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ORIGINAL RESEARCH

# Social Determinants of Health, Cardiovascular Health, and Outcomes in Community-Dwelling Adults Without Cardiovascular Disease

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## ABSTRACT

**BACKGROUND** Limited data exist regarding the prognostic implications of social determinants of health (SDOH) and cardiovascular health (CVH) in Chinese community populations.

**OBJECTIVES** The aim of this study was to evaluate the associations of SDOH and CVH with major adverse cardiovascular events (MACE) and all-cause death.

**METHODS** Individuals without cardiovascular disease were obtained from the China Patient-Centered Evaluative Assessment of Cardiac Events Million Persons Project. SDOH (educational attainment, economic stability, health care access, social support, and neighborhood) and CVH components were extracted. Participants were divided into groups with low and high burden of unfavorable SDOH and groups with poor, intermediate, and ideal CVH. MACE (a composite of coronary heart disease or myocardial infarction, stroke, heart failure, and cardiovascular death) and all-cause death were identified by linking hospital records with resident identity card number.

**RESULTS** Among the cohort (n = 38,571, median age 54 years, 60.5% women), the proportion of individuals with a high burden of unfavorable SDOH was 68.9%, and that with poor CVH was 30.7%. In reference to the group with a low burden of unfavorable SDOH, the adjusted HRs for MACE and all-cause death in the high burden group were 1.18 (95% CI: 1.08-1.30) and 1.35 (95% CI: 1.09-1.68), respectively. In reference to the group with ideal CVH, poor CVH was associated with higher risks for MACE and all-cause death. A high burden of unfavorable SDOH and poor CVH exerted joint effects on all-cause death (HR: 2.20; 95% CI: 1.08-4.48).

**CONCLUSIONS** A high burden of unfavorable SDOH and poor CVH were associated with increased risks for MACE and mortality. Dedicated efforts are needed to address these health disparities. (JACC: Asia 2024;4:44–54) © 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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Cardiovascular disease (CVD) is the leading cause of morbidity and mortality worldwide.[1-3] To reduce CVD burden, improvement in the management of traditional risk factors such as hypertension, dyslipidemia, diabetes, and obesity is fundamentally important.[1-3] These risk factors are potentially modifiable.[4,5] However, observational studies have shown that in the real-world setting, the control rates of these risk factors are low, particularly in low- and middle-income countries that contribute to a large proportion of global CVD burden.[1-3] Early prevention of CVD risk factors is cost effective with respect to reducing CVD burden, particularly in low- and middle-countries, where health care resources are limited.[1-3]

Factors associated with CVD risk development are complex and multifactorial, including lifestyle, genetic background, and environmental factors, among others.[4,5] In 2003, the World Health Organization presented a comprehensive framework of social determinants of health (SDOH), which are also associated with the development of CVD risk factors and various cardiovascular (CV) outcomes. Unlike traditional risk factors such as lifestyle, SDOH provide a different view of how crucial education, economic status, access to health care, social support, and neighborhood and environment are in the development of CVD risk.[6,7] The American Heart Association recently published Life's Essential 8, aiming to promote CV health (CVH) and the early prevention of CVD risk factors and ultimately to reduce CVD burden.[8] CVH includes health behaviors (diet, physical activity, smoking status, and sleep status) and factors (body mass index [BMI], non-high-density lipoprotein [HDL], blood glucose, and blood pressure) that are closely associated with SDOH.[9-16] These data were drawn mainly from developed countries,[9-15] and limited data exist regarding the association between SDOH and CVH in less developed countries such as China.[16] In addition, several studies among Western populations have suggested that SDOH are associated with CVD and mortality.[17-21] Nonetheless, to our knowledge, no study has specifically evaluated the associations between SDOH and CVD events in the Chinese population. In light of the huge and increasing CVD burden in the low- and middle-income countries,[1-3] enhancing our knowledge about the influences of SDOH on CVH and CVD development has important public health implications with respect to reducing global CVD burden.

The China Patient-Centered Evaluative Assessment of Cardiac Events (PEACE) Million Persons Project is a nationwide population-based CVD screening project. Using data from Guangdong Province, we included community-dwelling adults free of CVD and aimed to evaluate: 1) the association between SDOH and CVH; 2) the influences of SDOH on individual components and composite major adverse CV events (MACE) and all-cause death; 3) whether the association between CVH and MACE and all-cause death is modified by SDOH; and 4) whether SDOH and CVH exert joint effects on MACE and all-cause death.

**ABBREVIATIONS AND ACRONYMS**

**BMI** = body mass index
**CHD** = coronary heart disease
**CV** = cardiovascular
**CVD** = cardiovascular disease
**CVH** = cardiovascular health
**HDL** = high-density lipoprotein
**MACE** = major adverse cardiovascular event(s)
**MI** = myocardial infarction
**PEACE** = Patient-Centered Evaluative Assessment of Cardiac Events
**SDOH** = social determinant(s) of health

## METHODS

**STUDY DESIGN AND PARTICIPANTS.** Detailed information of the China PEACE Million Persons Project has been provided previously.[22,23] Briefly, the China PEACE Million Persons Project is a nationwide population-based study whose aim is to screen and evaluate the burden of prevalent CVD (including ischemic heart disease and ischemic and hemorrhagic stroke) in mainland China. Community-dwelling adults 35 to 75 years of age and currently registered in the selected region's Hukou (an official record identifying residents in the region) were eligible for the study. A purposive sampling method was used, and participants were recruited using extensive publicity campaigns on television and in newspapers. The present study was conducted in Guangdong Province, which is a subcohort of the China PEACE Million Persons Project. From 2016 to 2020, a total of 102,358 participants from 8 sites in Guangdong Province were enrolled after written inform consent was obtained. After excluding those with incomplete data on diet (n = 60,983) or physical activity (n = 60,836), those who had CVD at baseline (n = 2,033), and those lost to follow-up (n = 15), 38,571 participants free of CVD were included for the present study (Supplemental Figure 1). Baseline characteristics of included and excluded participants are shown in Supplemental Table 1. The study was approved by the central ethics committee at the China National Center for Cardiovascular Disease and the ethics committee of Guangdong Provincial People's Hospital (GDREC2016438H [R2]). All procedures were performed in accordance with the Declaration of Helsinki.

**DATA COLLECTION AND STUDY VARIABLES.** Data on demographics (age and sex), SDOH, CVH behaviors and factors, comorbid conditions (hypertension, dyslipidemia, and diabetes), and current medications were recorded during in-person

**TABLE 1 Definitions of SDOH**

| SDOH | Measures Used | Favorable SDOH Score = 1 Point |
|---|---|---|
| Educational attainment | Highest level of schooling completed | High school or more |
| Economic stability | Annual household income | ≥50,000 RMB |
| Health care access | Health insurance status | Insured |
| Social support | Marital status | Married and live with spouse |
| Neighborhood/ environment | Urbanization | Urban area |

RMB = renminbi; SDOH = social determinant(s) of health.

interviews conducted by trained staff members. Height and body weight were measured using standard protocols, and BMI was calculated by dividing weight in kilograms by the square of height in meters. Blood pressure was measured 2 times on the right upper arm after 5 minutes of rest in a seated position using an electronic blood pressure monitor (HEM-7430, Omron), and the average value was used. Fasting plasma glucose (BeneCheck BK6-20M Multi-Monitoring System, Suzhou Pu Chun Tang Biotechnology) and lipid profiles (CardioChek PA Analyzer, Polymer Technology Systems) were measured using fingertip blood samples, as described previously.[24]

**DEFINITION AND CLASSIFICATION OF SDOH AND CVH.** SDOH included educational attainment, economic stability, health care access, social support, and neighborhood and environment. The definitions of SDOH are shown in Table 1. Each favorable SDOH was assigned a value of 1, a value of 0 represented an unfavorable SDOH, and the values of SDOH were summed to create a total score that reflected overall SDOH status. An overall SDOH value of 0 to 3 was defined as a high burden of unfavorable SDOH, and a value of 4 or 5 indicated a low burden of unfavorable SDOH. The questionnaire used to record CVH information and definition of CVH is shown in Supplemental Table 2, and the classification of CVH components is presented in Supplemental Table 3. As described previously,[25] each of the 8 CVH components was assigned a value of 0 if poor, 1 if intermediate, and 2 if ideal. The values of the components were summed to create a total score that reflected overall CVH status. An overall CVH score of 0 to 8 was defined as poor, 9 to 12 as intermediate, and 13 to 16 as ideal.

**STUDY OUTCOMES.** Study outcomes included MACE (a composite of coronary heart disease [CHD] or myocardial infarction [MI], stroke, heart failure, and CV death), individual MACE components, and all-cause death. All these events were identified by linking hospital records with resident identity card number and adjudicated by study investigators who were unaware of the SDOH and CVH status of the participants. Specifically, CHD or MI was ascertained on the basis of the presence of chest pain or dyspnea, electrocardiographic alteration, coronary artery stenosis (≥50%) on imaging examination, and/or elevation of serum cardiac troponin level. Stroke was ascertained on the basis of the presence of neurologic deficit (eg, abnormal reflex and inability to speak) and cerebrovascular occlusion on imaging examination. Heart failure was ascertained on the basis of the presence of symptoms or signs (eg, dyspnea, ankle swelling), abnormality of cardiac structure or function on echocardiography, and elevation of natriuretic peptide level. If a death event was directly due to CV or cerebrovascular disease, this event was ascertained as CV death and otherwise as a non-CV death. Follow-up duration was calculated from the date of baseline interview to the date of first MACE or all-cause death event or to the end of December 2021 if no event occurred.

**STATISTICAL ANALYSIS.** Baseline characteristics and incidence rates of MACE, its components, and all-cause death were compared between the 2 SDOH groups. Distribution of continuous variables was examined using the Kolmogorov-Smirnov test, and continuous variables are expressed as median (Q1-Q3) if not normally distributed and compared using the Mann-Whitney *U* test. Categorical variables are presented as frequency (proportion) and were compared using the chi-square test. A Cox proportional hazards model was used to evaluate the association between overall SDOH status and individual SDOH with risk for outcomes, and the group with a low burden of unfavorable SDOH was served as the reference group. On the basis of prior studies and clinical knowledge,[1-3] covariates including age, sex, drinking status, and CVH components (diet, smoking, physical activity, sleep status, BMI, non-HDL, fasting blood glucose, and systolic and diastolic blood pressure) were incorporated in the models. The relationship between per 1-point increase in the overall SDOH and CVH score was evaluated using linear regression analysis, and estimated regression β coefficients and 95% CIs are reported. The association between CVH and risk for outcomes was determined stratified by overall SDOH status, and the group with poor CVH served as the reference group; *P* values for interaction are

reported. In addition, to evaluate whether SDOH and CVH exerted joint effects on outcomes, participants were stratified by overall SDOH and CVH status, resulting in 6 subgroups, and the group with low burden of unfavorable SDOH and ideal CVH served as the reference group in the Cox proportional hazards model. Age and sex were included in the model, and HRs and 95% CIs are reported. All analyses were conducted using R version 3.33 (R Project for Statistical Computing). All statistical testing was 2-sided, at a significance level of $P < 0.05$.

## RESULTS

**BASELINE CHARACTERISTIC COMPARISONS BETWEEN THE GROUPS WITH HIGH AND LOW BURDEN OF UNFAVORABLE SDOH.** Among the overall participants, the median age was 54 years, 60.5% were women, 68.9% had a high burden of unfavorable SDOH, and 30.7% had poor CVH. As shown in **Table 2**, compared with the group with a low burden of unfavorable SDOH, individuals in the group with a high burden of unfavorable SDOH were older, more likely to be women, and more likely to have poor CVH. Overall SDOH were positively correlated with CVH score ($\beta = 0.12$; 95% CI: 0.09-0.14; $P < 0.001$).

**COMPARISONS OF OUTCOMES BETWEEN THE GROUPS WITH HIGH AND LOW BURDEN OF UNFAVORABLE SDOH.** After a median follow-up duration of 3.56 years (Q1-Q3: 2.65-4.44 years), the incidence rates of MACE, its components, and all-cause death were significantly higher in the group with a high burden of unfavorable SDOH (**Table 3**). After adjustment for covariates, a high burden of unfavorable SDOH remained independently associated with higher risks for MACE (HR: 1.18; 95% CI: 1.08-1.30), stroke (HR: 1.27; 95% CI: 1.12-1.44), CV death (HR: 1.69; 95% CI: 1.09-2.62), and all-cause death (HR: 1.35; 95% CI: 1.09-1.68). With respect to individual SDOH (**Table 4**), lower educational attainment was associated with higher risks for MACE (HR: 1.22; 95% CI: 1.10-1.35) and all-cause death (HR: 2.07; 95% CI: 1.60-2.69), as was poorer social support (for MACE, HR: 1.19; 95% CI: 1.04-1.35; for all-cause death, HR: 1.31; 95% CI: 1.00-1.73).

**ASSOCIATION BETWEEN CVH AND OUTCOMES IN THE GROUPS WITH HIGH AND LOW BURDEN OF UNFAVORABLE SDOH.** In both SDOH groups, individuals with intermedia and ideal CVH had lower incidence rates of MACE, its components, and all-cause death in comparison with those with poor CVH (Supplemental Figure 2). After adjustment for covariates, in the group with a high burden of unfavorable SDOH, intermediate and ideal CVH remained independently associated with lower risks for MACE, its components, and all-cause death, and there was a gradient of association between CVH status and outcomes ($P$ for trend $< 0.001$). In the group with a low burden of unfavorable SDOH, intermediate and ideal CVH was independently associated with a lower risk for MACE and its components, except for CV death and all-cause death. However, there was no significant interaction between CVH and outcomes by SDOH ($P$ for interaction $>0.05$ for all).

**JOINT EFFECTS OF SDOH AND CVH ON OUTCOMES.** As shown in **Figure 1** and Supplemental Table 4, with reference to the subgroup with a low burden of unfavorable SDOH and ideal CVH, the HRs for MACE (2.73; 95% CI: 1.93-3.85), CHD or MI (3.49; 95% CI: 2.01-6.06), and heart failure (2.62; 95% CI: 1.31-5.25) were highest in the subgroup with a low burden of unfavorable SDOH and poor CVH; and the HR for all-cause death (2.20; 95% CI: 1.08-4.48) was highest in the subgroup with a high burden of unfavorable SDOH and poor CVH.

## DISCUSSION

To our knowledge, this is the first large-scale, population-based study to evaluate the influences of SDOH on CVH and adverse clinical outcomes in community-dwelling adults free of CVD in China. There are 3 important findings (**Central Illustration**). First, SDOH was positively correlated with CVH, and a high burden of unfavorable SDOH was associated with increased risk for MACE and all-cause death. Low educational attainment and poor social support were more strongly associated with outcomes, while a consistent association between income and mortality was not observed. Second, poor CVH was associated with adverse clinical outcomes, and the effect of CVH on MACE and mortality was not modified by overall SDOH status. Third, a high burden of unfavorable SDOH and poor CVH exerted joint effects on all-cause death. These findings support the notion that evaluation of SDOH is helpful to identify community populations with high CVD risk.[6,7] Future studies are needed to investigate how to effectively address these social factors so as to reduce the emerging CVD burden in China.[26]

Numerous studies have evaluated the associations between SDOH with CVD risk factors and events in different population groups, and the results of these studies demonstrated that a high burden of

**TABLE 2 Baseline Characteristics According to High and Low Burden of Unfavorable SDOH**

| | Overall (N = 38,571) | High Burden (n = 26,575) | Low Burden (n = 11,996) | *P* Value |
|---|---|---|---|---|
| Demographics | | | | |
| Age, y | 54.0 (47.0-63.0) | 56.0 (48.0-64.0) | 51.0 (43.0-59.0) | <0.001 |
| Women | 23,346 (60.5) | 16,894 (63.6) | 6,452 (53.8) | <0.001 |
| SDOH | | | | |
| Education high school or greater | 11,655 (30.2) | 3,132 (11.8) | 8,523 (71.0) | <0.001 |
| Annual household income ≥50,000 RMB | 18,056 (46.8) | 8,365 (31.5) | 9,691 (80.8) | <0.001 |
| Insured | 36,251 (94.7) | 24,637 (92.7) | 11,884 (99.1) | <0.001 |
| Married and live with spouse | 34,959 (90.6) | 23,184 (87.2) | 11,775 (98.2) | <0.001 |
| Urban area | 16,227 (42.2) | 7,253 (27.3) | 9,024 (75.2) | <0.001 |
| CVH behaviors | | | | |
| Diet | | | | <0.001 |
| Poor | 1,537 (4.0) | 1,172 (4.4) | 365 (3.0) | |
| Intermediate | 20,149 (52.2) | 14,359 (54.0) | 5,790 (48.3) | |
| Ideal | 16,885 (43.8) | 11,044 (41.6) | 5,841 (48.7) | |
| Physical activity | | | | <0.001 |
| Poor | 21,429 (55.6) | 15,330 (57.7) | 6,099 (50.8) | |
| Intermediate | 4,131 (10.7) | 2,693 (10.1) | 1,438 (12.0) | |
| Ideal | 13,011 (33.7) | 8,552 (32.2) | 4,459 (37.2) | |
| Smoking status | | | | <0.001 |
| Poor | 6,748 (17.5) | 4,563 (17.2) | 2,185 (18.2) | |
| Intermediate | 1,226 (3.2) | 755 (2.8) | 471 (3.9) | |
| Ideal | 30,597 (79.3) | 21,257 (80.0) | 9,340 (77.9) | |
| Sleep status | | | | <0.001 |
| Poor | 4,618 (12.0) | 2,850 (10.7) | 1,768 (14.7) | |
| Intermediate | 18,873 (48.9) | 12,638 (47.6) | 6,235 (52.0) | |
| Ideal | 15,080 (39.1) | 11,087 (41.7) | 3,993 (33.3) | |
| CVH factors | | | | |
| BMI | | | | <0.001 |
| Poor | 5,011 (13.0) | 3,608 (13.6) | 1,403 (11.7) | |
| Intermediate | 14,675 (38.0) | 10,200 (38.4) | 4,475 (37.3) | |
| Ideal | 18,885 (49.0) | 12,767 (48.0) | 6,118 (51.0) | |
| Non-HDL | | | | 0.001 |
| Poor | 11,322 (29.4) | 7,863 (29.6) | 3,459 (28.8) | |
| Intermediate | 9,072 (23.5) | 6,352 (23.9) | 2,720 (22.7) | |
| Ideal | 18,177 (47.1) | 12,360 (46.5) | 5,817 (48.5) | |
| Blood glucose | | | | <0.001 |
| Poor | 6,482 (16.8) | 4,749 (17.9) | 1,733 (14.4) | |
| Intermediate | 14,267 (37.0) | 9,764 (36.7) | 4,503 (37.5) | |
| Ideal | 17,822 (46.2) | 12,062 (45.4) | 5,760 (48.0) | |
| Blood pressure | | | | <0.001 |
| Poor | 16,981 (44.0) | 12,241 (46.1) | 4,740 (39.5) | |
| Intermediate | 11,808 (30.6) | 8,228 (31.0) | 3,580 (29.8) | |
| Ideal | 9,782 (25.4) | 6,106 (23.0) | 3,676 (30.6) | |
| Overall CVH status | | | | <0.001 |
| Poor | 11,836 (30.7) | 8,479 (31.9) | 3,357 (28.0) | |
| Intermediate | 21,940 (56.9) | 15,185 (57.1) | 6,755 (56.3) | |
| Ideal | 4,795 (12.4) | 2,911 (11.0) | 1,884 (15.7) | |

Values are median (Q1-Q3) or (n (%).

BMI = body mass index; CVH = cardiovascular health; HDL = high-density lipoprotein; SDOH = social determinants of health.

unfavorable SDOH was independently associated with the development of CVD risk factors[9-16] and CVD events.[20,21,27-32] One recent study from China showed that lower socioeconomic status was associated with increased risk for incident hypertension.[16] Consistent with results from developed countries,[20,21,27-32] the results of the present study confirm that in Chinese community populations free of CVD, SDOH were independently associated with risk for MACE and all-cause death. We found that people with a high burden of unfavorable SDOH were more likely to have poor CVH, and linear regression analysis also confirmed the positive relationship between SDOH and CVH.[9-16] Therefore, worse prognosis in individuals with a high burden of unfavorable SDOH might be in part driven by their poor CVH. Mediation analyses may be useful to better understand disease progression from SDOH to CVD risk factors to events and death. Multidisciplinary partnerships are needed to identify and address SDOH, with the goal of mitigating observed disparities in CVD and mortality risks. In addition, it is also important with respect to collecting and documenting data on additional SDOH, such as food insecurity; neighborhood safety; availability of green spaces; housing conditions; financial burden from health care, debt, and other financial considerations; and social networks and cohesion. Collectively, SDOH and traditional risk factors provide unprecedented opportunities to develop powerful CVD and mortality risk estimation tools.

CVH was first introduced in Life's Simple 7 by the American Heart Association in 2010.[33] In 2022, sleep status was included and the framework updated as Life's Essential 8, and the utility of new CVH score for predicting adverse clinical outcomes such as MACE and all-cause death needs to be further evaluated and validated in diverse populations and settings, as noted in the advisory.[8] The results of the present study demonstrate that among Chinese community-dwelling adults free of CVD, the new CVH score was useful to predict MACE, its components, and all-cause death. A gradient of association supported the dose-dependent relationship between CVH and adverse clinical outcomes. Another important finding is that the relationship between CVH and adverse clinical outcomes was not modified by SDOH. Individuals with a low burden of unfavorable SDOH have advantages to get access to health care resources, and future studies are needed to investigate how to make use of these advantages to improve CVH and reduce CVD burden. For disadvantaged and vulnerable populations (the group with a high burden of unfavorable

**TABLE 3** Association Between High Burden of Unfavorable SDOH and MACE and All-Cause Death

| | Unfavorable SDOH | | | High Burden vs Low Burden | | | |
|---|---|---|---|---|---|---|---|
| | High Burden (n = 26,575) | Low Burden (n = 11,996) | | | | | |
| | Incidence Rate per 1,000 Person-Years (95% CI) | Incidence Rate per 1,000 Person-Years (95% CI) | *P* Value | Model 1 HR (95% CI) | *P* Value | Model 2 HR (95% CI) | *P* Value |
| MACE | 21.57 (20.62-22.55) | 15.23 (14.05-16.49) | <0.001 | 1.22 (1.11-1.33) | <0.001 | 1.18 (1.08-1.30) | 0.007 |
| CHD/MI | 7.82 (7.27-8.41) | 6.93 (6.14-7.78) | 0.03 | 0.98 (0.85-1.13) | 0.46 | 0.94 (0.82-1.09) | 0.11 |
| Stroke | 12.27 (11.57-13.01) | 7.96 (7.12-8.87) | <0.001 | 1.30 (1.15-1.48) | <0.001 | 1.27 (1.12-1.44) | <0.001 |
| HF | 4.38 (3.97-4.82) | 3.76 (3.20-4.40) | 0.049 | 1.02 (0.84-1.23) | 0.61 | 0.98 (0.81-1.18) | 0.15 |
| CV death | 1.28 (1.07-1.53) | 0.62 (0.41-9.00) | <0.001 | 1.75 (1.13-2.71) | 0.02 | 1.69 (1.09-2.62) | 0.04 |
| All-cause death | 4.48 (4.07-4.93) | 2.71 (2.23-3.25) | <0.001 | 1.38 (1.11-1.71) | 0.01 | 1.35 (1.09-1.68) | 0.046 |

Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, diet, smoking, physical activity, sleep status, body mass index, non-high-density lipoprotein, fasting blood glucose, and systolic and diastolic blood pressure.

CHD = coronary heart disease; CV = cardiovascular; HF = heart failure; MACE = major adverse cardiovascular event(s); MI = myocardial infarction; SDOH = social determinants of health.

SDOH), government-funded projects such as promoting health literacy through social media, enhancing the primary care system, and investing more resources in these populations are crucial to improve CVH and ultimately reduce CVD burden for all.[26,34]

SDOH are positively correlated with CVH, and poor CVH could be one of the mechanisms by which a high burden of unfavorable SDOH exerts adverse effects on the CV system. However, it is unclear whether SDOH and CVH exert joint effects on adverse clinical outcomes. The results of the present study indicate that there were joint effects of a high burden of unfavorable SDOH and poor CVH on all-cause death. To reduce mortality risk in these vulnerable and high-risk populations, dedicated efforts are needed to address these adverse social factors and improve CVH. Our recent study showed that low educational attainment was the most important factor associated with poor CVH in Guangdong Province,[35] which was consistent with reports from other studies.[24,36,37] In addition, a prior study demonstrated that low educational attainment was the second modifiable risk factor for CVD in low- and middle-income countries such as China.[2] These findings together reinforce the importance and urgency of enhancing health literacy for these vulnerable populations, and there are actionable approaches, such as using social media to disseminate health-related information and educate people on how to avoid an unhealthy lifestyle.[38] Furthermore, a key aspect of addressing SDOH is to establish trust and build sustainable partnerships among health care systems and community partners, including local public health agencies. This is key to identifying outstanding SDOH and urgent community needs and connecting vulnerable patients with existing resources to address unfavorable SDOH and improve clinical outcomes.

**CLINICAL IMPLICATIONS.** Screening and prioritizing CV care (primary and secondary) are important for communities and individuals who experience the double jeopardy of high clinical CV risk (eg, diabetes, hypertension, obesity) and adverse SDOH. Contemporary clinical decision support systems, including in developed countries, are not yet set up to detect patients with concurrent social and clinical vulnerability. However, risk estimation and stratification are key to identifying and caring for society's most vulnerable subgroups. Furthermore, applying poly-social risk scores that comprehensively capture multiple SDOH and clinical risk factors could have important implications for outcome prediction.[39] Similar tools should be developed to predict MACE and mortality in diverse subpopulation groups. Such risk scores may offer much needed opportunities to inform and improve existing clinical decision support systems and real-world risk prediction algorithms, with the overall goal of improving care for society's most disadvantaged subgroups.

**STUDY LIMITATIONS.** First, there were differences in the definitions and classification of SDOH and CVH components between the present study and those recommend by the U.S. Department of Health and

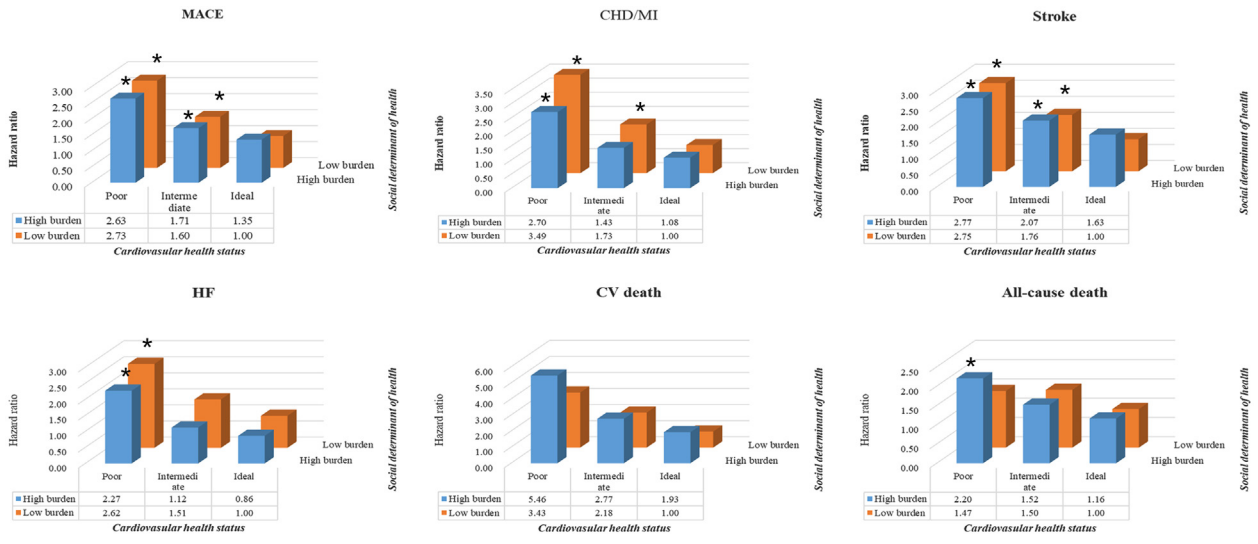
**TABLE 4 Associations of Individual Social Determinants of Health With MACE and All-Cause Death**

| | Incidence Rate per 1,000 Person-Years (95% CI) | Incidence Rate per 1,000 Person-Years (95% CI) | *P* Value | Model 1 HR (95% CI) | *P* Value | Model 2 HR (95% CI) | *P* Value |
|---|---|---|---|---|---|---|---|
| | **Educational Attainment** | | | | | | |
| | **Less Than High School (n = 26,916)** | **High School or More (n = 11,655)** | | | **Less Than High School vs High School or More** | | |
| MACE | 22.13 (21.17-23.11) | 13.56 (12.42-14.78) | <0.001 | 1.32 (1.19-1.45) | <0.001 | 1.22 (1.10-1.35) | 0.01 |
| CHD/MI | 8.22 (7.65-8.82) | 5.91 (5.17-6.72) | <0.001 | 1.15 (0.98-1.33) | 0.35 | 1.07 (0.92-1.25) | 0.87 |
| Stroke | 12.52 (11.82-13.26) | 7.13 (6.32-8.02) | <0.001 | 1.37 (1.20-1.57) | <0.001 | 1.27 (1.11-1.46) | 0.007 |
| HF | 4.84 (4.41-5.30) | 2.59 (2.12-3.15) | <0.001 | 1.57 (1.26-1.95) | <0.001 | 1.55 (1.24-1.94) | 0.01 |
| CV death | 1.32 (1.10-1.57) | 0.50 (0.31-0.76) | <0.001 | 2.26 (1.38-3.69) | <0.001 | 2.16 (1.32-3.56) | 0.01 |
| All-cause death | 4.79 (4.36-5.25) | 1.86 (1.46-2.33) | <0.001 | 2.11 (1.63-2.74) | <0.001 | 2.07 (1.60-2.69) | <0.001 |
| | **Economic Stability** | | | | | | |
| | **<50,000 RMB (n = 20,515)** | **≥50,000 RMB (n = 18,056)** | | | **<50,000 RMB vs ≥50,000 RMB** | | |
| MACE | 21.38 (20.29-22.53) | 17.80 (16.77-18.86) | 0.01 | 1.09 (1.00-1.17) | 0.09 | 1.07 (0.99-1.16) | 0.16 |
| CHD/MI | 7.99 (7.33-8.69) | 7.09 (6.46-7.77) | 0.57 | 1.02 (0.90-1.16) | 0.99 | 1.02 (0.90-1.16) | 0.98 |
| Stroke | 11.88 (11.07-12.73) | 10.00 (9.24-10.79) | 0.09 | 1.07 (0.96-1.19) | 0.36 | 1.05 (0.95-1.17) | 0.45 |
| HF | 4.39 (3.91-4.91) | 3.98 (3.52-4.49) | 0.84 | 1.01 (0.85-1.19) | 0.73 | 0.97 (0.82-1.14) | 0.41 |
| CV death | 1.37 (1.11-1.67) | 0.78 (0.59-1.02) | 0.006 | 1.78 (1.25-2.52) | 0.002 | 1.67 (1.18-2.38) | 0.008 |
| All-cause death | 4.33 (3.86-4.85) | 3.54 (3.10-4.02) | 0.16 | 1.19 (1.00-1.42) | 0.08 | 1.14 (0.95-1.36) | 0.26 |
| | **Health Care Access** | | | | | | |
| | **Uninsured (n = 2,050)** | **Insured (n = 36,521)** | | | **Uninsured vs Insured** | | |
| MACE | 16.73 (13.72-20.20) | 19.78 (19.00-20.57) | 0.005 | 0.81 (0.67-0.99) | 0.04 | 0.82 (0.67-0.99) | 0.04 |
| CHD/MI | 6.69 (4.88-8.96) | 7.60 (7.12-8.09) | 0.13 | 0.85 (0.62-1.16) | 0.35 | 0.86 (0.63-1.17) | 0.45 |
| Stroke | 8.79 (6.69-11.36) | 11.07 (10.49-11.66) | 0.01 | 0.76 (0.58-0.99) | 0.04 | 0.77 (0.59-1.01) | 0.08 |
| HF | 4.44 (3.01-6.33) | 4.18 (3.83-4.55) | 0.78 | 1.03 (0.71-1.51) | 0.82 | 0.99 (0.67-1.45) | 0.92 |
| CV death | 0.79 (0.29-1.74) | 1.10 (0.93-1.29) | 0.32 | 0.83 (0.34-2.03) | 0.71 | 0.69 (0.28-1.70) | 0.47 |
| All-cause death | 3.31 (2.10-4.97) | 3.98 (3.64-4.33) | 0.18 | 0.96 (0.62-1.49) | 0.88 | 0.91 (0.58-1.41) | 0.78 |
| | **Social Support** | | | | | | |
| | **Live Alone (n = 3,612)** | **Married and Live With Spouse (n = 34,959)** | | | **Live Alone vs Married and Live With Spouse** | | |
| MACE | 22.96 (20.35-25.82) | 19.29 (18.50-20.10) | 0.01 | 1.19 (1.05-1.36) | 0.02 | 1.19 (1.04-1.35) | 0.04 |
| CHD/MI | 7.73 (6.28-9.41) | 7.53 (7.05-8.04) | 0.90 | 1.06 (0.86-1.32) | 0.79 | 1.05 (0.84-1.30) | 0.59 |
| Stroke | 13.52 (11.56-15.72) | 10.78 (10.20-11.38) | 0.08 | 1.14 (0.96-1.35) | 0.67 | 1.14 (0.96-1.35) | 0.70 |
| HF | 5.56 (4.35-7.01) | 4.05 (3.70-4.42) | 0.02 | 1.45 (1.12-1.87) | 0.04 | 1.40 (1.09-1.82) | 0.006 |
| CV death | 1.86 (1.21-2.75) | 1.00 (0.83-1.19) | 0.006 | 2.07 (1.29-3.31) | 0.007 | 1.92 (1.20-3.08) | 0.01 |
| All-cause death | 4.96 (3.83-6.33) | 3.84 (3.50-4.20) | 0.07 | 1.35 (1.02-1.77) | 0.04 | 1.31 (1.00-1.73) | 0.06 |
| | **Neighborhood/Environment** | | | | | | |
| | **Rural Area (n = 22,294)** | **Urban Area (n = 16,277)** | | | **Rural Area vs Urban Area** | | |
| MACE | 20.16 (19.18-21.16) | 18.77 (17.59-20.02) | <0.001 | 1.11 (1.02-1.20) | 0.009 | 1.07 (0.98-1.16) | 0.13 |
| CHD/MI | 7.29 (6.72-7.90) | 7.97 (7.22-8.78) | 0.21 | 1.05 (0.93-1.20) | 0.47 | 1.08 (0.95-1.23) | 0.33 |
| Stroke | 11.49 (10.77-12.25) | 10.09 (9.24-11.00) | <0.001 | 1.18 (1.06-1.32) | 0.002 | 1.13 (1.01-1.26) | 0.006 |
| HF | 3.81 (3.41-4.26) | 4.80 (4.23-5.44) | 0.48 | 1.24 (1.04-1.46) | 0.02 | 1.31 (1.11-1.56) | 0.002 |
| CV death | 1.06 (0.85-1.30) | 1.12 (0.86-1.44) | 0.52 | 1.33 (0.94-1.88) | 0.12 | 1.48 (1.04-2.10) | 0.03 |
| All-cause death | 4.21 (3.78-4.67) | 3.51 (3.03-4.06) | <0.001 | 1.02 (0.84-1.22) | 0.93 | 1.12 (0.93-1.35) | 0.28 |

Model 1 was adjusted for age and sex. Model 2 was adjusted for age, sex, diet, smoking, physical activity, sleep status, body mass index, non-high-density lipoprotein, fasting blood glucose, systolic and diastolic blood pressure, educational attainment, economic stability, health care access, social support, and neighborhood and environment.

Abbreviations as in Tables 1 and 3.

**FIGURE 1** **Joint Effects of SDOH and CVH on Outcomes**




To evaluate whether social determinants of health (SDOH) and cardiovascular health (CVH) exerted joint effects on outcomes, participants were stratified by overall SDOH and CVH status, resulting in 6 subgroups, and the group with a low burden of unfavorable SDOH and ideal CVH served as the reference group in the Cox proportional hazards model. With reference to the subgroup with a low burden of unfavorable SDOH and ideal CVH, the HRs for major adverse cardiovascular events (MACE), coronary heart disease (CHD) or myocardial infarction (MI), and heart failure (HF) were highest in the subgroup with a low burden of unfavorable SDOH and poor CVH, and the HR for all-cause death was highest in the subgroup with a high burden of unfavorable SDOH and poor CVH. *$P < 0.05$.

Human Services Healthy People 2030 and the American Heart Association Life's Essential 8. Nonetheless, the results of the present study demonstrate that a high burden of unfavorable SDOH was an independent risk factor for adverse clinical outcomes, and maintaining ideal CVH could be beneficial to reduce MACE and all-cause death.

Second, this was an observational study, no causal relationship can be drawn, and these findings can be used only for hypothesis generation. Third, a substantial proportion of participants lacked complete data on diet and physical activity, resulting in a substantial reduction of sample size and selection biases.

Fourth, this was a study of community-dwelling adults free of CVD, and these findings might not generalize to those with prevalent CVD. Fifth, as we enrolled only individuals 35 to 75 years of age, these findings might not generalize to those younger than 35 years or older than 75 years.

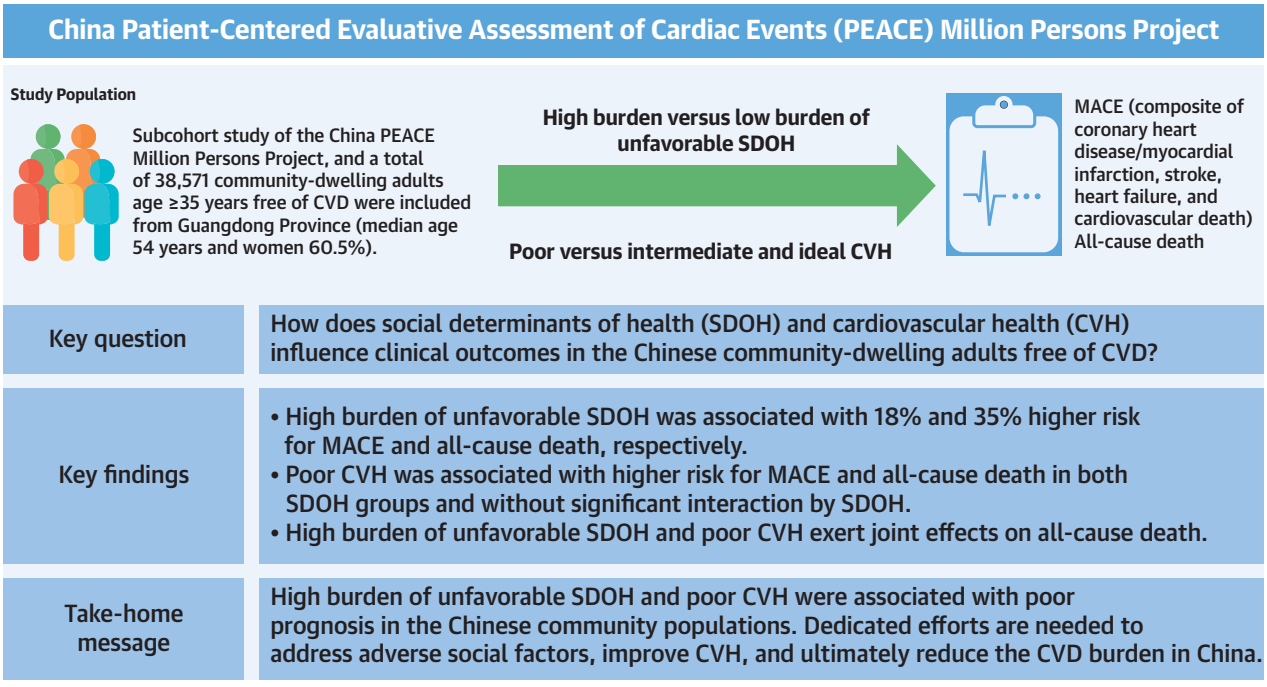
Sixth, we used a purposive sampling method to enroll participants, which could not represent the general Chinese community populations. Seventh, other important SDOH, such as housing status and conditions, food insecurity, social cohesion, neighborhood safety, and other measures of overall financial health including medical bills and costs, were unavailable. These data could further enhance our knowledge with respect to the association between SDOH and adverse clinical outcomes.

Last but not least, we collected hospitalization data only from Guangdong Province; events that occurred in other provinces or outside hospitals were not captured, which might have caused an underestimation of the event rate. In addition, these findings might not generalize to populations from other provinces because of potential socioeconomic and demographic differences.

## CONCLUSIONS

Among Chinese community-dwelling adults free of CVD, SDOH were associated with 18% and 35% higher adjusted risks for MACE and all-cause death, respectively. A high burden of unfavorable SDOH and poor CVH exerted joint effects on all-cause death. Multidisciplinary partnerships and sustained efforts are needed to identify and address SDOH, with a future

**CENTRAL ILLUSTRATION** **Association of SDOH and CVH With Outcomes**




In the subcohort of China PEACE Million Persons Project, 38,571 community-dwelling adults free of cardiovascular disease (CVD) were included from Guangdong Province. Social determinants of health (SDOH) and cardiovascular health (CVH) were independently associated with major adverse cardiovascular events (MACE), their individual components, and all-cause death. In addition, a high burden of unfavorable SDOH and poor CVH exerted joint effects on all-cause death.
CVD = cardiovascular disease; CVH = cardiovascular health; MACE = major adverse cardiovascular event(s); SDOH = social determinants of health.

focus on SDOH and traditional risk factors that may help identify socially vulnerable patients in real-world settings. Dedicated efforts are urgently needed to address these social factors so as to improve CVH and reduce the burden of CVD in China.

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## PERSPECTIVES

**COMPETENCY IN MEDICAL KNOWLEDGE:** Among Chinese community-dwelling adults free of CVD, a high burden of unfavorable SDOH and poor CVH are associated with increased risks for MACE and all-cause death. In addition, a high burden of unfavorable SDOH and poor CVH exert joint effects on all-cause death.

**TRANSLATIONAL OUTLOOK:** Multidisciplinary partnerships and sustained efforts are needed to identify and address SDOH, with a future focus on SDOH and traditional risk factors that may help identify socially vulnerable patients in real-world settings. Furthermore, dedicated efforts are urgently needed to address these social factors so as to improve CVH and reduce the burden of CVD in China.

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**KEY WORDS** cardiovascular health, outcomes, social determinants of health

**APPENDIX** For supplemental tables and figures, please see the online version of this paper.