tertile, those in the highest tertile were significantly older, had a lower BMI, and included a higher proportion of women and non-Hispanic White participants. They also had a higher proportion of never-smokers and participants reporting no physical activity. In addition, this group had significantly higher prevalences of hypertension, diabetes, CVD, and cancer, as well as higher high-density lipoprotein cholesterol levels, lower alanine transferase levels, and lower dietary energy intake.

Planetary Health Diet Index, Social Risk Profile Score, and Mortality Risk

After a median observation period of 104 months (interquartile range 55-154), 1875 deaths (10.45% of the weighted population) were recorded, of which 643 were attributable to CVD. As shown in Table 2, higher PHDI and SRP scores were each associated with lower risks of all-cause and CVD mortality, when analyzed as either continuous or categorical variables across the crude model, Model 1, and the fully adjusted Model 2. Compared with the highest PHDI tertile, the HRs (95% CIs) for the medium and low tertiles were 1.26 (1.09-1.47) and 1.72 (1.47-2.01), respectively, for all-cause mortality, and 1.38 (1.07-1.77) and 2.03 (1.57-2.63), respectively, for CVD mortality. Similarly, compared with an SRP score 6-8, scores of 3-5 and 0-2 were associated with HRs (95% CIs) of 1.46 (1.28-1.66) and 2.60 (2.12-3.19), respectively, for all-cause mortality, and 1.29 (1.01-1.64) and 2.38 (1.66-3.41), respectively, for CVD mortality. Restricted cubic spline curves further demonstrated an inverse, dose–response association of PHDI and SRP score with the risks of all-cause and CVD mortality (Figure 2).

Joint Analysis

In joint analyses (Table 3), compared with the reference group (highest PHDI tertile and SRP 6-8), all other combinations of lower PHDI tertiles or SRP scores were associated with progressively higher risks of all-cause and CVD mortality. The highest risks were observed among participants in the lowest PHDI tertile combined with an SRP score of 0-2 (all-cause mortality: HR = 3.86, 95% CI = 2.86-5.20; CVD mortality: HR = 4.94, 95% CI = 2.97-8.20).

Subgroup Analysis

In subgroup analyses (Supplementary Tables 3 and 4), the combined associations of a lower SRP score and lower PHDI scores with all-cause mortality were significantly stronger among participants aged <65 years than among those aged ≥65 years (*P* for interaction <.001). No significant interactions were observed for all-cause or CVD mortality when analysis were stratified by sex, race/ethnicity, BMI, diabetes, hypertension, or smoking or alcohol consumption status (all interaction *P* values >.05).

Sensitivity Analysis

Supplementary Tables 5–7 present the results of 3 sensitivity analyses. Across all analyses, lower PHDI and lower SRP scores were associated with higher risks of all-cause and CVD mortality. The combination of the lowest PHDI tertile and an SRP score of 0-2 was associated with the highest HRs for both mortality outcomes.

DISCUSSION

Among community-dwelling adults with MASLD followed for a median of 104 months, the authors identified several

Table 1. Comparison of Baseline Characteristics Among 13 518 US Adults with Metabolic Dysfunction–Associated Steatotic Liver Disease Stratified by the Tertiles of the Planetary Health Diet Index

		PHDI Tertile			
Characteristics	Total (N = 13 518)	Lowest Tertile	Medium Tertile	Highest Tertile	*P*
SRP score, mean ± SEM	5.47 ± 0.03	5.04 ± 0.05	5.51 ± 0.05	5.81 ± 0.04	<.001
SRP score categories, n (%)					<.001
0-2	1828 (9.13)	754 (12.77)	608 (8.43)	466 (6.42)	—
3-5	5975 (36.08)	2166 (41.57)	1996 (35.74)	1813 (31.25)	—
6-8	5715 (54.79)	1586 (45.66)	1902 (55.83)	2227 (62.33)	—
Age, years, mean ± SEM	50.24 ± 0.25	47.02 ± 0.30	50.30 ± 0.40	53.19 ± 0.28	<.001
Sex, n (%)					<.001
Male	6907 (51.90)	2558 (57.48)	2254 (51.04)	2095 (47.52)	—
Female	6611 (48.10)	1948 (42.52)	2252 (48.96)	2411 (52.48)	—
Race/ethnicity, n (%)					<.001
Non-Hispanic White	6143 (69.68)	1965 (65.81)	2059 (70.18)	2119 (72.82)	—
Non-Hispanic Black	2634 (10.12)	1057 (12.94)	862 (9.91)	715 (7.69)	—
Other	4741 (20.20)	1484 (21.25)	1585 (19.91)	1672 (19.49)	—
Smoking, n (%)					<.001
Never	7135 (52.86)	2168 (48.79)	2432 (54.58)	2535 (54.97)	—
Former	3983 (29.40)	1245 (26.66)	1305 (28.40)	1433 (32.96)	—
Current	2400 (17.74)	1093 (24.55)	769 (17.02)	538 (12.07)	—
Drinking, n (%)					.05
Never	1966 (11.99)	569 (10.49)	696 (12.59)	701 (12.81)	—
Former	3317 (21.75)	1102 (22.72)	1111 (21.73)	1104 (20.87)	—
Current	8235 (66.26)	2835 (66.79)	2699 (65.68)	2701 (66.32)	—
Physical activity, n (%)					<.001
No	5319 (35.49)	1629 (32.75)	1740 (33.94)	1950 (39.59)	—
Moderate	5278 (40.26)	1803 (40.66)	1785 (40.52)	1690 (39.62)	—
Vigorous	2921 (24.25)	1074 (26.59)	981 (25.54)	866 (20.79)	—
Hypertension, n (%)	7410 (50.92)	2368 (48.86)	2452 (50.24)	2590 (53.52)	.005
Cardiovascular disease, n (%)	1963 (12.03)	648 (12.34)	608 (10.75)	707 (12.94)	.04
Diabetes, n (%)	3813 (22.80)	1132 (20.50)	1298 (22.96)	1383 (24.79)	<.001
Cancer, n (%)	1409 (10.65)	398 (8.19)	494 (11.61)	517 (12.02)	<.001
Body mass index, kg/m^2, mean ± SEM	34.16 ± 0.09	34.50 ± 0.13	34.18 ± 0.13	33.81 ± 0.13	<.001
HbA1c, %, mean ± SEM	5.86 ± 0.01	5.84 ± 0.02	5.86 ± 0.02	5.88 ± 0.02	.31
Alanine transferase, IU/L, mean ± SEM	29.08 ± 0.28	30.57 ± 0.73	29.07 ± 0.37	27.68 ± 0.34	<.001
Aspartate transferase, IU/L, mean ± SEM	25.66 ± 0.14	25.77 ± 0.29	25.93 ± 0.28	25.30 ± 0.23	.19
HDL-c, mg/dL, mean ± SEM	45.67 ± 0.15	44.18±0.23	45.57 ± 0.23	47.15 ± 0.30	<.001
Energy intake, kcal/d, mean ± SEM	2079.75 ± 10.53	2156.53 ± 17.78	2052.49 ± 15.07	2034.48 ± 16.99	<.001
All-cause mortality, n (%)	1875 (10.45)	713 (12.25)	630 (10.40)	532 (8.82)	<.001
Cardiovascular mortality, n (%)	643 (3.46)	263 (4.30)	213 (3.47)	167 (2.67)	.001

Data are presented as means ± SEM for continuous variables and counts (weighted percentages) for categorical variables. Continuous and categorical variables were compared using survey-weighted linear regression and Rao–Scott chi-squared test, respectively.
HDL-c, high-density lipoprotein cholesterol; PHDI, planetary health diet index; SEM, standard error of the mean; SRP, social risk profile.

key observations. First, greater adherence to the PHD and lower levels of social disadvantage were associated with lower risks of all-cause mortality and CVD mortality. Second, poor diet quality and greater social disadvantage were cumulatively associated with increased mortality risk. Third, the associations of PHDI and SRP scores with all-cause mortality were stronger among participants aged <65 years than among older adults. The main findings were further supported by a series of sensitivity analyses. Taken together, these findings suggest that poor diet quality and social disadvantage are independently and jointly associated with increased mortality risk among US adults with MASLD, particularly in nonelderly adults.

To the best of the authors' understanding, no previous study has evaluated the association between PHDI and mortality risk among individuals with MASLD. The observed inverse associations between PHD adherence and all-cause and CVD mortality are consistent with previous evidence suggesting that this dietary pattern is associated with lower risks of various noncommunicable illnesses.[27]A previous meta-analysis of 28 publications

Table 2. Associations of Planetary Health Diet Index, Social Risk Profile Score, and Risks of All-Cause and Cardiovascular Disease Mortality in 13 518 US Adults with Metabolic Dysfunction–Associated Steatotic Liver Disease

	Crude Model		Model 1		Model 2	
	HR (95% CI)	*P*	HR (95% CI)	*P*	HR (95% CI)	*P*
All-cause mortality						
PHDI (per 1 increase)	0.990 (0.986-0.994)	<.001	0.984 (0.980-0.989)	<.001	0.983 (0.978-0.987)	<.001
PHDI tertiles						
Highest tertile	1 (reference)	—	1 (reference)	—	1 (reference)	—
Medium tertile	1.11 (0.95-1.29)	.20	1.25 (1.08-1.46)	.003	1.26 (1.09-1.47)	.002
Lowest tertile	1.35 (1.16-1.57)	<.001	1.65 (1.43-1.91)	<.001	1.72 (1.47-2.01)	<.001
SRP score (per 1 increase)	0.900 (0.873-0.927)	<.001	0.841 (0.810-0.873)	<.001	0.858 (0.827-0.891)	<.001
SRP score categories						
6-8	1 (reference)	—	1 (reference)	—	1 (reference)	—
3-5	1.47 (1.315-1.639)	<.001	1.52 (1.35-1.72)	<.001	1.46 (1.28-1.66)	<.001
0-2	1.74 (1.437-2.102)	<.001	2.94 (2.38-3.62)	<.001	2.60 (2.12-3.19)	<.001
Cardiovascular disease mortality						
PHDI (per 1 increase)	0.982 (0.976-0.989)	<.001	0.975 (0.968-0.982)	<.001	0.974 (0.967-0.982)	<.001
PHDI tertiles						
Highest tertile	1 (reference)	—	1 (reference)	—	1 (reference)	—
Medium tertile	1.23 (0.95-1.59)	.12	1.39 (1.08-1.79)	.01	1.38 (1.07-1.77)	.01
Lowest tertile	1.57 (1.23-2.01)	<.001	1.98 (1.55-2.54)	<.001	2.03 (1.57-2.63)	<.001
SRP score (per 1 increase)	0.927 (0.882-0.975)	.003	0.848 (0.796-0.904)	<.001	0.879 (0.825-0.937)	<.001
SRP score categories						
6-8	1 (reference)	—	1 (reference)	—	1 (reference)	—
3-5	1.28 (1.02-1.60)	.03	1.38 (1.09-1.76)	.008	1.29 (1.01-1.64)	.04
0-2	1.47 (1.07-2.02)	.02	2.94 (2.08-4.14)	<.001	2.38 (1.66-3.41)	<.001

Model 1 was adjusted for age (continuous), sex (men vs women), smoking status (never, former, or current), alcohol consumption (never, former, or current), body mass index (continuous), and physical activity (none, moderate, or vigorous). Model 2 was further adjusted for hypertension (yes vs no), diabetes (yes vs no), cardiovascular disease (yes vs no), history of cancer (yes vs no), alanine transferase, (continuous), aspartate transferase (continuous), glycated hemoglobin A1c (continuous), high-density lipoprotein cholesterol (continuous), and total energy intake (continuous). Both PHDI and SRP scores were analyzed as both continuous variables (per 1-unit increase) and categorical variables. For categorical analyses, the highest PHDI tertile and an SRP score of 6-8 served as the reference groups.
HR, hazard ratio; PHDI, planetary health diet index; SRP, social risk profile.

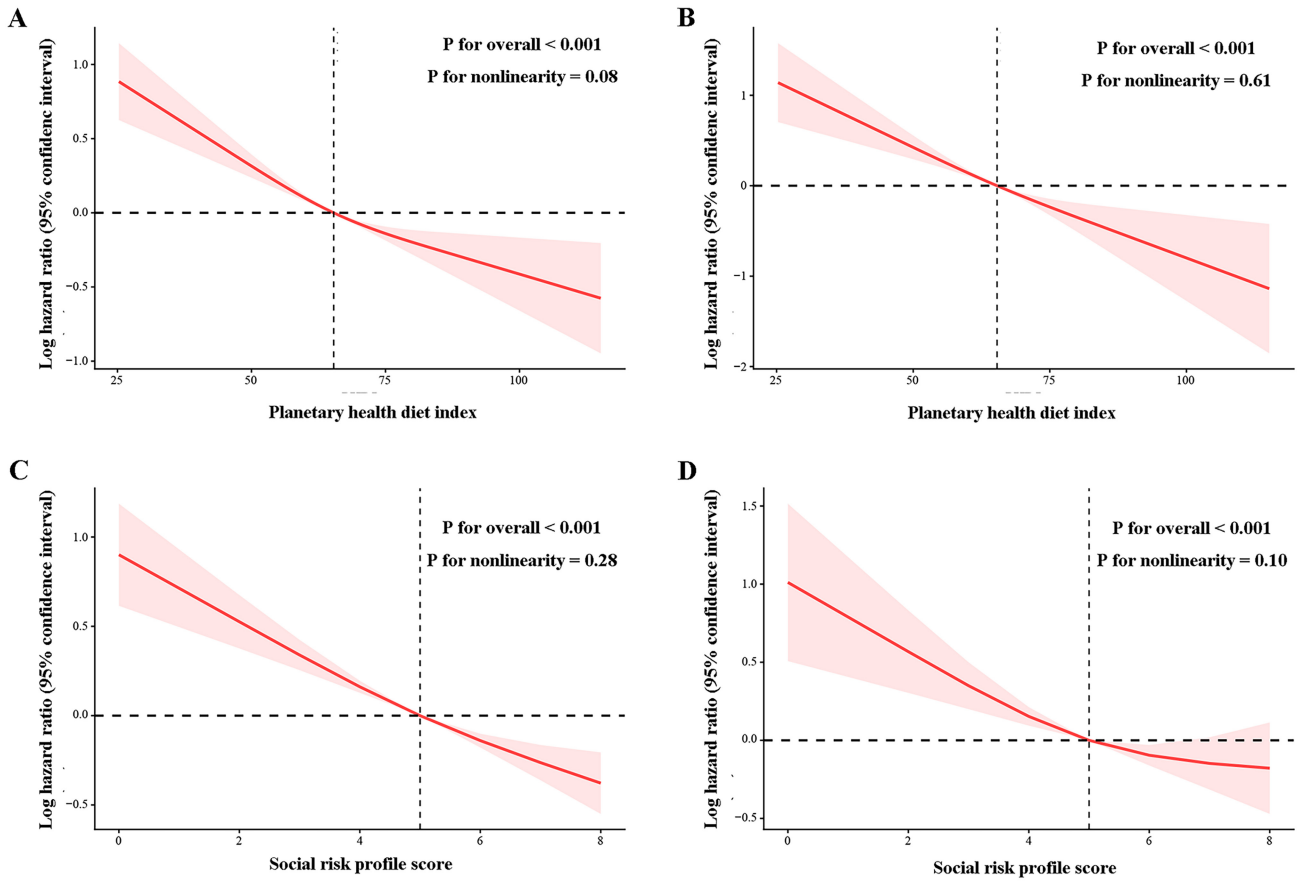

Figure 2. Restricted cubic spline curve for the associations of the planetary health diet index and social risk profile score with all-cause and cardiovascular disease mortality among 13 518 US adults with metabolic dysfunction–associated steatotic liver disease. The shaded band indicates 95% CIs.

involving more than 2.21 million participants found that greater adherence to the PHD was associated with a 17% lower risk of all-cause mortality (95% CI: 0.78-0.89) and a 16% lower risk of CVD mortality (95% CI: 0.81-0.87).[28] Another recent meta-analysis reported similar findings.[29] In this study, the authors found that higher PHDI scores were inversely associated with all-cause and CVD mortality in a dose–response manner. Qiu et al[30] previously demonstrated that greater adherence to the PHD was associated with a lower risk of developing MASLD. However, evidence regarding the association between PHDI and mortality risk among individuals with established MASLD remains limited. The mechanisms underlying the inverse association between PHDI and mortality among individuals with MASLD remain unclear and are likely multifactorial. A diet rich in dietary fibers, vitamins, and minerals may improve insulin resistance, a key pathogenic factor contributing to adverse outcomes in MASLD.[31] In addition, the abundance of antioxidant and polyphenolic compounds in grains, legumes, fruits, and vegetables that characterize the PHD may help mitigate inflammation and oxidative stress in MASLD.[32]

Notably, each 1-point increase in the SRP score was associated with a 14.2% lower risk of all-cause mortality and a 12.1% lower risk of CVD mortality. This finding is consistent with previous studies documenting strong associations between social vulnerability and adverse clinical outcomes in MASLD, including cancer and CVD mortality.[19,33] Faulkner et al[34] reported that neighborhood social determinants of health were associated with mortality, liver-related events, and major adverse cardiovascular events among 69 191 individuals with MASLD. A meta-analysis of 18 studies involving 547 634 individuals from 11 cohorts reported that lower income was consistently associated with an increased risk of adverse clinical outcomes in MASLD.[35] Despite increasing evidence linking socioeconomic disadvantage to clinical outcomes in

Table 3. Joint Analysis of the Planetary Health Diet Index and Social Risk Profile Score and All-Cause and Cardiovascular Disease Mortality Among 13 518 US Adults with Metabolic Dysfunction–Associated Steatotic Liver disease

	SRP Score 6-8		SRP Score 3-5		SRP Score 0-2		*P* for trend
PHDI Tertiles	HR (95% CI)	*P*	HR (95% CI)	*P*	HR (95% CI)	*P*	
All-cause mortality							<.001
Highest tertile	1 (reference)	—	1.49 (1.20-1.87)	<.001	2.61 (1.78-3.84)	<.001	
Medium tertile	1.29 (1.01-1.64)	.07	1.67 (1.34-2.09)	<.001	3.30 (2.46-4.43)	<.001	
Lowest tertile	1.68 (1.33-2.13)	<.001	2.36 (1.91-2.92)	<.001	3.86 (2.86-5.20)	<.001	
Cardiovascular disease mortality							<.001
Highest tertile	1 (reference)	—	1.57 (1.09-2.27)	.03	2.04 (1.03-4.06)	.08	
Medium tertile	1.44 (0.95-2.18)	.15	1.79 (1.25-2.55)	.003	3.35 (1.94-5.76)	<.001	
Lowest tertile	2.32 (1.60-3.36)	<.001	2.29 (1.60-3.29)	<.001	4.94 (2.97-8.20)	<.001	

The hazard ratios (95% CIs) were adjusted for age (continuous), sex (men vs women), smoking status (never, former, or current), alcohol consumption (never, former, or current), body mass index (continuous), physical activity (none, moderate, or vigorous), hypertension (yes vs no), diabetes (yes vs no), cardiovascular disease (yes vs no), history of cancer (yes vs no), alanine transferase, (continuous), aspartate transferase (continuous), glycated hemoglobin A1c (continuous), high-density lipoprotein cholesterol (continuous), and total energy intake (continuous). Participants in the highest PHDI tertile with an SRP score of 6-8 served as the reference groups. *P* values were adjusted for multiple comparisons using the Benjamini–Hochberg method, with a false discovery rate of 0.05.
HR, hazard ratio; PHDI, planetary health diet index; SRP, social risk profile.

MASLD, screening has predominantly been conducted in primary care clinics.[36]

A noteworthy finding was that PHDI and SRP score exhibited a cumulative association with both all-cause and CVD mortality risk among individuals with MASLD. This finding is consistent with a study by Liu et al[37] in patients with chronic kidney disease, which demonstrated that the inverse association between higher PHDI and adverse outcomes was stronger among individuals living in socioeconomically deprived neighborhoods. Lower socioeconomic status may pose barriers to adherence to a high-quality PHDI. For example, a recent cross-sectional survey of 437 860 participants from the UK Biobank found that lower socioeconomic status, particularly lower educational attainment, was strongly associated with lower adherence to a healthy diet.[38] Previous studies have also shown that lower educational attainment and food insecurity are associated with lower adherence to the PHD.[39] These findings suggest that concurrent improvements in dietary quality and SRP are important for improving long-term outcomes in MASLD. In clinical practice, physicians providing healthcare services to patients with MASLD should actively screen for social risk and facilitate social engagement to provide targeted and integrated care. Meanwhile, public health strategies should extend beyond nutritional guidance to address structural social inequities, including healthcare access, economic stability, healthcare insurance, and neighborhood environments, to provide equitable care for patients with MASLD. A dual approach integrating dietary counseling and social policies is essential to reduce mortality and advance health equity among individuals with MASLD.

Subgroup analyses showed that the associations of PHDI and SRP score with all-cause mortality risk were more pronounced among nonelderly adults than in older adults. This age-related heterogeneity is consistent with a previous study showing that the association between SRP and all-cause mortality was stronger among nonelderly populations; each 1-point increase in SRP score was associated with a 21% higher risk among young adults, 28% among middle-aged adults, and only 13% among older adults.[40] This gradient may be explained by 2 mechanisms. First, the high baseline mortality rate from age-related diseases introduces substantial competing risks; this elevated background hazard may attenuate the relative contribution of diet and social vulnerability, as many deaths stem from causes largely independent of these factors. Second, cumulative physiological damage in older adults may be only partially reversible through improvements in diet or social conditions. Conversely, nonelderly adults may have greater physiological reserve and fewer irreversible changes, allowing the protective associations of a healthy diet and favorable social conditions to emerge more clearly. Collectively, these findings suggest that interventions targeting dietary improvement and social risk reduction may yield greater mortality benefits when implemented earlier in life.

The study's principal strengths include its national representativeness, large sample size, and extended follow-up, which enhance the precision and generalizability of the estimates. Leveraging this population-based cohort design, the authors confirmed the expected associations while identifying a previously unreported age-dependent interaction, with significantly stronger associations observed among adults aged <65 years. Several limitations, however, warrant careful consideration. First, the observational design precludes causal inference, as residual or unmeasured confounding cannot be entirely excluded. Second, misclassification bias cannot be ruled out because the diagnosis of MASLD was not verified using vibration-controlled transient elastography, which is currently a reference standard for noninvasive assessment. Third, the wide 95% CIs for certain HR estimates indicate limited precision, particularly in subgroup analyses. Fourth, despite extensive adjustment for demographic, lifestyle, and clinical covariates, residual confounding remains a concern, including from unmeasured factors such as genetic predisposition or environmental exposures. Fifth, both SRP and PHDI were based on self-reported data, introducing the possibility of recall or social desirability bias. Moreover, the lack of longitudinal data prevented us from capturing changes in SRP and dietary patterns over time. Sixth, although the authors applied a validated algorithm and used multiple 24-hour dietary recalls for 2003-2018 cycles, self-reported dietary data are inherently subject to recall bias and may not fully reflect long-term intake. Finally, the findings are based exclusively on a US cohort, limiting their direct generalizability to non-US populations with different dietary patterns, healthcare systems, or social structures.

In conclusion, among US community-dwelling adults with MASLD, lower PHD adherence and greater social vulnerability were independently and cumulatively associated with higher risks of all-cause and CVD mortality, particularly among those aged <65 years. These findings suggest that routine screening for social risk factors alongside dietary counseling should be integrated into MASLD management, particularly for younger patients. Future prospective studies with repeated assessments of dietary and social exposures are warranted to establish causality and evaluate the effectiveness of targeted multilevel interventions.

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Supplementary Table 1. Components and scoring algorithms for planetary health diet index

Food groups	Category minimal score (0 points)	Category maximum score (10 points)
Adequacy components		
Whole grains	0 g	≥ 75 g for women and ≥90 g for men
Whole fruits (excluding fruit juice)	0 g	≥ 200 g
Non-starchy vegetables	0 g	≥ 300 g
Nuts and seeds	0 g	≥ 50 g
Legumes	0 g	100g for non-soy legumes and 50g for soybean/soy foods
Unsaturated oils	0% of total energy intake	≥10% of total energy intake
Moderation components		
Starchy vegetables	≥200 g	≤50 g
Dairy	≥4.08 serving-equivalents	≤1.02 serving-equivalents
Red and processed meat	≥300 g	≤14 g
Poultry	≥58 g	≤29g
Eggs	≥120 g	≤12 g
Fish	≥50 g	≤15 g
Saturated oils and *trans* fats	≥21% of total energy intake	≤3.5% of total energy intake
Added sugar and fruit juice	≥25% of total energy intake	≤5% of total energy intake

Supplementary Table 2. Construction and scoring of the social risk profile score

Social risk profile domains	Specific components	Dichotomization	Score
Healthcare access and quality	Healthcare	Regular place to go	1
		No regular place to go, or ER/hospital or other	0
	Health insurance type	Private insurance	1
		Government or no insurance	0
Economic stability	Employment	Employed, student, retired	1
		Unemployed	0
	Poverty-income ratio	≥ 300%	1
		< 300%	0
	Food security	Fully secure	1
		Marginal, low, or very low	0
Neighborhood and built environment	Housing instability	Own a home (Purchased or paying mortgage)	1
		Rent or other arrangements	0
Social and community context	Marital status	Married or living with a partner	1
		Widowed, divorced, separated, or never married	0
Education access and quality	Education level	College or above	1
		High school or lower	0

Supplementary Table 3. Stratified analysis for the associations between planetary health diet index (PHDI), social risk profile score, and all-cause mortality in 13,518 US adults with metabolic dysfunction-associated steatotic liver disease

	Social risk profile score of 6-8			Social risk profile score of 3-5			Social risk profile score of 0-2			*P* for interaction
	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	
Age, years										< .001
< 65	1 (Reference)	1.43 (0.87-2.34)	2.07 (1.31-3.25)	1.51 (0.92-2.48)	1.85 (1.09-3.14)	3.71 (2.39-5.76)	4.03 (2.29-7.08)	5.94 (3.68-9.57)	6.80 (4.42-10.46)	
≥ 65	1 (Reference)	1.20 (0.92-1.56)	1.43 (1.09-1.87)	1.29 (0.99-1.68)	1.44 (1.14-1.83)	1.56 (1.25-1.96)	2.70 (1.73-4.22)	1.78 (1.07-2.93)	1.91 (1.23-2.96)	
Sex										.83
Men	1 (Reference)	1.19 (0.86-1.64)	1.52 (1.15-2.01)	1.71 (1.25-2.35)	1.63 (1.22-2.18)	2.54 (1.88-3.43)	3.39 (1.86-6.17)	4.49 (2.83-7.13)	4.22 (3.00-5.93)	
Women	1 (Reference)	1.28 (0.80-2.03)	1.85 (1.23-2.78)	1.67 (1.17-2.38)	2.20 (1.58-3.05)	2.64 (1.84-3.80)	4.05 (2.62-6.25)	4.33 (2.80-6.68)	5.81 (3.84-8.81)	
Race/ethnicity										.06
White	1 (Reference)	1.22 (0.93-1.61)	1.62 (1.25-2.11)	1.40 (1.07-1.83)	1.82 (1.42-2.32)	2.15 (1.66-2.78)	3.89 (2.47-6.12)	4.37 (2.92-6.55)	5.81 (4.01-8.42)	
Black	1 (Reference)	1.26 (0.67-2.36)	1.68 (0.90-3.16)	1.64 (0.92-2.91)	1.76 (0.95-3.26)	3.62 (2.14-6.12)	2.92 (1.38-6.19)	4.82 (2.69-8.65)	4.13 (2.19-7.79)	
Other	1 (Reference)	2.06 (0.95-4.48)	2.92 (1.45-5.88)	2.37 (1.39-4.02)	1.63 (0.94-2.81)	4.05 (2.28-7.21)	3.88 (1.91-7.87)	4.25 (2.39-7.56)	4.63 (2.34-9.16)	
Body mass index, kg/m^2										.83
< 30	1 (Reference)	1.26 (0.84-1.91)	1.44 (0.97-2.13)	1.31 (0.88-1.94)	1.41 (0.97-2.06)	2.02 (1.37-2.98)	3.52 (1.82-6.82)	4.17 (2.28-7.65)	4.97 (3.07-8.04)	
≥ 30	1 (Reference)	1.26 (0.93-1.72)	1.83 (1.39-2.40)	1.51 (1.17-1.95)	1.88 (1.47-2.41)	2.56 (1.93-3.39)	3.20 (2.13-4.80)	3.54 (2.50-5.00)	4.47 (3.22-6.20)	
Diabetes										.22
No	1 (Reference)	1.46 (1.06-2.02)	1.96 (1.45-2.66)	1.38 (0.98-1.93)	1.67 (1.22-2.29)	2.62 (1.95-3.50)	3.66 (2.25-5.95)	4.00 (2.66-6.02)	5.11 (3.57-7.30)	
Yes	1 (Reference)	0.93 (0.62-1.40)	1.25 (0.87-1.81)	1.32 (0.96-1.81)	1.56 (1.12-2.17)	1.97 (1.40-2.76)	2.18 (1.37-3.46)	2.85 (1.87-4.34)	3.19 (2.00-5.08)	
Hypertension										.23
No	1 (Reference)	1.46 (0.91-2.34)	2.04 (1.28-3.23)	1.49 (0.89-2.51)	1.57 (1.03-2.37)	3.18 (2.06-4.91)	4.85 (2.64-8.92)	5.21 (2.77-9.82)	7.84 (4.44-13.83)	
Yes	1 (Reference)	1.19 (0.91-1.56)	1.57 (1.17-2.11)	1.38 (1.09-1.74)	1.73 (1.35-2.22)	2.12 (1.67-2.68)	2.51 (1.65-3.80)	3.13 (2.20-4.44)	3.48 (2.57-4.73)	

(Continued)

	Social risk profile score of 6-8			Social risk profile score of 3-5			Social risk profile score of 0-2			*P* for interaction
	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	
Smoking										.07
Never	1 (Reference)	1.38 (0.95-2.01)	1.31 (0.92-1.88)	1.14 (0.82-1.60)	1.57 (1.13-2.20)	2.12 (1.52-2.95)	3.33 (1.86-5.96)	3.66 (2.49-5.38)	4.01 (2.65-6.07)	
Former	1 (Reference)	1.34 (0.95-1.87)	1.82 (1.32-2.50)	1.71 (1.26-2.34)	2.02 (1.47-2.77)	2.07 (1.51-2.82)	2.97 (1.77-4.97)	2.07 (1.21-3.54)	3.41 (1.82-6.39)	
Current	1 (Reference)	0.66 (0.26-1.69)	1.70 (0.78-3.71)	1.18 (0.58-2.40)	0.88 (0.42-1.82)	2.07 (1.06-4.07)	2.00 (0.83-4.85)	3.22 (1.52-6.84)	3.27 (1.63-6.53)	
Drinking										.74
Never	1 (Reference)	0.98 (0.57-1.67)	1.18 (0.72-1.95)	1.00 (0.63-1.58)	1.36 (0.82-2.24)	2.26 (1.35-3.80)	2.82 (1.17-6.81)	2.87 (1.42-5.77)	4.55 (2.45-8.45)	
Former	1 (Reference)	1.36 (0.90-2.04)	2.10 (1.45-3.06)	1.77 (1.21-2.61)	1.97 (1.38-2.81)	2.13 (1.45-3.15)	3.00 (1.76-5.11)	3.65 (2.38-5.59)	4.70 (2.98-7.42)	
Current	1 (Reference)	1.24 (0.88-1.73)	1.53 (1.09-2.14)	1.30 (0.93-1.82)	1.54 (1.10-2.14)	2.40 (1.78-3.26)	3.52 (2.15-5.75)	3.77 (2.20-6.48)	4.07 (2.61-6.37)	

Supplementary Table 4. Stratified analysis for the associations between planetary health diet index (PHDI), social risk profile score, and cardiovascular disease mortality in 13,518 US adults with metabolic dysfunction-associated steatotic liver disease

	Social risk profile score of 6-8			Social risk profile score of 3-5			Social risk profile score of 0-2			*P* for interaction
	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	
Age, years										.11
< 65	1 (Reference)	1.74 (0.69-4.39)	2.72 (1.32-5.59)	1.21 (0.51-2.87)	1.95 (0.88-4.32)	2.97 (1.51-5.86)	3.91 (1.52-10.09)	6.14 (2.80-13.43)	8.65 (4.20-17.79)	
≥ 65	1 (Reference)	1.33 (0.86-2.07)	2.02 (1.30-3.15)	1.40 (0.91-2.14)	1.50 (1.01-2.24)	1.70 (1.11-2.59)	1.31 (0.57-3.01)	1.77 (0.78-4.01)	2.40 (1.07-5.35)	
Sex										.42
Men	1 (Reference)	1.09 (0.63-1.91)	1.88 (1.22-2.88)	1.26 (0.70-2.26)	1.78 (1.04-3.03)	1.97 (1.22-3.17)	3.02 (0.99-9.23)	5.94 (3.04-11.57)	4.29 (1.99-9.25)	
Women	1 (Reference)	2.47 (1.00-6.08)	3.28 (1.61-6.67)	2.66 (1.35-5.22)	2.81 (1.34-5.90)	3.71 (1.89-7.28)	3.49 (1.46-8.36)	4.38 (1.83-10.50)	10.98 (4.98-24.23)	
Race/ethnicity										.29
White	1 (Reference)	1.34 (0.84-2.13)	2.15 (1.46-3.17)	1.28 (0.84-1.96)	1.80 (1.20-2.70)	1.85 (1.21-2.84)	1.44 (0.46-4.54)	3.12 (1.38-7.06)	5.41 (2.72-10.78)	

(*Continued*)

	Social risk profile score of 6-8			Social risk profile score of 3-5			Social risk profile score of 0-2			*P* for interaction
	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	PHDI-High	PHDI-Medium	PHDI-Low	
Black	1 (Reference)	1.96 (0.58-6.62)	3.44 (1.20-9.90)	2.22 (0.81-6.11)	1.97 (0.63-6.19)	6.41 (2.41-17.02)	4.32 (0.96-19.42)	5.05 (1.75-14.55)	7.87 (2.76-22.44)	
Other	1 (Reference)	5.31 (1.61-17.56)	6.49 (1.94-21.72)	4.95 (1.84-13.33)	2.87 (1.01-8.17)	4.61 (1.57-13.52)	8.83 (2.15-36.28)	10.87(3.76-31.45)	14.50 (5.54-37.93)	
Body mass index, kg/m^2										.06
< 30	1 (Reference)	0.99 (0.52-1.87)	1.84 (1.05-3.23)	0.77 (0.39-1.50)	0.64 (0.32-1.30)	1.19 (0.67-2.12)	2.76 (0.55-13.84)	4.02 (1.50-10.79)	6.13 (2.70-13.91)	
≥ 30	1 (Reference)	1.81 (1.05-3.13)	2.66 (1.66-4.24)	1.96 (1.24-3.09)	2.66 (1.67-4.24)	3.02 (1.90-4.79)	2.56 (1.30-5.03)	3.80 (2.01-7.19)	6.09 (3.30-11.22)	
Diabetes										.35
No	1 (Reference)	1.85 (1.03-3.32)	2.96 (1.91-4.60)	1.32 (0.72-2.40)	2.10 (1.28-3.45)	2.76 (1.76-4.31)	2.51 (0.76-8.31)	2.96 (1.43-6.15)	6.27 (3.33-11.79)	
Yes	1 (Reference)	0.95 (0.49-1.82)	1.51 (0.85-2.68)	1.31 (0.80-2.16)	1.26 (0.72-2.19)	1.58 (0.90-2.79)	1.74 (0.70-4.31)	3.80 (1.93-7.48)	4.23 (2.30-7.78)	
Hypertension										.50
No	1 (Reference)	2.33 (0.91-5.96)	3.72 (1.78-7.77)	1.59 (0.65-3.87)	1.70 (0.75-3.85)	4.00 (1.81-8.87)	4.55 (1.07-19.45)	6.33 (1.91-21.00)	11.88 (4.42-31.94)	
Yes	1 (Reference)	1.26 (0.81-1.95)	2.03 (1.32-3.13)	1.35 (0.91-1.99)	1.73 (1.15-2.60)	1.87 (1.24-2.82)	1.87 (0.83-4.25)	2.98 (1.73-5.14)	4.37 (2.59-7.36)	
Smoking										.18
Never	1 (Reference)	1.68 (0.85-3.32)	2.20 (1.29-3.73)	1.31 (0.71-2.40)	1.95 (1.12-3.39)	2.07 (1.27-3.37)	2.71 (1.10-6.68)	3.59 (1.67-7.72)	5.49 (2.67-11.28)	
Former	1 (Reference)	1.50 (0.85-2.64)	2.00 (1.23-3.24)	1.54 (0.93-2.56)	1.71 (0.97-3.01)	1.74 (1.04-2.89)	1.11 (0.21-5.91)	2.16 (0.90-5.19)	1.21 (0.28-5.16)	
Current	1 (Reference)	0.22 (0.02-2.31)	4.20 (0.56-31.84)	1.57 (0.21-11.96)	1.18 (0.15-9.47)	3.41 (0.48-24.16)	3.73 (0.39-35.44)	5.48 (0.70-42.81)	7.77 (1.06-57.12)	
Drinking										.51
Never	1 (Reference)	2.89 (0.76-11.08)	3.20 (0.76-13.40)	3.63 (0.96-13.78)	3.19 (0.83-12.30)	5.22 (1.35-20.20)	2.64 (0.45-15.63)	7.59 (1.60-36.04)	9.18 (2.15-39.18)	
Former	1 (Reference)	1.80 (0.82-3.95)	3.98 (2.03-7.78)	2.44 (1.23-4.83)	2.97 (1.57-5.60)	2.88 (1.37-6.04)	2.80 (0.86-9.10)	5.84 (2.32-14.72)	6.98 (3.23-15.09)	
Current	1 (Reference)	1.26 (0.75-2.11)	1.80 (1.10-2.93)	0.92 (0.52-1.64)	1.30 (0.74-2.29)	1.80 (1.21-2.66)	3.02 (1.08-8.47)	2.54 (1.31-4.93)	5.71 (3.12-10.44)	

Supplementary Table 5. Sensitivity analysis for the combined associations of the planetary health diet index and social risk profile index with all-cause and cardiovascular disease mortality among US adults with metabolic dysfunction-associated steatotic liver disease, excluding those who died within the first 24 months of follow-up

PHDI tertiles	SRP score 6-8	SRP score 3-5	SRP score 0-2
All-cause mortality			
High	1 (Reference)	1.38 (1.07-1.77)	2.36 (1.53-3.64)
Medium	1.21 (0.93-1.58)	1.55 (1.22-1.96)	3.22 (2.35-4.40)
Low	1.65 (1.29-2.12)	2.08 (1.65-2.62)	3.63 (2.57-5.12)
Cardiovascular disease mortality			
High	1 (Reference)	1.35 (0.89-2.04)	1.94 (0.92-4.07)
Medium	1.16 (0.77-1.74)	1.64 (1.10-2.43)	3.01 (1.68-5.37)
Low	2.18 (1.48-3.22)	1.89 (1.29-2.75)	4.75 (2.74-8.24)

Abbreviations: PHDI, planetary health diet index; SRP, social risk profile. The hazard ratios (95% confidence intervals) were adjusted for age (continuous), sex (men vs women), smoking (never vs former vs current), alcohol consumption (never vs former vs current), body mass index (continuous), physical activity (no vs moderate vs vigorous), hypertension (yes vs no), diabetes (yes vs no), cardiovascular disease (yes vs no), history of cancer (yes vs no), alanine transferase, (continuous), aspartate transferase (continuous), glycated hemoglobin A1c (continuous), and high-density lipoprotein cholesterol (continuous), and total energy intake (continuous)

Supplementary Table 6. Sensitivity analysis for the combined associations of the planetary health diet index and social risk profile index with all-cause and cardiovascular disease mortality among US adults with metabolic dysfunction-associated steatotic liver disease, excluding those with preexisting cardiovascular diseases

PHDI tertiles	SRP score 6-8	SRP score 3-5	SRP score 0-2
All-cause mortality			
High	1 (Reference)	1.51 (1.12-2.04)	3.07 (1.78-5.29)
Medium	1.43 (1.04-1.95)	1.49 (1.11-2.00)	4.44 (2.98-6.62)
Low	1.82 (1.33-2.47)	2.57 (1.94-3.41)	4.83 (3.35-6.96)
Cardiovascular disease mortality			
High	1 (Reference)	1.27 (0.77-2.11)	2.57 (0.86-7.65)
Medium	1.50 (0.86-2.62)	1.57 (0.93-2.66)	4.97 (2.57-9.62)
Low	2.51 (1.54-4.09)	2.43 (1.52-3.86)	5.69 (3.18-10.18)

Abbreviations: PHDI, planetary health diet index; SRP, social risk profile. The hazard ratios (95% confidence intervals) were adjusted for age (continuous), sex (men vs women), smoking (never vs former vs current), alcohol consumption (never vs former vs current), body mass index (continuous), physical activity (no vs moderate vs vigorous), hypertension (yes vs no), diabetes (yes vs no), history of cancer (yes vs no), alanine transferase, (continuous), aspartate transferase (continuous), glycated hemoglobin A1c (continuous), and high-density lipoprotein cholesterol (continuous), and total energy intake (continuous)

Supplementary Table 7. Sensitivity analysis for the combined associations of the planetary health diet index and social risk profile index with all-cause and cardiovascular disease mortality among US adults with metabolic dysfunction-associated steatotic liver disease, using multiple imputation for the 672 participants with missing covariates

	Crude Model			Fully adjusted model		
PHDI tertile	SRP score 6-8	SRP score 3-5	SRP score 0-2	SRP score 6-8	SRP score 3-5	SRP score 0-2
All-cause mortality						
High	1 (Reference)	1.49 (1.18-1.87)	1.82 (1.24-2.66)	1 (Reference)	1.42 (1.13-1.79)	2.63 (1.74-3.96)
Medium	1.03 (0.80-1.32)	1.54 (1.23-1.92)	1.92 (1.42-2.59)	1.21 (0.95-1.55)	1.62 (1.29-2.03)	3.19 (2.35-4.33)
Low	1.32 (1.03-1.69)	1.70 (1.36-2.12)	1.95 (1.52-2.51)	1.60 (1.27-2.02)	2.08 (1.66-2.59)	3.85 (2.85-5.20)
CVD mortality						
High	1 (Reference)	1.50 (1.04-2.18)	1.35 (0.71-2.58)	1 (Reference)	1.46 (0.99-2.15)	2.21 (1.10-4.41)
Medium	1.09 (0.72-1.67)	1.60 (1.10-2.31)	1.75 (1.01-3.04)	1.26 (0.83-1.91)	1.71 (1.17-2.49)	3.25 (1.87-5.65)
Low	1.76 (1.22-2.55)	1.61 (1.12-2.31)	2.27 (1.42-3.62)	2.15 (1.50-3.10)	2.01 (1.41-2.86)	5.21 (3.21-8.46)

Abbreviations: PHDI, planetary health diet index; SRP, social risk profile. The Fully adjusted model were adjusted for age (continuous), sex (men vs women), smoking (never vs former vs current), alcohol consumption (never vs former vs current), body mass index (continuous), physical activity (no vs moderate vs vigorous), hypertension (yes vs no), diabetes (yes vs no), cardiovascular disease (yes vs no), history of cancer (yes vs no), alanine transferase, (continuous), aspartate transferase (continuous), glycated hemoglobin A1c (continuous), and high-density lipoprotein cholesterol (continuous), and total energy intake (continuous)