

Association of life's essential 8 with prevalence and all-cause mortality of chronic kidney disease among US adults: Results from the National Health and Nutrition Examination Survey (2015–2018)

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ABSTRACT

Background and Objectives: The association between chronic kidney disease (CKD) and cardiovascular disease has been previously evaluated. This study aimed to evaluate the association between the American Heart Association's Life's Essential 8 (LE8) and the prevalence and all-cause mortality of CKD in a nationally representative population of adults in the US. **Methods:** This retrospective analysis included participants from the National Health and Nutrition Examination Survey spanning 2015–2018. We used multivariable survey logistic regression model to calculate the adjusted odds ratios (AORs) of the LE8 score for the prevalence of CKD. Survey-weighted Cox proportional hazards models were used to calculate the adjusted hazards ratios (AHRs) of the LE8 score for the risk of all-cause mortality among participants with CKD. **Results:** Of the 8907 included participants, 789 had stage 3 to 5 CKD, and 8118 were in the non-CKD group. The adjusted prevalence rate of CKD was 10.7% in the low LE8 score group, and lower in the moderate (7.9%) and high (7.7%) LE8 score groups. Compared with low LE8 scores, moderate LE8 score (adjusted odds ratio [AOR] 0.628, 95% confidence interval [CI]: 0.463 to 0.853, $P = 0.004$) and high LE8 scores (AOR 0.328, 95% CI: 0.142 to 0.759, $P = 0.011$) were associated with lower prevalence rates of CKD. A similar association was found for health factors scores. Additionally, an increase in the LE8 score was associated with a lower risk of all-cause mortality (adjusted hazard ratio [AHR] 0.702, 95% CI: 0.594 to 0.829, $P < 0.001$). **Conclusion:** The results of this study suggest the association of higher LE8 and its subscale scores with a lower prevalence and all-cause mortality of CKD.

Key words: life's essential 8, chronic kidney disease, all-cause mortality

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INTRODUCTION

Chronic kidney disease (CKD) arises from many heterogeneous disease pathways and is defined as the persistence of structural or functional abnormalities in the kidneys for more than 3 months.^[1] The prevalence of CKD was estimated to be 9.1% worldwide according to the Global

Burden of Kidney Disease (2017), which has increased by 29.3% from 1990 to 2017.^[2] End stage renal disease (ESRD) represents the end stage of CKD with a glomerular filtration rate (GFR) < 15 mL/min/1.73 m², which requires kidney replacement therapy (in the form of dialysis or kidney transplantation). The number of patients receiving renal replacement therapy has

consistently increased, aggravating the social and economic burdens.^[3] In addition, patients with CKD tend to have a significantly increased risk of cardiovascular disease (CVD), which is the leading cause of death in this clinical population.^[4] Therefore, accurate prediction of cardiovascular risk is of great significance for both disease prevention and progression. Multiple non-invasive approaches would be applied to explore early detection of cardiovascular related disease.^[5]

In 2010, the American Heart Association (AHA) developed Life's Simple 7 (LS7) for cardiovascular health (CVH) measurement. The LS7 score includes seven health behaviors and factors (diet, physical activity, cigarette smoking, body mass index [BMI], total cholesterol, blood pressure and blood glucose) and a higher LS7 score is associated with lower CVD risk, longer lifespan and better quality of life.^[6–8] The 2022 AHA Life's Essential 8 (LE8) is a more comprehensive measurement and sensitive scoring system for interindividual differences by adding sleep as an eighth CVH metric and optimizing the scoring algorithm.^[9,10] Recent studies have shown that LE8 proves higher prevalence of CVH than LS7, and LE8 score is strongly and inversely associated with the risk of CVD death and all-cause mortality among the general population.^[11–13] Furthermore, a higher LE8 score is associated with a longer life expectancy and the absence of major chronic diseases, including cardiovascular disease, diabetes, cancer, and dementia.^[14]

Considering the close association between CKD and CVD risk, promoting CVH seems to be an appropriate prevention and management strategy for reducing the burden of CKD. To date, several studies have suggested that an ideal CVH is associated with a decreased risk of CKD.^[15,16] However, little is known about the association of the novel CVH construct with CKD. In this study, using the National Health and Nutrition Examination Surveys (NHANES) data from 2015 to 2018, we aimed to evaluate the association of LE8 and its metric scores with the prevalence and all-cause mortality of CKD in a nationally representative population of adults in the US.

MATERIALS AND METHODS

Data source and study design

The NHANES is a series of independent, nationally representative, cross-sectional surveys designed to collect nationally representative health and nutrition data from the US household population.^[17] The samples used in our study were obtained from 2 cycles of the NHANES spanning 2015–2018. The NHANES is approved by the National Center for Health Statistics Research Ethics Review Board, and all participants provided informed consent.

We initially included data from 11,288 adult participants (age ≥ 20 years) from the NHANES 2015–2018 ($n = 19,225$). Among the adult participants, those with missing information of CKD ($n = 1224$) and CVH ($n = 1157$) were excluded. Participants with missing information of others characteristics (the missing rates are shown in Table S1 as supplementary materials) were not excluded; further, we used the “NOMCAR” option in estimation procedures to treat missing values as not missing completely at random as suggested by software tips of the NHANES (<https://www.cdc.gov/nchs/nhanes/tutorials/softwaretips.aspx>).

This study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline (Supplemental Checklist).^[18]

Measurement of cardiovascular health

The assessment of CVH was based on eight essential metrics, including four health behaviors (diet, physical activity, nicotine exposure, and sleep) and four health factors (BMI, blood lipids, blood glucose, and blood pressure). Each CVH metric was scored ranging from 0 to 100 points, and detailed algorithms for calculating the scores for each metric of the NHANES data have been published previously (Table S2).^[9,10,19] Diet metric was evaluated by the Healthy Eating Index (HEI) 2015, and calculated by using the official SAS code provided by the National Cancer Institute.^[20,21] The information of physical activity, nicotine exposure, and sleep, diabetes history, and medication treatment history was obtained by self-reported questionnaires. The weight, height, blood pressure, blood lipids, plasma glucose, and hemoglobin A1c were collected from “Examination Data” and “Laboratory Data” sections of the NHANES.

The overall LE8 score was calculated for each individual by summing the scores for each of the eight metrics and dividing the total score by 8. The LE8 score ranged from 0–100 points. The health behaviors score and health factors score were calculated by summing the scores for the corresponding metrics and dividing the total score by 4. The CVH score was divided into three groups using the cut points suggested by the AHA: high CVH (80–100), moderate CVH (50–79), and low CVH (0–49).^[9]

Assessment of renal function

The estimated glomerular filtration rate (eGFR) was calculated based on the CKD-EPI 2009 (Chronic Kidney Disease Epidemiology Collaboration) equation.^[22,23] The primary objective of our study was to investigate the association between CVH scores and stage 3–5 CKD, which was defined as an eGFR of less than 60 ml per minute per 1.73 m². Moreover, we evaluated the association between CVH scores and stage 1–5 CKD, which was

defined as a GFR of less than 60 ml per minute per 1.73 m² or persistent albuminuria (urinary albumin-to-creatinine ratio > 30 mg/g).^[24]

Follow-up data

The mortality status and time of NHANES CKD participants was collected from public-use linked mortality files updated with mortality follow-up data through 26 April 2022 (<https://www.cdc.gov/nchs/data-linkage/mortality-public.htm>).

Demographic characteristics

Demographic characteristics of the NHANES were collected, including age, gender, race (Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, Other Race), poverty ratio, education level (high school or less, some college or associate degree, college graduate or above), marital status (married, single or separated), and drink status (yes or no). Age was stratified into three strata (20–39 years, 40–59 years, or ≥ 60 years); and the poverty ratio was stratified into three strata (< 1.3 low income, 1.3–3.5 middle income, and > 3.5 high income).

Statistical analysis

The NHANES uses a complex multi-stage sampling method to select the study population. Therefore, it is necessary to assign corresponding weights, clustering and stratification to the data to correct for sampling errors during the analysis process. We applied the weighting and stratification methods suggested by the NHANES instructions. We calculated the weighted means and weighted percentages with corresponding 95% confidence intervals (CI) for the continuous and categorical variables. We applied the t-test and chi-square test to conduct univariate analyses to compare demographic characteristics between the non-CKD and CKD groups.

To investigate the association of CVH scores with the prevalence of CKD, univariable and multivariable survey logistic regression models, which considered weights, cluster, and strata, were used to obtain crude and adjusted odds ratios (AORs) and corresponding 95% CIs of the comparison between the CKD and non-CKD groups. Logistic regression models were adjusted for all demographic characteristics (only using age and poverty ratio as a continuous variable), and the adjusted prevalence rate of CKD was estimated with logistic regression model. We further performed logistic regression models with restricted cubic splines (RCS) with 3 knots (the 25th, 50th, and 75th percentiles) for CVH scores adjusting for all covariates above to evaluate the dose–response relationship. Moreover, we also conducted subgroup analyses based on the demographic characteristics, and the p values

for the production terms between CVH scores and the stratified factors were used to estimate the significance of interactions.

Survey-weighted Cox proportional hazards models were used to analyze the association between CVH scores and the risk of all-cause mortality among participants with CKD. The models were adjusted for all demographic characteristics, and adjusted hazards ratios (AHRs) and 95% CIs were reported.

Figures (excluding the flowchart) were generated using the R software package (version 4.1.2). The remaining statistical analyses were performed using the SAS software (version 9.4; SAS Institute Inc., Cary, NC). All reported p values were two-sided, and a P value < 0.05 was regarded as statistically significant.

RESULTS

Participants and demographic characteristics

Based on the inclusion and exclusion criteria, 8907 participants were included in the study out of 19,225 participants in the 2015–2018 NHANES database (Figure 1). Among the included participants, 789 had stage 3–5 CKD (CKD group), and 8118 were in the non-CKD group.

The demographic characteristics of the two groups are shown in Table 1. Compared with the non-CKD group, participants in the CKD group were older (weighted mean: 70.2 *vs.* 46.7), and had lower educational levels. The weighted percentage of females may have been higher in the CKD group. The current drink rate was lower in the CKD group, probably due to their physical conditions. For the CVH scores and eight metrics, we found the weighted means of scores were significantly lower in the CKD group excluded the HEI-2015 diet score. The weighted means of LE8 score for the non-CKD group and the CKD group were 69.0 (68.2–69.9) *vs.* 61.0 (59.8–62.2), and of the health factors score were 69.2 (68.3–70.0) *vs.* 56.5 (54.6–58.3). However, the health behaviors score was slightly lower in CKD group [68.9 (68.0–69.9) *vs.* 65.5(64.0–67.1)]. The distribution of CVH scores in the total and subgroups of participants are shown in Figure 2B.

Association between cardiovascular health and prevalence of chronic kidney disease

The adjusted prevalence rates of CKD were 10.7% (95% CI: 7.9%–13.5%) for low LE8 score, 7.9% (95% CI: 6.7%–9.1%) for moderate LE8 score, and 7.7% (95% CI: 5.9%–9.5%) for high LE8 score (Figure. 2A). In the multivariable logistic model, compared with the low LE8 score, moderate LE8 score (AOR 0.628, 95% CI:

Table 1: Demographic characteristics of the non- chronic kidney disease and chronic kidney disease population in NHANES 2015–2018

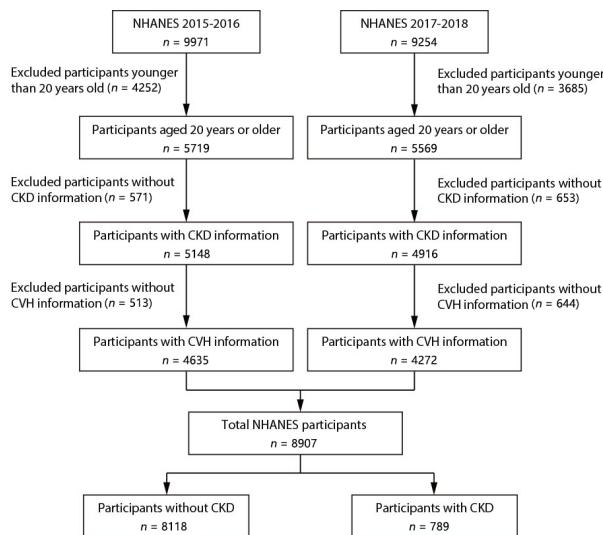
	No.	Overall (n = 8907)	Non-CKD (n = 8118)	CKD (n = 789)	P
Year cycle					0.800
2015–2016	4635	50.2 (46.8–53.5)	50.3 (46.8–53.7)	49.3 (41.8–56.9)	
2017–2018	4272	49.8 (46.5–53.2)	49.7 (46.3–53.2)	50.7 (43.1–58.2)	
Age		48.4 (47.4–49.3)	46.7 (45.9–47.6)	70.2 (69.1–71.2)	< 0.001
Age strata					< 0.001
20–39	2835	35.1 (32.9–37.3)	37.6 (35.4–39.9)	1.9 (0.8–2.9)	
40–59	2898	35.9 (33.8–38.0)	37.7 (35.5–39.9)	12.2 (7.7–16.8)	
≥60	3174	29.0 (26.5–31.4)	24.7 (22.4–27.0)	85.9 (81.4–90.5)	
Gender					0.001
Male	4313	48.5 (47.2–49.7)	48.9 (47.7–50.2)	42.1 (37.8–46.5)	
Female	4594	51.5 (50.3–52.8)	51.1 (49.8–52.3)	57.9 (53.5–62.2)	
Race					< 0.001
Mexican American	1404	8.7 (6.0–11.4)	9.0 (6.2–11.9)	3.8 (2.0–5.6)	
Other Hispanic	1021	6.5 (4.9–8.0)	6.7 (5.1–8.4)	2.8 (1.5–4.1)	
Non-Hispanic White	3157	65.2 (60.3–70.1)	64.2 (59.3–69.1)	78.7 (73.8–83.5)	
Non-Hispanic Black	1915	10.5 (7.8–13.2)	10.6 (7.9–13.2)	9.7 (6.3–13.2)	
Non-Hispanic Asian	1031	5.0 (3.6–6.3)	5.2 (3.8–6.6)	2.1 (0.9–3.2)	
Other Race	379	4.2 (3.4–4.9)	4.3 (3.5–5.1)	2.9 (1.3–4.4)	
Poverty ratio		3.1 (3.0–3.2)	3.1 (3.0–3.2)	3.0 (2.7–3.2)	0.196
Poverty ratio strata					0.044
< 1.3	2360	19.6 (17.7–21.5)	19.6 (17.8–21.5)	18.8 (15.3–22.3)	
1.3–3.5	3264	36.5 (34.0–39.1)	36.1 (33.5–38.7)	42.5 (36.7–48.2)	
> 3.5	2378	43.9 (40.2–47.5)	44.2 (40.6–47.9)	38.8 (31.4–46.1)	
Education levels					0.001
High school or less	3892	36.4 (33.2–39.5)	35.8 (32.7–39.0)	43.3 (38.6–48.1)	
Some college or associate degree	2816	32.0 (29.8–34.1)	31.9 (29.6–34.1)	33.1 (28.8–37.3)	
College graduate or above	2194	31.7 (27.4–35.9)	32.3 (27.9–36.7)	23.6 (17.3–29.9)	
Marital status					0.387
Married	4539	54.8 (52.1–57.5)	55.0 (52.3–57.7)	52.5 (46.1–58.9)	
Single or separated	4365	45.2 (42.5–47.9)	45.0 (42.3–47.7)	47.5 (41.1–53.9)	
Drink status					< 0.001
Yes	6821	84.7 (83.3–86.2)	85.3 (84.0–86.7)	77.0 (72.1–81.9)	
No	1777	15.3 (13.8–16.7)	14.7 (13.3–16.0)	23.0 (18.1–27.9)	
LE8 score (out of 100 possible points)					
LE8 score		68.5 (67.7–69.3)	69.0 (68.2–69.9)	61.0 (59.8–62.2)	< 0.001
Health behaviors score		68.7 (67.7–69.7)	68.9 (68.0–69.9)	65.5 (64.0–67.1)	< 0.001
HEI-2015 diet score		40.5 (39.5–41.5)	40.5 (39.5–41.6)	40.6 (39.2–42.1)	0.907
Physical activity score		75.1 (73.5–76.7)	76.3 (74.6–77.9)	59.4 (55.5–63.4)	< 0.001
Nicotine exposure score		73.2 (71.6–74.8)	72.7 (70.9–74.4)	80.5 (77.3–83.7)	< 0.001
Sleep health score		86.0 (85.1–86.8)	86.3 (85.4–87.2)	81.6 (79.3–83.8)	< 0.001
Health factors score		68.3 (67.4–69.1)	69.2 (68.3–70.0)	56.5 (54.6–58.3)	< 0.001
Body mass index score		57.1 (55.2–58.9)	57.4 (55.6–59.2)	52.3 (48.7–56.0)	0.001
Blood lipids score		66.9 (65.4–68.3)	67.2 (65.7–68.6)	62.7 (59.7–65.7)	0.006
Blood glucose score		81.8 (80.7–82.9)	83.0 (81.9–84.1)	65.6 (63.7–67.6)	< 0.001
Blood pressure score		67.3 (66.2–68.5)	69.0 (67.8–70.2)	45.2 (41.2–49.2)	< 0.001
Cardiovascular health					< 0.001
Low (0–49)	1090	9.2 (8.2–10.2)	8.5 (7.5–9.5)	19.0 (15.9–22.2)	
Moderate (50–79)	6231	68.4 (66.8–70.1)	67.9 (66.1–69.8)	75.2 (70.9–79.5)	
High (80–100)	1586	22.3 (20.3–24.3)	23.6 (21.5–25.7)	5.8 (2.1–9.4)	

Note: Weighted percentages (95% confidence intervals) were presented for categorical characteristics, and weighted means (95% confidence intervals) were presented for continuous characteristics. CKD group and non-CKD group was divided based on stage 3–5 CKD, which was defined as a GFR of less than 60 mL per minute per 1.73 m². Missing rates: Poverty ratio and poverty ratio strata (10.16%, 10.05% vs. 11.28%); Education levels (0.06%, 0.06% vs. 0%); Marital status (0.03%, 0.03% vs. 0%); Drink status (3.47%, 3.61% vs. 2.03%). CKD: chronic kidney disease; LE8: life's essential 8; HEI: healthy eating index.

Table 2: Association between the cardiovascular health score and prevalence of stage 3–5 chronic kidney disease

	Univariable model		Model I		Model II	
	OR (95% CI)	P	OR (95% CI)	P	OR (95% CI)	P
LE8 score						
Low (0–49)	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	0.493 (0.398–0.611)	< 0.001	0.639 (0.487–0.838)	0.002	0.628 (0.463–0.853)	0.004
High (80–100)	0.109 (0.056–0.211)	< 0.001	0.309 (0.150–0.636)	0.002	0.328 (0.142–0.759)	0.011
Per 10 points increase	0.663 (0.621–0.709)	< 0.001	0.797 (0.726–0.876)	< 0.001	0.814 (0.727–0.913)	< 0.001
Health behaviors score						
Low (0–49)	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	0.782 (0.604–1.012)	0.061	0.814 (0.594–1.115)	0.192	0.875 (0.605–1.264)	0.464
High (80–100)	0.580 (0.463–0.726)	< 0.001	0.652 (0.483–0.880)	0.007	0.746 (0.523–1.065)	0.104
Per 10 points increase	0.889 (0.847–0.933)	< 0.001	0.908 (0.857–0.962)	0.002	0.930 (0.861–1.004)	0.061
Health factors score						
Low (0–49)	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	0.564 (0.448–0.710)	< 0.001	0.705 (0.528–0.941)	0.019	0.740 (0.557–0.982)	0.038
High (80–100)	0.115 (0.075–0.177)	< 0.001	0.364 (0.215–0.615)	< 0.001	0.401 (0.228–0.707)	0.003
Per 10 points increase	0.720 (0.683–0.758)	< 0.001	0.856 (0.790–0.928)	< 0.001	0.867 (0.796–0.944)	0.002

Note: Stage 3–5 CKD was defined as a GFR of less than 60 mL per minute per 1.73 m². Model I: Adjusted for age, gender, race. Model II: Adjusted for age, gender, race, poverty ratio, year cycle, education levels, marital status, drink status. CVH: cardiovascular health; CKD: chronic kidney disease; LE8: life's essential 8; OR: odds ratio; CI: confidence interval.

**Figure 1: The flow chart of the study population selection process.**

0.463–0.853, $P = 0.004$) and high LE8 score (AOR 0.328, 95% CI: 0.142–0.759, $P = 0.011$) were associated with lower prevalence rates of CKD (Table 2). No nonlinear association was observed between the LE8 score and CKD ($P = 0.308$ for nonlinearity, Figure S1), and AOR for per 10 points of LE8 score increase was 0.814 (95% CI: 0.727–0.913, $P < 0.001$) in association with prevalence rates of CKD. For health factors score, we found a trend similar to that of the LE8 score, and the AOR for per 10

points of health factors score increase was 0.867 (95% CI: 0.796–0.944, $P = 0.002$). However, there was no significant association between health behaviors score and prevalence of CKD (AOR 0.930, 95% CI: 0.861–1.004, $P = 0.061$). We also evaluated the association between CVH and stage 1–5 CKD, and found results similar to those of the primary analyses. Higher LE8 score and health factors score were associated with lower prevalence rates of stage 1–5 CKD (Table S3).

Among the eight CVH metrics, we found per 10 points increase of sleep health score (AOR 0.946, 95% CI: 0.908–0.984, $P = 0.008$), body mass index score (AOR 0.930, 95% CI: 0.897–0.965, $P < 0.001$), and blood glucose score (AOR 0.913, 95% CI: 0.874–0.953, $P < 0.001$) was associated with lower prevalence rates of CKD (Table S4). Although there was no significant association between the HEI-2015 diet score and CKD in univariable model, per 10 points of score increase was potentially associated with a lower prevalence of CKD in the multivariable model (AOR 0.879, 95% CI: 0.810–0.955, $P = 0.003$).

Association between cardiovascular health and all-cause mortality among chronic kidney disease participants

During a median follow-up of 35 months, 108 all-cause mortalities were recorded among the 789 participants with CKD. In multivariable Cox proportional hazards models, increase of LE8 score (AHR 0.665, 95% CI: 0.504–0.876,

Table 3: Survey-weighted association of cardiovascular health score with all-cause mortality among stage 3–5 chronic kidney disease participants

	No. of Mortality/ Total	Univariable model		Model I		Model II	
		HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
LE8 score							
Low (0–49)	39/195	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	66/566	0.421 (0.257–0.688)	0.001	0.383 (0.236–0.621)	< 0.001	0.431 (0.226–0.821)	0.012
High (80–100)	3/28	0.198 (0.040–0.981)	0.047	0.247 (0.048–1.273)	0.092	0.470 (0.079–2.808)	0.395
Per 10 points increase		0.670 (0.564–0.795)	< 0.001	0.619 (0.503–0.761)	< 0.001	0.665 (0.504–0.876)	0.005
Health behaviors score							
Low (0–49)	42/198	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	53/423	0.333 (0.198–0.560)	< 0.001	0.339 (0.192–0.600)	< 0.001	0.344 (0.190–0.624)	< 0.001
High (80–100)	13/168	0.240 (0.109–0.527)	< 0.001	0.248 (0.113–0.544)	0.001	0.336 (0.143–0.788)	0.014
Per 10 points increase		0.696 (0.606–0.799)	< 0.001	0.680 (0.577–0.800)	< 0.001	0.702 (0.594–0.829)	< 0.001
Health factors score							
Low (0–49)	43/308	1 (Reference)	-	1 (Reference)	-	1 (Reference)	-
Moderate (50–79)	54/426	0.801 (0.515–1.245)	0.312	0.777 (0.477–1.266)	0.300	1.076 (0.561–2.063)	0.819
High (80–100)	11/55	1.030 (0.350–3.027)	0.956	1.050 (0.365–3.020)	0.925	1.216 (0.319–4.634)	0.767
Per 10 points increase		0.939 (0.813–1.084)	0.378	0.921 (0.764–1.110)	0.374	0.980 (0.788–1.220)	0.852

Note: Stage 3–5 CKD was defined as a GFR of less than 60 mL per minute per 1.73 m². Model I: Adjusted for age, gender, race. Model II: Adjusted for age, gender, race, poverty ratio, year cycle, education levels, marital status, drink status. CVH: cardiovascular health; CKD: chronic kidney disease; LE8: life's essential 8; HR: hazard ratio; CI confidence interval.

$P = 0.005$) and health behaviors score (AHR 0.702, 95% CI: 0.594–0.829, $P < 0.001$) was associated with a lower risk of all-cause mortality. Due to the low health factors score of the CKD participants, we did not find a significant association between health factors score and all-cause mortality (Table 3). Similar results were observed among stage 1–5 CKD participants (Table S5)

Subgroup analyses

Subgroup analyses were based on the seven strata factors. There were lower prevalence rates of CKD (AOR < 1) with increased LE8 score and health factors score in most of the subgroup analyses (Figure 3). We found significant interactions between the LE8 score and gender ($P = 0.028$, Table S6). A higher LE8 score was associated with a lower prevalence of CKD among male participants, but not among female participants. A similar association was also found between health behaviors score and health factors score. Additionally, higher CVH scores were associated with lower CKD prevalence rates among older (age ≥ 60 years old) and married participants.

DISCUSSION

In this large and nationally representative cross-sectional

study, we found that a higher LE8 score was associated with a lower prevalence of CKD and lower risk of all-cause mortality in patients with CKD. In addition, subgroup analysis indicated that reverse relationship between LE8 score (including health behaviors score and health factors score) and the prevalence of CKD was significantly among male, older (age ≥ 60 years) and married participants. These results suggested that we need studies to show if attaining higher CVH scores could reduce the burden of CKD.

To our knowledge, this is the first study to examine the association between the AHA's new LE8 metrics and a scoring algorithm for CKD. The association between ideal CVH determined using the LS7 metrics and the CKD prevalence has been evaluated in previous studies. In a prospective cohort study from the Kailuan community in China, the frequency of CKD decreased with an increase in cumulative exposure to the ideal CVH.^[15] Two cohort studies among the Framingham Heart Study and the Korean Genome and Epidemiology Study also revealed that a better CVH score was associated with a lower risk of developing CKD.^[16,25] However, the CVH definition of LS7 was divided into three categories: poor, intermediate and ideal CVH respectively, and this definition is unable to

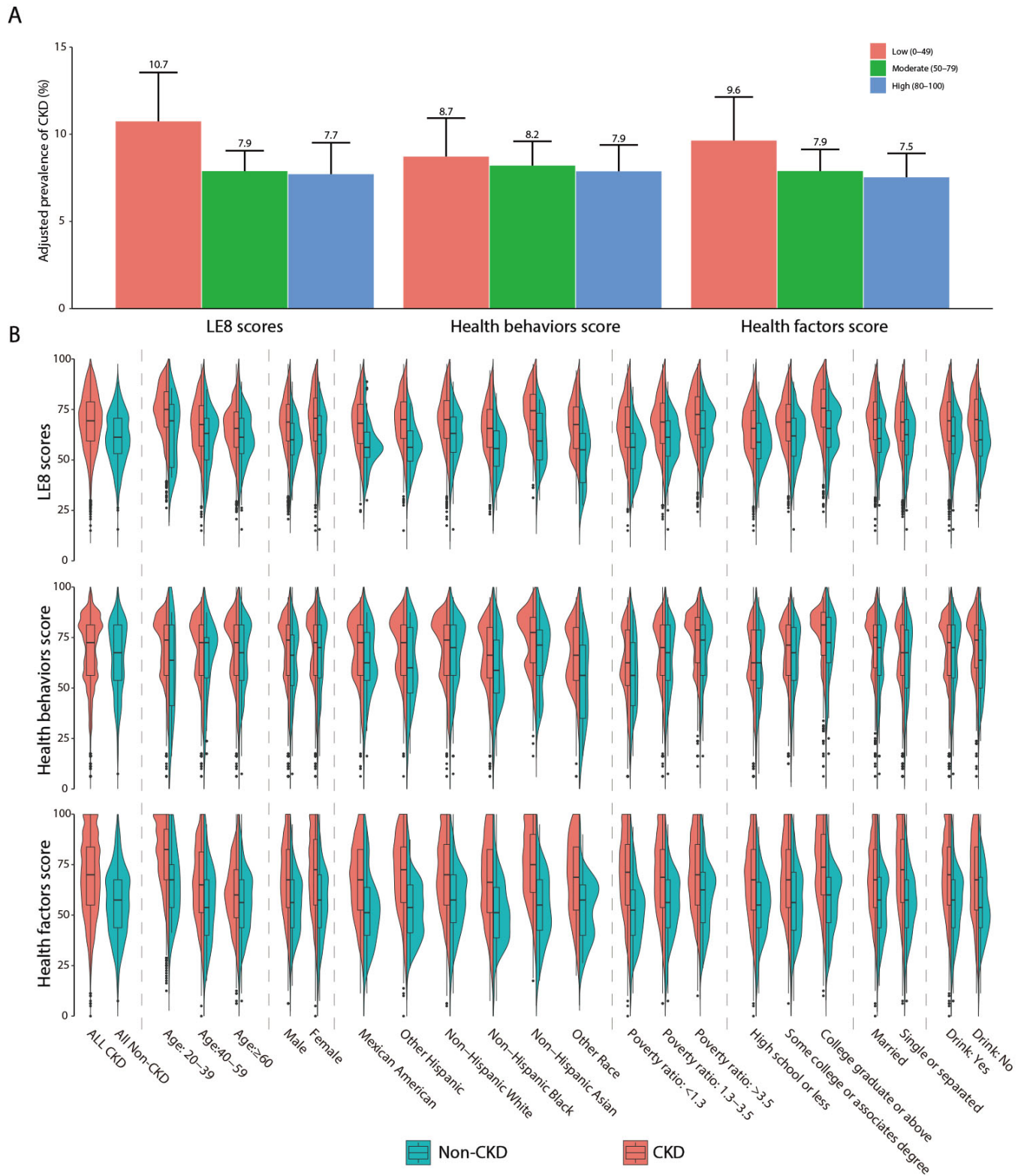


Figure 2: The prevalence rate of CKD and distribution of CVH score. (A) the bar plots of adjusted prevalence rate of CKD in different CVH score groups. (B) the violin plots of CVH scores distribution for all study population and subgroup population in CKD and non-CKD groups.

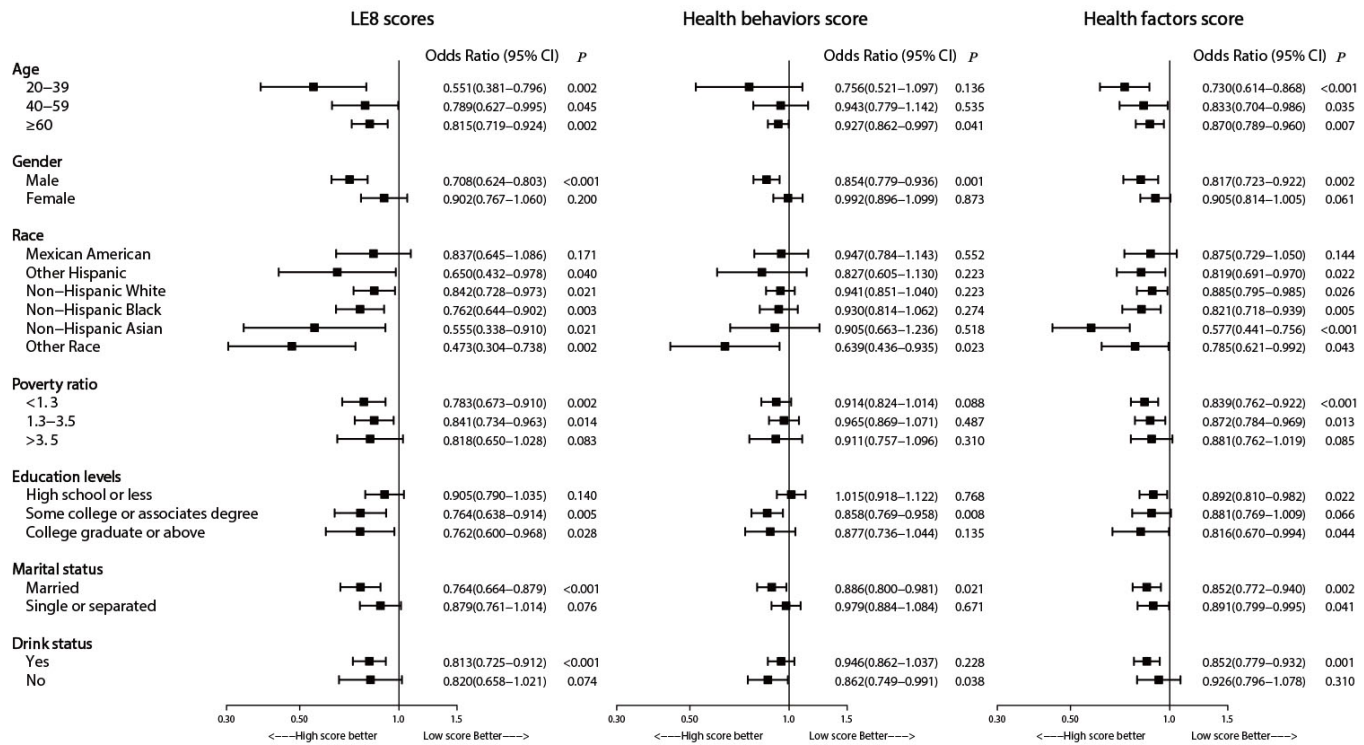


Figure 3: The association of CVH score with prevalence rate of CKD in subgroup analyses.

be utilized to assess dose-response effects.^[9] Our findings are consistent with the current knowledge that the ideal CVH is inversely related to the prevalence of CKD, using LE8 as the novel definition of CVH. This study also investigated the relationship between health behaviors score or health factors score and the prevalence of CKD. Interestingly, the results showed that health factors score but not health behaviors score had a significant association with the prevalence CKD. Health factors include BMI, blood lipids, blood glucose and blood pressure, and abnormalities in these factors refer to a pathological state known as metabolic syndrome (MetS).^[26] A large number of studies have confirmed that MetS can bring changes in renal structure and function, and increase the risk of CKD.^[27–30] Additionally, a high MetS score is associated with an increased risk of progressive decline in renal function.^[31] Therefore, a more rigorous standard of health factors might be preferable for CKD prevention in the general population, and health factors score might help individuals maintain better metabolic homeostasis. In the current study, the association between the individual metrics and the CKD prevalence was further assessed. We found that the increase of sleep health score, BMI score and blood glucose score were related to lower prevalence rates of CKD. The multi-dimensionality of sleep and its strong association with other determinants

of CVH has led to its inclusion in the LE8 score.^[9] Recent evidence suggested that short or long sleep duration was associated with higher prevalence of CKD compared with intermediate duration, and short sleep duration was particularly associated with the risk of incident ESRD outcome.^[32] Thus, health care providers may encourage people to avoid short-duration sleeping behavior to reduce the risk of CKD. In addition, the association between the LE8 score and the prevalence of CKD was found to be stronger among male, older and married participants. These results suggested that LE8 improved the methods for the quantification of CVH by increasing the sensitivity of scoring to interindividual differences. These findings highlight the importance of CKD prevention in this population.

Higher LS7 or LE8 scores were inversely associated with the risk of all-cause mortality.^[19,25] However, the association between LE8 and all-cause mortality among CKD subtypes was first explored in this study. Our findings showed that an increase of LE8 score and health behaviors score rather than the health factors score was related to a lower risk of all-cause mortality among stage 1–5 CKD patients. Health behaviors also includes four aspects: diet, physical activity, nicotine exposure and sleep. In addition to the increasing the prevalence

of CKD, short or long sleep duration has also been independently associated with high mortality and low quality of life in adults with CKD.^[33-35] A meta-analysis of cohort studies showed that healthy dietary patterns comprising many fruits and vegetables, fish, legumes, whole grains, and fibers, as well as reducing red meat, sodium, and refined sugar intake, were associated with lower mortality in patients with CKD.^[36,37] Higher levels of physical activity were documented to reduce the risk of CVD events and mortality in CKD patients.^[38,39] In view of the hazards of smoking, previous studies found that smoking significantly increased the risks for vascular and nonvascular morbidity and mortality in patients with CKD.^[40,41] Therefore, compared with strictly controlling health factors, modifying health behaviors (healthy diet, high levels of physical activity, avoiding smoking, adequate sleep) may be a more favorable strategy to improve quality of life and outcomes in CKD populations.

The strengths of this study include the use of a large, nationally representative sample of adults in the United States and a comprehensive assessment of CVH metrics. However, this study has several limitations. Firstly, the health behavior metrics assessments were based on self-reported questionnaires which are subject to measurement errors. Secondly, individuals with missing information of CKD and CVH were excluded from the analysis; therefore, the results may not be representative of the entire population. Finally, the nature of the cross-sectional study design prevented us from inferring the causality and temporality between CVH and CKD. Till now, based on the China-PAR cohort and Kailuan cohort. The association between LE8 scores and cardiovascular outcomes, including years lived without cardiovascular disease (CVD), 10-year and lifetime risks of atherosclerotic CVD and premature CVD and all-cause mortality in aged 18–40 years old Chinese people was measured^[12,42,43]. With its excellent predictive capacity in cross-cultural populations, verifying the possible predictive efficacy of LE8 for CKD would be an attractive approach in Eastern Asia.

In the present study, based on US adult data, higher Life's Essential 8 and its subscales scores were associated with lower prevalence and all-cause mortality of CKD. LE8 is a potent approach to explore for promoting cardiovascular and renal health. Studies on cross-cultural populations that address the association between LE8 and kidney disease are needed in future.

Supplementary Information

Supplementary materials are only available at the official site of the journal (www.intern-med.com).

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Author Contributions

Study concept and design: Wei Chen, Yingyi Qin, Yuanjun Tang. Analysis and interpretation of data: Yuanjun Tang, Yachen Si, Boxiang Tu, Ying Xu, Yingyi Qin. Statistical analysis: Fuchuan Xiao, Xiaolu Bian, Ying Xu, Yingyi Qin. Drafting of the manuscript: Wei Chen, Yachen Si, Yingyi Qin. Revision of the manuscript: Wei Chen, Yingyi Qin.

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Ethical Approval

The current study was a secondary analysis of NHANES data, the original survey was approved by the National Center for Health Statistics Research Ethics Review Board.

Informed Consent

All participants provided written informed consent. More details are available on the NHANES website.

Conflict of Interest

The authors declare that they have no conflict of interest.

Data Availability Statement

The National Health and Nutrition Examination Survey dataset is publicly available at the National Center for Health Statistics of the Center for Disease Control and Prevention (<https://www.cdc.gov/nchs/nhanes/index.htm>).

REFERENCES

1. Glasscock RJ, Warnock DG, Delanaye P. The global burden of chronic kidney disease: estimates, variability and pitfalls. *Nat Rev Nephrol* 2017;13:104–114.
2. GBD Chronic Kidney Disease Collaboration. Global, regional, and national burden of chronic kidney disease, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* 2020;395:709–733.
3. Webster AC, Nagler EV, Morton RL, Masson P. Chronic Kidney Disease.

- Lancet 2017;389:1238–52.
4. Matsushita K, Ballew SH, Wang AY, Kalyesubula R, Schaeffner E, Agarwal R. Epidemiology and risk of cardiovascular disease in populations with chronic kidney disease. *Nat Rev Nephrol* 2022;18:696–707.
5. He M, Jiang R, Fei-Sun, Cao JX, Wang L, Shi JY. Cardiac magnetic resonance imaging-derived septum swing index detects pulmonary hypertension: A diagnostic study. *J Transl Int Med* 2023;11:459–467.
6. Lloyd-Jones DM, Hong Y, Labarthe D, Mozaffarian D, Appel LJ, Van Horn L, *et al.* Defining and setting national goals for cardiovascular health promotion and disease reduction: the American Heart Association's strategic Impact Goal through 2020 and beyond. *Circulation* 2010;121:586–613.
7. Polonsky TS, Ning H, Daviglus ML, Liu K, Burke GL, Cushman M, *et al.* Association of Cardiovascular Health With Subclinical Disease and Incident Events: The Multi-Ethnic Study of Atherosclerosis. *J Am Heart Assoc* 2017;6:e004894.
8. M Isozior N, Kunutsor SK, Voutilainen A, Kurl S, Kauhanen J, A Laukanen J. Association between ideal cardiovascular health and risk of sudden cardiac death and all-cause mortality among middle-aged men in Finland. *Eur J Prev Cardiol* 2021;28:294–300.
9. Lloyd-Jones DM, Allen NB, Anderson CAM, Black T, Brewer LC, Foraker RE, *et al.* Life's Essential 8: Updating and Enhancing the American Heart Association's Construct of Cardiovascular Health: A Presidential Advisory From the American Heart Association. *Circulation* 2022;146:e18–e43.
10. Lloyd-Jones DM, Ning H, Labarthe D, Brewer L, Sharma G, Rosamond W, *et al.* Status of Cardiovascular Health in US Adults and Children Using the American Heart Association's New "Life's Essential 8" Metrics: Prevalence Estimates From the National Health and Nutrition Examination Survey (NHANES), 2013 Through 2018. *Circulation* 2022;146:822–835.
11. Isozior NM, Kunutsor SK, Voutilainen A, Laukkanen JA. Life's Essential 8 and the risk of cardiovascular disease death and all-cause mortality in Finnish men. *Eur J Prev Cardiol* 2023;30:658–667.
12. Xing A, Tian X, Wang Y, Chen S, Xu Q, Xia X, *et al.* 'Life's Essential 8' cardiovascular health with premature cardiovascular disease and all-cause mortality in young adults: the Kailuan prospective cohort study. *Eur J Prev Cardiol* 2023;30:593–600.
13. Perng W, Aris IM, Slopen N, Younoszai N, Swanson V, Mueller NT, *et al.* Application of Life's Essential 8 to assess cardiovascular health during early childhood. *Ann Epidemiol* 2023;80:16–24.
14. Wang X, Ma H, Li X, Heianza Y, Manson JE, Franco OH, *et al.* Association of Cardiovascular Health With Life Expectancy Free of Cardiovascular Disease, Diabetes, Cancer, and Dementia in UK Adults. *JAMA Intern Med* 2023;183:340–349.
15. Hou J, Li J, Huang J, Lu C, Zhou J, Liu Y, *et al.* Relationship between the exposure to cumulative cardiovascular health behaviors and factors and chronic kidney disease- The Kailuan study. *PLoS One* 2018;13:e0203171.
16. Cho SMJ, Jeon JY, Yoo TH, Lee HY, Lee YH, Kim HC. Ideal cardiovascular health duration and risk of chronic kidney disease and cardiovascular disease. *Heart* 2022;108:523–528.
17. Centers for Disease Control and Prevention; National Center for Health Statistics. National Health and Nutrition Examination Survey. [Accessed Jan 3, 2023]. Available from: <https://www.cdc.gov/nchs/nhanes/index.htm>.
18. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *BMJ* 2007;335:806–808.
19. Yi J, Wang L, Guo X, Ren X. Association of Life's Essential 8 with all-cause and cardiovascular mortality among US adults: A prospective cohort study from the NHANES 2005–2014. *Nutr Metab Cardiovasc Dis* 2023;33:1134–1143.
20. Vilar-Gomez E, Nephew LD, Vuppalachni R, Gawrieh S, Mladenovic A, Pike F, *et al.* High-quality diet, physical activity, and college education are associated with low risk of NAFLD among the US population. *Hepatology* 2022;75:1491–1506.
21. National Cancer Institute. Healthy eating index SAS code. 2022. <https://epi.grants.cancer.gov/hei/sas-code.html>. Accessed 10 Jan 2023.
22. Levey AS, Stevens LA, Schmid CH, Zhang YL, Castro AF 3rd, Feldman HI, *et al.* A new equation to estimate glomerular filtration rate. *Ann Intern Med* 2009;150:604–612.
23. Inker LA, Eneanya ND, Coresh J, Tighiouart H, Wang D, Sang Y, *et al.* New Creatinine- and Cystatin C-Based Equations to Estimate GFR without Race. *N Engl J Med* 2021;385:1737–1749.
24. Inker LA, Astor BC, Fox CH, Isakova T, Lash JP, Peralta CA, *et al.* KDOQI US commentary on the 2012 KDIGO clinical practice guideline for the evaluation and management of CKD. *Am J Kidney Dis* 2014;63:713–735.
25. Corlin L, Short ML, Vasani RS, Xanthakis V. Association of the Duration of Ideal Cardiovascular Health Through Adulthood With Cardiometabolic Outcomes and Mortality in the Framingham Offspring Study. *JAMA Cardiol* 2020;5:549–556.
26. Eckel RH, Grundy SM, Zimmet PZ. The metabolic syndrome. *Lancet* 2005;365:1415–1428.
27. Lea J, Cheek D, Thornley-Brown D, Appel L, Agodoa L, Contreras G, *et al.* Metabolic syndrome, proteinuria, and the risk of progressive CKD in hypertensive African Americans. *Am J Kidney Dis* 2008;51:732–740.
28. Thomas G, Sehgal AR, Kashyap SR, Srinivas TR, Kirwan JP, Navaneethan SD. Metabolic syndrome and kidney disease: a systematic review and meta-analysis. *Clin J Am Soc Nephrol* 2011;6:2364–2373.
29. Navaneethan SD, Schold JD, Kirwan JP, Arrigain S, Jolly SE, Poggio ED, *et al.* Metabolic syndrome, ESRD, and death in CKD. *Clin J Am Soc Nephrol* 2013;8:945–952.
30. Wu N, Qin Y, Chen S, Yu C, Xu Y, Zhao J, *et al.* Association between metabolic syndrome and incident chronic kidney disease among Chinese: A nation-wide cohort study and updated meta-analysis. *Diabetes Metab Res Rev* 2021;37:e3437.
31. Wu M, Shu Y, Wang L, Song L, Chen S, Liu Y, *et al.* Metabolic syndrome severity score and the progression of CKD. *Eur J Clin Invest* 2022;52:e13646.
32. Park S, Lee S, Kim Y, Lee Y, Kang MW, Kim K, *et al.* Short or long sleep duration and CKD: A mendelian randomization study. *J Am Soc Nephrol* 2020;31:2937–2947.
33. Ricardo AC, Goh V, Chen J, Cedillo-Couvert E, Kapella M, Prasad B, *et al.* Association of Sleep Duration, Symptoms, and Disorders with Mortality in Adults with Chronic Kidney Disease. *Kidney Int Rep* 2017;2:866–873.
34. Sung SA, Hyun YY, Lee KB, Park HC, Chung W, Kim YH, *et al.* Sleep Duration and Health-Related Quality of Life in Predialysis CKD. *Clin J Am Soc Nephrol* 2018;13:858–865.
35. Lee HJ, Kwak N, Kim YC, Choi SM, Lee J, Park YS, *et al.* Impact of Sleep Duration on Mortality and Quality of Life in Chronic Kidney Disease: Results from the 2007–2015 KNHANES. *Am J Nephrol* 2021;52:396–403.
36. Kelly JT, Palmer SC, Wai SN, Ruospo M, Carrero JJ, Campbell KL, *et al.* Healthy Dietary Patterns and Risk of Mortality and ESRD in CKD: A Meta-Analysis of Cohort Studies. *Clin J Am Soc Nephrol* 2017;12:272–279.
37. Rysz J, Franczyk B, Ciałkowska-Rysz A, Gluba-Brzózka A. The Effect of Diet on the Survival of Patients with Chronic Kidney Disease. *Nutrients* 2017;9:495.
38. Rampersad C, Brar R, Connelly K, Komenda P, Rigatto C, Prasad B, *et al.* Association of Physical Activity and Poor Health Outcomes in Patients With Advanced CKD. *Am J Kidney Dis* 2021;78:391–398.
39. Gao J, Lu Y, Gokulnath P, Vulugundam G, Li G, Li J, *et al.* Benefits of physical activity on cardiometabolic diseases in obese children and adolescents. *J Transl Intern Med* 2022;10:236–245.
40. Staplin N, Haynes R, Herrington WG, Reith C, Cass A, Fellström B, *et al.* Smoking and Adverse Outcomes in Patients With CKD: The Study of Heart and Renal Protection (SHARP). *Am J Kidney Dis* 2016;68:371–380.

41. Kelly JT, Su G, Zhang L, Qin X, Marshall S, González-Ortiz A, *et al.* Modifiable Lifestyle Factors for Primary Prevention of CKD: A Systematic Review and Meta-Analysis. *J Am Soc Nephrol* 2021;32:239–253.
42. Jin C, Li J, Liu F, Li X, Hui Y, Chen S, *et al.* Life's Essential 8 and 10-Year and Lifetime Risk of Atherosclerotic Cardiovascular Disease in China. *Am J Prev Med* 2023;64:927–935.
43. Xing A, Tian X, Wang Y, Chen S, Xu Q, Xia X, *et al.* 'Life's Essential 8' cardiovascular health with premature cardiovascular disease and all-cause mortality in young adults: the Kailuan prospective cohort study. *Eur J Prev Cardiol* 2023;30:593–600.

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