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Social Determinants of Health and Risk of Mortality in Adults with Gout or Hyperuricemia: Insights from the 1999-2018 NHANES

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Background: Hyperuricemia and gout are common metabolic disorders that show substantial disparities in prevalence and management across different socioeconomic status.

Aims: To investigate the association between social determinants of health (SDOH) and mortality risk in adults with hyperuricemia and/or gout, to assess whether the interaction between SDOH and gout/hyperuricemia status influences mortality risk.

Study Design: A retrospective cohort study.

Methods: We analyzed 6,560 United States (US) adults (mean age 58 years, 60.02% men) with hyperuricemia and/or gout from the 1999–2018 National Health and Nutrition Examination Survey. The primary study outcomes were all-cause and cardiovascular mortality. A control group of 6,560 adults without hyperuricemia or gout was measured using propensity-score matching based on age, sex, and race. SDOH was measured using a composite score (range 0–8) created from eight socioeconomic indicators: education, employment, food security, family income-to-poverty ratio, marital status, health insurance coverage, insurance type, and home ownership.

Results: Over a median follow-up of 101 months, 1,335 (14.76%) deaths occurred among participants with hyperuricemia and/or gout, including 496 (5.33%) cardiovascular deaths. Relative to adults with hyperuricemia and/or gout who had an SDOH score of 7–8, the hazard ratios (95% confidence intervals) for those with SDOH scores of 5–6, 3–4, and ≤ 2 were 1.48 (1.21–1.81), 1.85 (1.49–2.28), and 2.38 (1.82–3.11), respectively, for all-cause mortality, and 1.62 (1.16–2.25), 1.65 (1.18–2.31), and 2.10 (1.24–3.54), respectively, for cardiovascular mortality. Restricted cubic spline analyses demonstrated an inverse relationship between SDOH and both mortality outcomes. Subgroup analysis indicated that the association between SDOH and mortality risk was stronger among participants younger than 60 years. Interaction analyses showed that hyperuricemia/gout status did not significantly modify the association between SDOH and mortality.

Conclusion: Cumulative social disadvantage, indicated by a lower SDOH score, independently predicted higher mortality risk in US adults with hyperuricemia and/or gout, with the most pronounced effects observed in individuals under 60 years. Notably, the unfavorable cardiovascular effects associated with SDOH appeared more evident in adults without hyperuricemia or gout than in those with these conditions.

INTRODUCTION

Hyperuricemia, a common metabolic disturbance, presents a clinical spectrum that ranges from an asymptomatic state to painful gouty arthritis. Long-term uncontrolled hyperuricemia or gout may also contribute other health conditions, such as renal impairment, kidney stones, joint deformities, and an elevated risk of diabetes and cardiovascular mortality.[1] A recent analysis documented a steady rise in the global burden of gout, with annual incidence increasing by 5.5% from 1990 to 2017.[2] Although current understanding maintains that gout and hyperuricemia affect individuals across all racial and socioeconomic background,[3] notable disparities persist in both the prevalence and the optimal management of hyperuricemia or gout. For example, a recent report on the United States (US) population identified race- and sex-specific variations in gout prevalence, with age-standardized prevalence estimates of 7.0% in Black men, 5.4% in White men, 3.5% in Black women, and 2.0% in White women.[4] To the best of our knowledge, the precise mechanisms underlying these disparities remain largely unclear.

Social determinants of health (SDOH) are potentially modifiable conditions shaped by environmental factors that may exert a substantial influence on health outcomes.[5] These determinants include educational background, housing conditions, access to

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health care, and economic status. Increasing evidence highlights the significant role of SDOH in shaping the incidence and outcomes of numerous chronic conditions.[6-8] A prior analysis demonstrated that a lower education level was predictive of a reduced risk of experiencing ≥ 2 gout attacks within the past year.[9] Conversely, a Swedish registry-based matched cohort study found that lower education was associated with a higher risk of all-cause and cardiovascular mortality in adults with gout, yet the contribution of educational inequalities to mortality appeared smaller in individuals with gout than in those without,[10] suggesting that additional dimensions of SDOH may also influence mortality risk.

To our knowledge, the associations between individual and cumulative SDOH factors and mortality risk in patients with hyperuricemia and/or gout have not been comprehensively evaluated. Therefore, this study sought to examine the association between individual and composite SDOH and mortality risk in a population-based sample of US adults with gout and/or hyperuricemia drawn from the National Health and Nutrition Examination Survey (NHANES).

MATERIALS AND METHODS

Data source and subjects

All individuals participating in NHANES provided written informed consent, and the study was conducted with approval from the National Center for Health Statistics Ethics Review Board. The use of pre-existing, de-identified public data indicated that separate ethics approval for this analysis was not required.

This study pooled data from the 1999–2018 NHANES cycles and focused on participants aged ≥ 20 years with gout and/or hyperuricemia. Gout was defined as a "Yes" response to the question "Has a doctor or other health professional ever told you that you had gout?".[11] The diagnostic threshold for hyperuricemia was a serum uric acid concentration exceeding 420 μmol/L in men and 360 μmol/L in women. Exclusion criteria included pregnant women, participants with cancer, or those missing data on SDOH, follow-up, or covariates. The final dataset contained 6,560 eligible participants for analysis (Figure 1).

To facilitate comparison, a 1:1 propensity score-matched control cohort was constructed using the MatchIt package in R with a caliper width of 0.2. Each participant with hyperuricemia and/or gout was matched to an individual without these conditions based on age, sex, and race (Supplementary Table 1).

Social determinants of health determination

Consistent with previous studies,[12,13] SDOH in this study was based on the Healthy People 2030 Initiative, which incorporated eight subsidiary facets across five domains. Specifically, the domains assessed were: 1) education access and quality, represented by the participant's education level (≥ college vs. ≤ high school); 2) economic stability, reflected by the employment status (employed, student, retired vs. unemployed), food security (full food secure vs. marginal, low, or very low food secure), and family income-to-poverty ratio (≥ 300% vs. < 300%); 3) social context, referring to marital status (married or partnered vs. not married or no partner); 4) health care availability and quality, based on healthcare insurance (having a routine care source vs. relying on emergency services or lacking a usual care source) and insurance type (private vs. government or no insurance); and 5) neighborhood environment, denoted by home ownership (own a home vs. rent or other). All 8 subsidiary factors were dichotomized and assigned a score of 0 for unfavorable SDOH and 1 for favorable SDOH. A composite SDOH score on a scale from 0 to 8, was then calculated, with higher scores reflecting a greater social advantage.[14-16]

Ascertainment of mortality

Information on the survival status of included NHANES participants was obtained from the linked mortality files updated through December 31, 2019.[17] Deaths for which the underlying cause was coded I00–I09, I11, I13, I20–I51, or I60–I69 according to the International Classification of Diseases, 10th Revision, were classified as cardiovascular mortality.[18]

Covariates

Covariate selection was guided by a directed acyclic graph (Supplementary Figure 1) to estimate the direct effect of SDOH on mortality risk. Hyperlipidemia was defined as meeting any of the following criteria: total cholesterol > 240 mg/dL, triglycerides > 200 mg/dL, low-density lipoprotein cholesterol > 160 mg/dL, or high-density lipoprotein cholesterol < 40 mg/dL in men or < 50 mg/dL in women.[19] For this analysis, activity intensity was classified as moderate based on a mild elevation in respiratory or heart rate, and vigorous based on a marked elevation. Smoking and drinking status, as well as diabetes and hypertension, were diagnosed as previously reported.[20,21] Cardiovascular disease was defined as a composite of self-reported angina, stroke, congestive heart failure, coronary heart disease, or myocardial infarction. Estimated glomerular filtration rate was calculated using the 2009 CKD-EPI creatinine-based equation.[22]

Statistical analysis

To compare baseline characteristics across different SDOH categories,[14,23] one-way analysis of variance or chi-squared test were applied, as appropriate. Univariate and multivariable Cox proportional hazards models were employed to quantify the effect of SDOH on mortality risks, with results presented as hazard ratios (HRs) and 95% confidence intervals (CIs). Model 1 adjusted for demographics and lifestyle factors, including age, sex, race, smoking, drinking, body mass index, and physical activity. In Model 2, further adjustments were made for hypertension, diabetes, hyperlipidemia, estimated glomerular filtration rate, use of statins and antigout agents, and cardiovascular disease. Restricted cubic splines ("rcssci" R package) were incorporated to explore potential non-linear trends between SDOH and mortality. Subgroup analysis assessed the impact of the cumulative SDOH score on mortality risk across age, sex, race, body mass index, physical activity, and diabetes categories. Sensitivity analyses were conducted by excluding participants who died within 24 months of follow-up to reduce the risk of reverse

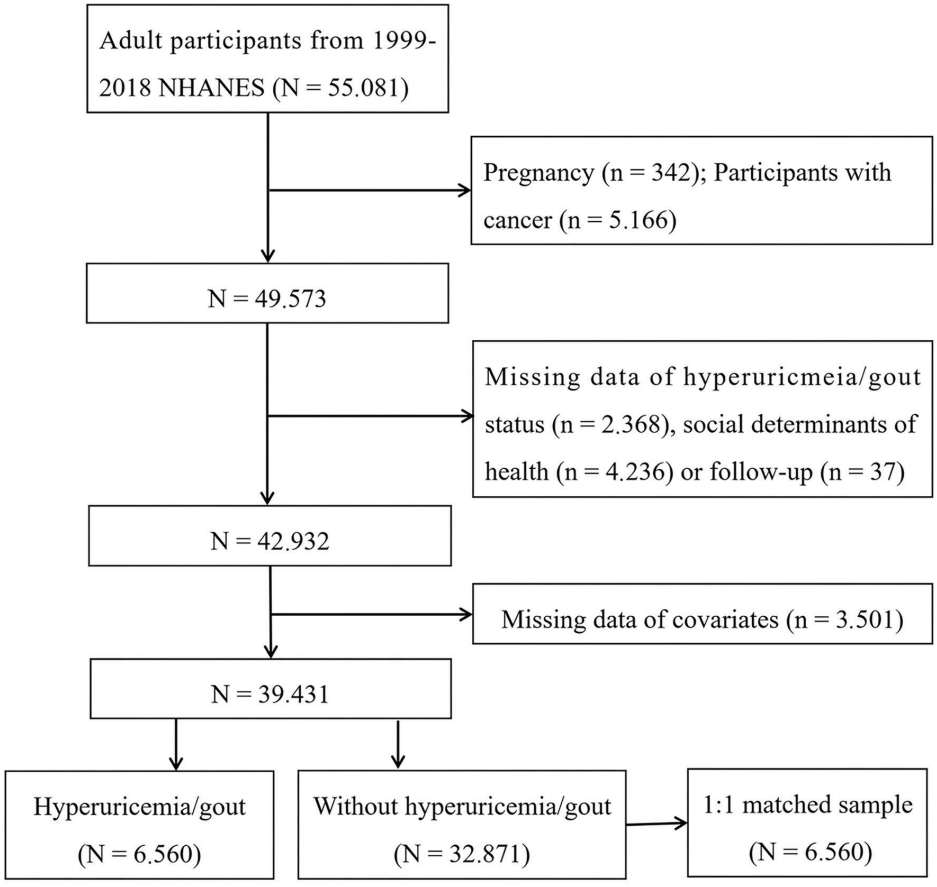

FIG. 1. Flowchart for participant inclusion and exclusion. NHANES, National Health and Nutrition Examination Survey.

causation, and by excluding those with cardiovascular disease at baseline. Population-attributable fractions were estimated for each SDOH factor to quantify its relative impact on mortality risk, with the metric representing the proportional reduction in mortality expected under a counterfactual scenario in which a specific risk factor was entirely eliminated. All analyses were weighted, and a two-sided p value < 0.05 indicated statistical significance.

RESULTS

Baseline characteristics

The final sample consisted of 6,560 participants with hyperuricemia and/or gout (mean age 58.13 years), of whom 60.02% were men, and the mean serum uric acid level was 437.98 μmol/L. As shown in Supplementary Table 2, although the included and excluded cohorts were largely comparable, excluded participants with hyperuricemia were more likely to be current smokers and heavy drinkers. Overall, 896 (9.46%), 1,857 (22.05%), 2,126 (33.42%), and 1,681 (35.07%) participants had an SDOH score of ≤ 2, 3–4, 5–6, and 7–8, respectively. Compared with participants with an SDOH score of 7–8, those with a score of ≤ 2 were significantly younger and had a higher proportion of non-Hispanic Black women (Table 1). This lowest SDOH category also displayed a consistently less favorable health profile, including higher rates of current smoking and heavy drinking, a greater prevalence of physical inactivity, and a higher mean body mass index. The burden of comorbidities, such as hypertension, diabetes, and cardiovascular disease, was also significantly greater. Additionally, the low SDOH group had higher serum uric acid levels and estimated glomerular filtration rate but lower use of statin and anti-gout medications.

Univariate and multivariable Cox regression analysis

A total of 1,335 deaths (14.76%) occurred among participants with hyperuricemia and/or gout during a median follow-up of 101 months (interquartile range 55–149). When stratified by SDOH score, the all-cause mortality counts (and proportions within each category) were 155 (14.67%), 420 (18.31%), 519 (17.59%), and 241 (9.86%) for scores ≤ 2, 3–4, 5–6, and 7–8, respectively. Among these, 496 cardiovascular deaths (5.33% of the cohort) were distributed as 47 (4.36%), 155 (5.95%), 204 (7.14%), and 90 (3.49%) across the same SDOH categories. In the matched control group, 1,685 deaths were identified. All-cause mortality counts by SDOH strata were 180 (20.91%), 544 (24.10%), 664 (21.52%), and 297 (11.93%) for scores of ≤ 2, 3–4, 5–6, and 7–8, respectively. Of these, 545 were cardiovascular deaths, including 55 (6.20%), 185 (7.62%), 215 (6.64%), and 90 (3.44%) across the corresponding categories.

In the fully adjusted multivariable Cox analysis (Table 2), each one-point increase in SDOH score corresponded to a 16% lower risk of all-cause mortality and a 14% lower risk of cardiovascular mortality. For all-cause mortality, the HRs (95% CIs) increased with decreasing SDOH score: 1.48 (1.21–1.81) for a score of 5–6, 1.85 (1.49–2.28) for a score of 3–4, and 2.38 (1.82–3.11) for ≤ 2. A similar graded pattern was noted for cardiovascular mortality, with HRs of 1.62 (1.16–2.25), 1.65 (1.18–2.31), and 2.10 (1.24–3.54) across the same score categories. Notably, mortality risks were comparable between the matched control group and participants with hyperuricemia and/or gout with an SDOH score of 7–8 (Supplementary Table 3). However, progressively higher HRs for all-cause and cardiovascular mortality emerged with lower SDOH categories relative to the controls (Supplementary Table 3).

TABLE 1. Comparison of Baseline Characteristics of US Adult Individuals with Hyperuricemia or Gout Stratified by the Social Risk Profile Score.

SDOH score	Total (n = 6560)	≤ 2 (n = 896)	3-4 (n = 1857)	5-6 (n = 2126)	7-8 (n = 1681)	*p* value
Age, years	49.69 ± 0.29	43.13 ± 0.61	47.36 ± 0.65	50.85 ± 0.55	51.80 ± 0.43	< 0.001
Sex (n, %)						< 0.001
Male	3825 (60.02)	470 (55.65)	1017 (56.22)	1215 (57.05)	1123 (66.42)	
Female	2735 (39.98)	426 (44.35)	840 (43.78)	911 (42.95)	558 (33.58)	
Race (n, %)						< 0.001
Mexican American	841 (6.12)	161 (13.54)	336 (10.30)	227 (5.09)	117 (2.47)	
Non-Hispanic Black	1658 (12.32)	325 (26.90)	532 (18.02)	483 (10.40)	318 (6.64)	
Non-Hispanic White	3007 (70.33)	253 (43.10)	670 (57.00)	1114 (74.40)	970 (82.18)	
Other Hispanic	440 (4.42)	103 (10.73)	148 (6.59)	116 (3.32)	73 (2.39)	
Other race	614 (6.81)	54 (5.73)	171 (8.09)	186 (6.78)	203 (6.32)	
Smoking (n, %)						< 0.001
Never	3277 (50.63)	362 (37.46)	894 (46.05)	1082 (51.71)	939 (56.04)	
Former	2013 (30.25)	195 (20.11)	500 (25.07)	725 (32.26)	593 (34.32)	
Current	1270 (19.12)	339 (42.43)	463 (28.88)	319 (16.03)	149 (9.63)	
Drinking (n, %)						< 0.001
Never	901 (11.32)	136 (12.69)	306 (14.12)	297 (12.07)	162 (8.48)	
Former	1282 (16.01)	176 (17.89)	411 (18.45)	479 (19.41)	216 (10.89)	
Mild	2081 (33.66)	163 (17.13)	453 (23.24)	671 (32.23)	794 (46.04)	
Moderate	889 (14.94)	110 (12.79)	213 (12.77)	289 (13.85)	277 (17.92)	
Heavy	1407 (24.01)	311 (39.50)	474 (31.42)	390 (22.43)	232 (16.67)	
Physical activity (n, %)						< 0.001
None	3609 (48.74)	530 (53.14)	1094 (53.10)	1184 (50.12)	801 (43.50)	
Moderate	1531 (26.41)	167 (21.47)	392 (22.84)	511 (27.01)	461 (29.42)	
Vigorous	1420 (24.85)	199 (25.39)	371 (24.06)	431 (22.87)	419 (27.08)	
BMI, kg/m²	32.42±0.13	33.71±0.45	32.73±0.24	32.41±0.21	31.88±0.25	0.002
Hypertension (n, %)	4027 (55.42)	519 (50.85)	1128 (53.04)	1364 (58.02)	1016 (55.67)	0.03
Diabetes (n, %)	1641 (19.23)	238 (20.60)	501 (21.01)	554 (20.31)	348 (16.71)	0.02
CVD (n, %)	1132 (13.03)	187 (17.67)	355 (15.46)	392 (13.59)	198 (9.71)	< 0.001
Hyperlipidemia (n, %)	5410 (82.06)	740 (82.18)	1512 (79.99)	1766 (82.88)	1392 (82.56)	0.36
Statin (n, %)	1527 (19.84)	147 (12.26)	395 (16.95)	529 (20.31)	456 (23.25)	< 0.001
Anti-gout agent (n, %)	352 (4.72)	36 (3.05)	79 (3.54)	122 (4.87)	115 (5.77)	0.03
eGFR, mL/min/1.73 m²	85.35 ± 0.40	92.58 ± 0.97	87.51 ± 0.78	83.63 ± 0.70	83.67 ± 0.67	< 0.001
Uric acid, μmol/L	437.98 ± 0.91	441.27 ± 2.63	441.70 ± 2.05	438.27 ± 1.59	434.47 ± 1.64	0.02

Data are presented as mean ± standard error for continuous variables and as count (percentage) for categorical variables.
BMI, body mass index; CVD, cardiovascular disease; eGFR, estimated glomerular filtration rate; SDOH, social determinants of health. *p* values were derived by comparison among the 4 groups with different scores of social determinants of health.

TABLE 2. Associations Between Social Determinant of Health Score with All-Cause and Cardiovascular Mortality in US Adult Individuals with Hyperuricemia or Gout.

	Crude model		Model 1		Model 2	
All-cause mortality						
SDOH score (continuous)	0.90 (0.87-0.92)	< 0.001	0.84 (0.81-0.88)	< 0.001	0.84 (0.81-0.88)	< 0.001
SDOH score category						
7-8	Ref.	/	Ref.	/	Ref.	/
5-6	1.85 (1.54-2.23)	< 0.001	1.53 (1.25-1.88)	< 0.001	1.48 (1.21-1.81)	< 0.001
3-4	1.97 (1.62-2.39)	< 0.001	1.91 (1.55-2.35)	< 0.001	1.85 (1.49-2.28)	< 0.001
≤ 2	1.58 (1.27-1.97)	< 0.001	2.46 (1.89-3.20)	< 0.001	2.38 (1.82-3.11)	< 0.001
Cardiovascular mortality						
SDOH score (continuous)	0.92 (0.88-0.96)	< 0.001	0.85 (0.79-0.91)	< 0.001	0.86 (0.80-0.92)	< 0.001
SDOH score category						
7-8	Ref.	/	Ref.	/	Ref.	/
5-6	2.13 (1.56-2.91)	< 0.001	1.73 (1.24-2.42)	0.001	1.62 (1.16-2.25)	0.004
3-4	1.82 (1.33-2.48)	< 0.001	1.78 (1.27-2.50)	< 0.001	1.65 (1.18-2.31)	0.004
≤ 2	1.34 (0.83-2.16)	0.23	2.25 (1.33-3.81)	0.003	2.10 (1.24-3.54)	0.006

The crude model was unadjusted. Model 1 was adjusted for age, sex, race, smoking, drinking, body mass index, and physical activity. Model 2 was further adjusted for hypertension, diabetes, hyperlipidemia, estimated glomerular filtration rate, use of statins and anti-gout agents, and cardiovascular disease, in addition to factors listed in Model 1.
SDOH, social determinants of health.

Restricted cubic spline analysis indicated an inverse, non-linear association between SDOH and mortality in the hyperuricemia/gout cohort, as shown in Figure 2. Similar patterns were observed in the control group for all-cause (p for non-linearity = 0.043) and cardiovascular (p for nonlinearity = 0.152) mortality.

Subgroup analysis

Associations between SDOH and mortality risks were consistently observed across subgroups stratified by sex, race, body mass index, diabetes status, and physical activity level, with no evidence of significant interaction. However, a significant effect modification by age was detected, with stronger associations of SDOH with both all-cause (p for interaction = 0.002) and cardiovascular mortality (p for interaction = 0.011) among participants younger than 60 years compared to those aged 60 years or older (Figure 3).

We further examined the interaction between SDOH and gout/hyperuricemia status on mortality risk. As indicated in Supplementary Table 4, the p for interaction was 0.35 for all-cause mortality and 0.09 for cardiovascular mortality.

Population-attributable fraction analysis

The population-attributable fraction analyses (Table 3) showed that unemployment and lack of access to health care contributed the most to all-cause and cardiovascular mortality, suggesting that improvements in these two factors could potentially reduce the risk of all-cause or cardiovascular mortality by 18.0% and 41.7%, respectively.

Sensitivity analysis

As shown in Supplementary Tables 5 and 6, the main results were supported by sensitivity analyses. In the first sensitivity analysis, relative to the reference group, HRs (95% CIs) for all-cause mortality increased from 1.46 (1.18–1.80) for a score of 5–6 to 2.26 (1.6–3.02) for ≤ 2, while the corresponding HRs (95% CIs) for cardiovascular mortality were 1.64 (1.14–2.36), 1.50 (1.02–2.19), and 2.15 (1.21–3.82). In the second sensitivity analysis, HRs (95% CIs) for SDOH scores of 5–6, 3–4, and ≤ 2 were 1.52 (1.18–1.97), 1.77 (1.35–2.32), and 2.35 (1.68–3.31) for all-cause mortality, and 1.73 (1.07–2.82), 1.99 (1.26–3.14), and 2.20 (1.06–4.59) for CVD mortality, respectively.

DISCUSSION

In this analysis of nationwide, large-scale data, we demonstrated that a lower SDOH score, reflecting social disadvantage, was associated with an elevated risk of all-cause and cardiovascular mortality in 6,560 adults with hyperuricemia and/or gout. Furthermore, this association remained robust and appeared stronger in participants < 60 years than in those aged ≥ 60 years. Employment status had the highest population-attributable fraction for all-cause mortality, while access to healthcare was the leading contributor to cardiovascular mortality. Importantly, a formal test for interaction between SDOH and gout/hyperuricemia status was non-significant. These findings indicate that adverse SDOH is linked to an increased mortality risk in patients with gout and/or hyperuricemia, and suggest that improving unemployment and access to healthcare may be the most effective strategies to enhance survival in this population.

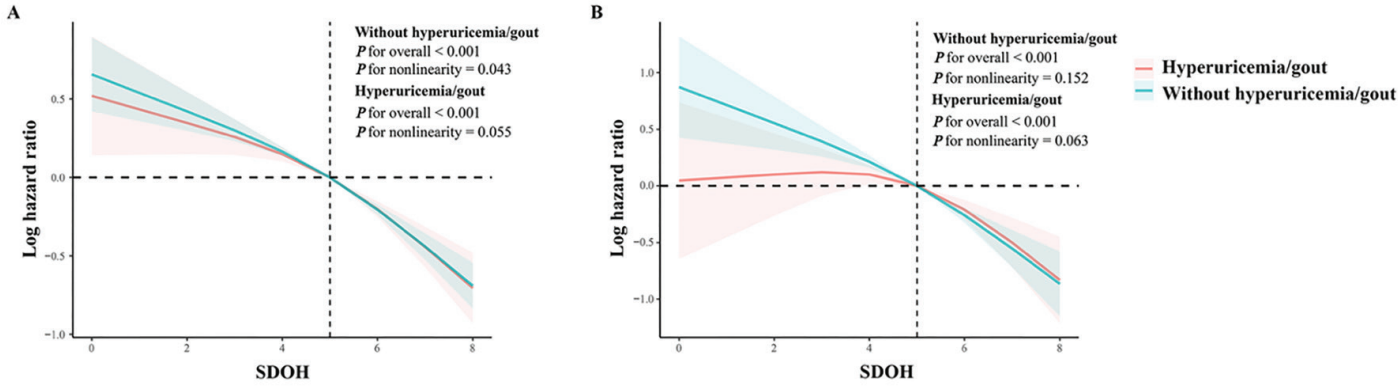

FIG. 2. Restricted cubic spline curves showing the dose-response relationship between social determinants of health (SDOH) score and all-cause (a) or cardiovascular mortality (b) in United States adults with and without hyperuricemia or gout.

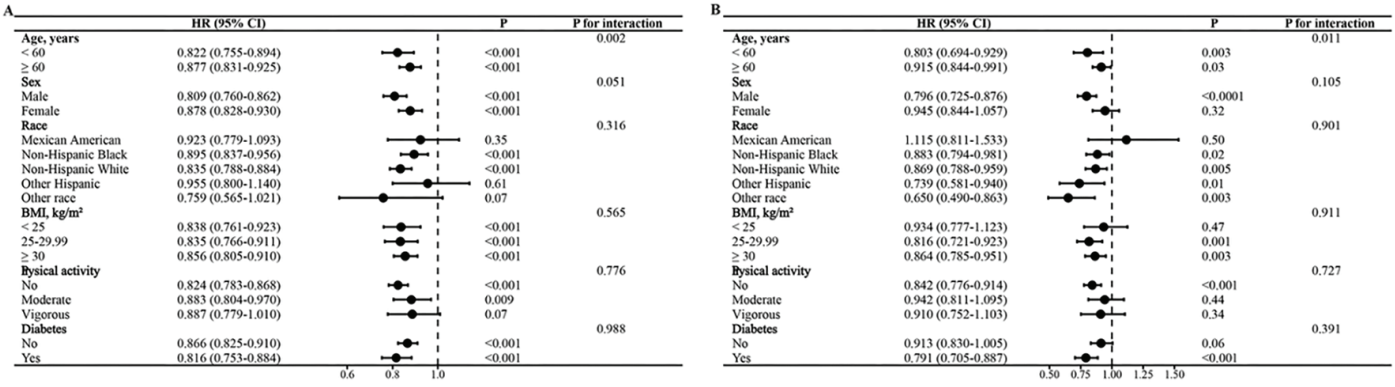

FIG. 3. Forest plots showing the associations between social determinants of health score and all-cause (a) or cardiovascular mortality (b) in United States adults with hyperuricemia or gout stratified by participant's age, sex, race, body mass index (BMI), physical activity, and diabetes status.
HR, hazard ratio; CI, confidence interval.

TABLE 3. Population Attributable Fraction Analysis of the Individual Factor for All-Cause and Cardiovascular Mortality in US Adults with Hyperuricemia or Gout.

	All-cause mortality (%) (95% CI)	Cardiovascular mortality (%) (95% CI)
Employment	18.0 (9.1, 28.8)	30.0 (9.1, 50.8)
Poverty-income ratio	6.0 (3.0, 9.1)	5.6 (0.2, 11.1)
Food security	-4.0 (-12.8, 4.0)	-0.9 (-18.1, 16.2)
Education level	3.6 (0.5, 7.5)	0.1 (-6.1, 6.7)
Access to health care	-1.0 (-9.0, 3.7)	41.7 (16.7, 66.8)
Health insurance type	-2.0 (-7.2, 13.2)	-4.1 (-13.0, 3.4)
Housing instability	11.2 (-3.1, 26.4)	-5.7 (-20.0, 8.6)
Marital status	-3.2 (-7.0, 1.5)	-2.0 (-10.4, 6.5)

CI, confidence interval.

Hyperuricemia and/or gout is well-known to exhibit substantial disparities in incidence and treatment. Contrary to its traditional classification as a "rich man's disease," the study by Bowen-Davies et al.[9] demonstrated that lower socioeconomic status at the individual and community level is associated with greater frequency and severity of gout flares. Our study extends this disparity to long-term outcomes, further highlighting the close association between unfavorable SDOH and increased mortality risk. In this study, a lower SODH score was associated with younger age, female sex, non-Hispanic Black race, unhealthy lifestyle factors, and higher body mass index. These characteristics of social disadvantage are not limited to gout or hyperuricemia but also apply to the general population.[24]

The current study suggests that, compared with participants who had an SDOH of 7–8, those with scores of 5–6, 3–4, and ≤ 2 experienced a 48%, 85%, and 138% higher risk of all-cause mortality, and a 62%, 65%, and 110% higher risk of cardiovascular mortality, respectively. The precise explanations for the associations between lower SDOH and increased mortality in individuals with hyperuricemia and/or gout remain only partially understood. Prior research has highlighted several explanations for the increased mortality risk observed in those with unfavorable SDOH. First, participants with adverse SDOH may have limited access to medications due to high costs or neglect,[25] as shown by the significantly lower use of statins and antigout medications in this cohort. These findings echo earlier work linking socioeconomic disadvantage to worse gout-related outcomes, including greater disease severity and lower adherence to therapy.[26] Second, unhealthy behaviors and chronic morbidities may be more prevalent among individuals with less favorable SDOH.[27] Third, individuals with lower SDOH may have reduced access to social and economic resources and healthy foods, potentially influencing lifestyle choices, resource allocation, and behavioral engagement. A previous population study showed that a healthy lifestyle, characterized by non-smoking, adequate physical activity, a healthy diet, and no to moderate alcohol use, can reduce the risk of gout by one third, even among genetically predisposed individuals.[28] Ultimately, studies suggest that lower SDOH may be linked to chronic psychological stress, triggering a pro-inflammatory state and diminished sensitivity to regulatory mechanisms.[29] Such inflammation may increase the risk of cardiovascular disease and infection, both of which can increase mortality rate.

Stratified analysis showed the inverse relationship between lower SDOH and mortality was more pronounced in participants younger than 60 years. In this study, individuals with an adverse SDOH profile tended to be younger, implying that young adults with hyperuricemia or gout may be more likely to be socioeconomically disadvantaged. A prior study comparing early-onset and late-onset gout found that early-onset gout is linked to lifestyle factors, whereas late-onset gout is associated with greater cardio-metabolic burden.[30] Given the close association between SDOH and lifestyle behaviors, our findings suggest a potential opportunity to improve outcomes in young adults with hyperuricemia or gout by targeting SDOH.

Notably, our interaction analysis showed that the relationship between adverse SDOH and cardiovascular mortality tended to be stronger in the non-disease control group. This finding suggests that individuals without hyperuricemia and/or gout may be more susceptible to the cardiovascular impacts of social disadvantage. We hypothesize that in patients with a high-risk condition like hyperuricemia and/or gout, mortality risk may be primarily driven by powerful clinical factors, thereby overshadowing the relative contribution of SDOH.[31] Conversely, among relatively healthier individuals, the absence of such dominant clinical risks may allow the impact of social determinants to become more evident. These results highlight the importance of implementing comprehensive clinical and public health interventions that address both biological risk factors and social determinants, tailored to the needs of different patient populations.

The population-attributable fraction analysis indicated that not all SDOH domains contributed equally to mortality risk in adults with hyperuricemia and/or gout. Improving unemployment and enhancing access to healthcare would theoretically be the most effective measures to reduce all-cause and cardiovascular mortality, respectively. Indeed, unemployment has been linked to heavy alcohol consumption and higher mortality rates in various populations.[32] Substantial evidence connects heavy alcohol consumption with triggering gout flares and exacerbating hyperuricemia.[33] The reason why access to healthcare was the strongest contributor to cardiovascular mortality may relate to the fact that cardiovascular conditions, such as acute coronary syndrome, can be reduced or prevented with timely healthcare access.

Another notable finding of this study is that adults with hyperuricemia and/or gout and an SDOH score of 7–8 had long-term outcomes comparable to the control group. In contrast, those with SDOH score < 6 experienced significantly worse outcomes, highlighting the critical role of SDOH in shaping long-term prognosis. This finding carries important implications for public health policy and clinical practice. On one hand, policymakers and public health officials should work to expand health insurance coverage and ensure timely access to high-quality primary care for common chronic conditions such as gout and hyperuricemia. Moreover, our study suggest that clinicians caring for patients with hyperuricemia or gout should also screen for socioeconomic status to provide targeted, integrated care.

This study benefits from a large, nationally representative sample, rigorous sensitivity analyses supporting the robustness of the findings, and detailed evaluation of individual SDOH factors. However, several limitations warrant consideration. First, most SDOH factors included were measured at the individual level. Prior studies indicate that neighborhood- or state-level factors, such as living environment, regional economic status, transportation, geographic remoteness, religious beliefs, and regional availability of medical resources, may also significantly affect mortality risk in patients with chronic conditions.[34,35] Additionally, because SDOH variables were collected through interviews and questionnaires, recall bias cannot be excluded. Second, all SDOH variables were measured once, which may not capture the effects of changes in SDOH over the life course on mortality risk.[36] Third, some variables may also partially capture the broader spectrum of socioeconomic inequality. For example, marital status in the "Social and Community Context" domain may reflect social support networks but cannot fully represent the complexity of social relationships or levels of social engagement. Fourth, although we adjusted for multiple confounders, the possibility of residual confounding, such as psychological stress—remains.[37] It is also important to emphasize that although hyperuricemia and gout share considerable overlap, they remain distinct clinical entities. Fifth, the use of a single adjustment set for all population-attributable fraction models ensures comparability but prevents causal interpretation of individual covariate coefficients due to potential mediation or mutual confounding. Finally, because of the retrospective observational design, establishing causality between SDOH and mortality will require further prospective cohort studies.

In conclusion, this large, nationwide observational study showed that a less favorable SDOH score is an independent determinant of higher mortality risk in US adults with hyperuricemia or gout, with the association particularly strong in adults aged < 60 years. Furthermore, the population-attributable fraction analysis indicated that improving unemployment and broadening health insurance coverage would be the most effective approaches to reducing all-cause and cardiovascular mortality, respectively. Moreover, the impact of unfavorable SDOH on cardiovascular mortality tended to be more pronounced in participants without hyperuricemia and/or gout with those with these conditions.

Ethics Committee Approval: This study utilized data from the publicly available National Health and Nutrition Examination Survey (NHANES). The NHANES protocol was approved by the National Center for Health Statistics Ethics Review Board, and written informed consent was obtained from all participants. As the data are de-identified and publicly accessible, no further ethical approval was required from our institution.

Informed Consent: All individuals participating in NHANES provided written informed consent.

Data Sharing Statement: The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Authorship Contributions: Concept- S.L.; Design- S.L.; Fundings- C.L.; Data Collection or Processing- S.S., Y.Z.; Analysis or Interpretation- C.L., Q.W., Y.Z.; Writing- C.L., Q.W.; Critical Review- S.L.

Conflict of Interest: The authors declare that they have no conflict of interest.

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Supplementary Tables: https://www.balkanmedicaljournal.org/img/files/BalkanMedJ-2025-6-149-supplement-table.pdf

Supplementary Figure: https://www.balkanmedicaljournal.org/img/files/BalkanMedJ-2025-6-149-supplement-figure.pdf

REFERENCES

1. Vareldzis R, Perez A, Reisin E. Hyperuricemia: an intriguing connection to metabolic syndrome, diabetes, kidney disease, and hypertension. *Curr Hypertens Rep*. 2024;26:237-245. [CrossRef]
2. Safiri S, Kolahi AA, Cross M, et al. Prevalence, incidence, and years lived with disability due to gout and its attributable risk factors for 195 countries and territories 1990-2017: a systematic analysis of the Global Burden of disease study 2017. *Arthritis Rheumatol*. 2020;72:1916-1927. [CrossRef]
3. Butler F, Alghubayshi A, Roman Y. The Epidemiology and genetics of hyperuricemia and gout across major racial groups: a literature review and population genetics secondary database analysis. *J Pers Med*. 2021;11:231. [CrossRef]
4. McCormick N, Lu N, Yokose C, et al. Racial and sex disparities in gout prevalence among US adults. *JAMA Netw Open*. 2022;5:e2226804. [CrossRef]
5. Braveman P, Gottlieb L. The social determinants of health: it's time to consider the causes of the causes. *Public Health Rep*. 2014;129(Suppl 2):19-31. [CrossRef]
6. Reyes-Ortiz CA, Marín-Vargas E, Ocampo-Chaparro JM. Social determinants of health and metabolic syndrome in Colombian older adults. *Nutr Metab Cardiovasc* Dis. 2024;34:1751-1760. [CrossRef]
7. Hill-Briggs F, Adler NE, Berkowitz SA, et al. Social determinants of health and diabetes: a scientific review. *Diabetes Care*. 2020;44:258-279. [CrossRef]
8. Lu J, Li M, He J, et al. Association of social determinants, lifestyle, and metabolic factors with mortality in Chinese adults: a nationwide 10-year prospective cohort study. *Cell Rep Med*. 2024;5:101656. [CrossRef]
9. Bowen-Davies Z, Muller S, Mallen CD, Hayward RA, Roddy E. Gout severity, socioeconomic status, and work absence: a cross-sectional study in primary care. *Arthritis Care Res (Hoboken)*. 2018;70:1822-1828. [CrossRef]
10. Kiadaliri A, Moreno-Betancur M, Turkiewicz A, Englund M. Educational inequalities in all-cause and cause-specific mortality among people with gout: a register-based matched cohort study in southern Sweden. *Int J Equity Health*. 2019;18:164. [CrossRef]
11. Yokose C, McCormick N, Lu N, et al. Trends in prevalence of gout among US Asian adults, 2011-2018. *JAMA Netw Open*. 2023;6:e239501. [CrossRef]
12. Bundy JD, Mills KT, He H, et al. Social determinants of health and premature death among adults in the USA from 1999 to 2018: a national cohort study. *Lancet Public Health*. 2023;8:e422-e431. [CrossRef]
13. Zhu R, Wang R, He J, et al. Prevalence of cardiovascular-kidney-metabolic syndrome stages by social determinants of health. *JAMA Netw Open*. 2024;7:e2445309. [CrossRef]
14. Li J, Lei L, Wang W, et al. Social risk profile and cardiovascular-kidney-metabolic syndrome in US adults. *J Am Heart Assoc*. 2024;13:e034996. [CrossRef]
15. Liang JH, Liu ML, Pu YQ, et al. Cumulative inequality in social determinants of health in relation to depression symptom: An analysis of nationwide cross-sectional data from U.S. NHANES 2005-2018. *Psychiatry Res*. 2024;336:115894. [CrossRef]
16. Xiong R, Zhou X. Social determinants of health and all-cause or cardiovascular mortality on osteoarthritis adults in the USA: a national cohort study. *Front Public Health*. 2025;13:1676418. [CrossRef]
17. Mirel LB, El Bural Félix S, Zhang C, Golden C, Cox CS. Comparative analysis of the national health interview survey public-use and restricted-use linked mortality files. *Natl Health Stat Report*. 2020:1-32. [CrossRef]
18. Kong X, Wang W. Synergistic effect of psoriasis and metabolic syndrome on risk of all-cause and cardiovascular mortality in US adults: a nationwide cohort study. *Clin Exp Dermatol*. 2024;50:113-119. [CrossRef]
19. Shao Y, Wang N, Shao M, et al. The lean body mass to visceral fat mass ratio is negatively associated with cardiometabolic disorders: a cross-sectional study. *Sci Rep*. 2025;15:3422. [CrossRef]
20. Zhang Q, Xiao S, Jiao X, Shen Y. The triglyceride-glucose index is a predictor for cardiovascular and all-cause mortality in CVD patients with diabetes or pre-diabetes: evidence from NHANES 2001-2018. *Cardiovasc Diabetol*. 2023;22:279. [CrossRef]
21. Kong X, Wang W. Associations between the composite dietary antioxidant index and abdominal aortic calcification among United States adults: a cross-sectional study. *JPEN J Parenter Enteral* Nutr. 2024;48:571-579. [CrossRef]
22. Levey AS, Stevens LA, Schmid CH, et al. A new equation to estimate glomerular filtration rate. Erratum in: *Ann Intern Med*. 2011;155:408. [CrossRef]
23. Xu L, Chen F, Huang Y, You B, Zhang X, Sun B. Social determinants of health and all-cause or cardiovascular mortality in chronic kidney disease: insights from 1999-2018 US National Health and Nutrition Examination Survey. *Ren Fail*. 2025;47:2506811. [CrossRef]
24. Röhr S, Wittmann F, Engel C, et al. Social factors and the prevalence of social isolation in a population-based adult cohort. *Soc Psychiatry Psychiatr Epidemiol*. 2022;57:1959-1968. [CrossRef]
25. Hayward RA, Rathod T, Roddy E, Muller S, Hider SL, Mallen CD. The association of gout with socioeconomic status in primary care: a cross-sectional observational study. *Rheumatology (Oxford)*. 2013;52:2004-2008. [CrossRef]
26. Zandman-Goddard G, Amital H, Shamrayevsky N, Raz R, Shalev V, Chodick G. Rates of adherence and persistence with allopurinol therapy among gout patients in Israel. *Rheumatology (Oxford)*. 2013;52:1126-1131. [CrossRef]
27. Smith J, Martin A, Mundadan J, et al. Exploring the prevalence of gout among underrepresented low socioeconomic status type 2 diabetes populations. *Diabetol Metab Syndr*. 2025;17:25. [CrossRef]
28. Zhang Y, Yang R, Dove A, et al. Healthy lifestyle counteracts the risk effect of genetic factors on incident gout: a large population-based longitudinal study. *BMC Med*. 2022;20:138. [CrossRef]
29. Lam PH, Chen E, Chiang JJ, Miller GE. Socioeconomic disadvantage, chronic stress, and proinflammatory phenotype: an integrative data analysis across the lifecourse. *PNAS Nexus*. 2022;1:pgac219. [CrossRef]
30. Zhang B, Fang W, Zeng X, et al. Clinical characteristics of early- and late-onset gout: a cross-sectional observational study from a Chinese gout clinic. *Medicine (Baltimore)*. 2016;95:e5425. [CrossRef]
31. Wang Z, Chang X, Chen H, Wang Y, Tang X, Qin Y. Social determinants of health and mortality on hyperuricemia adults in the USA from 2007 to 2016: a national cohort study. *BMC Public Health*. 2025;25:1970. [CrossRef]

32. Saul C, Lange S, Probst C. Employment status and alcohol-attributable mortality risk-a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2022;19:7354. [CrossRef]
33. Neogi T, Chen C, Niu J, Chaisson C, Hunter DJ, Zhang Y. Alcohol quantity and type on risk of recurrent gout attacks: an internet-based case-crossover study. *Am J Med*. 2014;127:311-318. [CrossRef]
34. Feng T, Li C, Zheng J, et al. Prevalence of and Risk Factors for Hyperuricemia in Urban Chinese Check-Up Population. *Int J Endocrinol*. 2024;2024:8815603. [CrossRef]
35. Pan Z, Huang M, Fang M, Xie X, Huang Z. Socioeconomic differences in hyperuricemia and gout: a systematic review and meta-analysis. *Endocrine*. 2020;69:286-293. [CrossRef]
36. Thimm-Kaiser M, Benzekri A, Guilamo-Ramos V. Conceptualizing the mechanisms of social determinants of health: a heuristic framework to inform future directions for mitigation. *Milbank Q*. 2023;101:486-526. [CrossRef]
37. Serlachius A, Gamble G, House M, et al. Illness perceptions and mortality in patients with gout: a prospective observational study. *Arthritis Care Res (Hoboken)*. 2017;69:1444-1448. [CrossRef]