





# Socio-economic status and 1 year mortality among patients hospitalized for heart failure in China

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## Abstract

**Aims** This study explored the association between socio-economic status (SES) and mortality among patients hospitalized for heart failure (HF) in China.

**Methods and results** We used data from the China Patient-centred Evaluative Assessment of Cardiac Events-Pro prospective Heart Failure Study (China PEACE 5p-HF Study), which enrolled patients hospitalized primarily for HF from 52 hospitals between 2016 and 2018. SES was measured using the income, employment status, educational attainment, and partner status. Individual socio-economic risk factor (SERF) scores were assigned based on the number of coexisting SERFs, including low income, unemployed status, low education, and unpartnered status. We assessed the effects of SES on 1 year all-cause mortality using Cox models. We used the Harrell *c* statistic to investigate whether SES added incremental prognostic information for mortality prediction. A total of 4725 patients were included in the analysis. The median (interquartile range) age was 67 (57–76) years; 37.6% were women. In risk-adjusted analyses, patients with low/middle income [low income: hazard ratio (HR) 1.61, 95% confidence interval (CI) 1.21–2.14; middle income: HR 1.32, 95% CI 1.00–1.74], unemployment status (HR 1.43, 95% CI 1.10–1.86), low education (HR 1.25, 95% CI 1.03–1.53), and unpartnered status (HR 1.22, 95% CI 1.03–1.46) had a higher risk of death than patients with high income, who were employed, who had a high education level, and who had a partner, respectively. Compared with the patients without SERFs, those with 1, 2, 3, and 4 SERFs had 1.52-, 2.01-, 2.45-, and 3.20-fold increased risk of death, respectively. The addition of SES to fully adjusted model improved the mortality prediction, with increments in *c* statistic of 0.01 ( $P < 0.01$ ).

**Conclusions** In a national Chinese cohort of patients hospitalized for HF, low income, unemployment status, low education, and unpartnered status were all associated with a higher risk of death 1 year following discharge. In addition, incorporating SES into a clinical-based model could better identify patients at risk for death. Tailored clinical interventions are needed to mitigate the excess risk experienced by those socio-economic deprived HF patients.

**Keywords** Socio-economic status; Heart failure; Mortality

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## Introduction

A growing body of studies found that socio-economic status (SES) was associated with risk of death in a variety of medical conditions such as ischaemic heart disease, stroke, chronic obstructive pulmonary disease, and cancers.<sup>1</sup> This association may be attributed to lower financial capacity to pay for adequate health care service, poor health literacy, unhealthy

lifestyle behaviours, and mental issues.<sup>2,3</sup> A consideration of the role of social determinants on health outcomes in clinical setting and attempt to mitigate the excess risk experienced by those with socio-economic deprivation is essential.

Heart failure (HF), a global public health problem, has an estimated prevalence of 64.3 million patients worldwide, and the mortality remains high despite the advances in treatments.<sup>4</sup> As HF represents the end stage of various

cardiac conditions requiring multiple medications for the disease and complications, close follow-up, nutritional, and psychosocial support,<sup>5,6</sup> it is possible that SES-related mortality differences may also be present in patients with HF. However, it is still unclear whether such an association exists due to the paucity of evidence and conflicting results. Socio-economic deprivation has been associated with higher mortality in some studies,<sup>7–10</sup> whereas in others, no association<sup>11–13</sup> or only a partial association<sup>14</sup> has been observed. Variations in the study populations, measures of SES, and health care system may partly explain these inconsistencies.

Assessing the impact of SES on the prognosis of patients with HF is especially important in China, which is experiencing an HF epidemic. Studies have estimated that there are 13.8 million HF patients in China, accounting for one-fifth of the prevalent cases worldwide.<sup>15</sup> Moreover, along with the deepening of medical reform in China that aims to provide affordable, equitable access to quality basic health care for all its citizens, China achieved universal health insurance coverage.<sup>16</sup> However, little attention has been paid to whether universal health care coverage guarantees equal clinical outcomes for HF patients with different socio-economic backgrounds. Understanding whether socio-economic disadvantage is associated with worse outcomes among this large population of patients with HF may provide insights to inform actionable targets for interventions and achieve a reduction in mortality.

Accordingly, in this study, we analysed data from the China Patient-centred Evaluative Assessment of Cardiac Events-Pro prospective Heart Failure Study (China PEACE 5p-HF Study) to investigate the association of several SES indicators, including income, employment status, education, and partner status, with mortality among patients hospitalized for HF.

## Methods

### Study design and participants

The protocol of the China PEACE 5p-HF Study has been published.<sup>17</sup> In brief, this large, nationwide prospective study recruited patients hospitalized primarily for HF from 52 hospitals throughout 20 provinces between 2016 and 2018. Patients aged 18 years or older who were hospitalized with a primary diagnosis of new-onset HF or decompensation of chronic HF were enrolled in the study. Index hospitalization was defined as the first hospitalization that met all selection criteria during the enrolment period. For the purpose of this study, we excluded those who died during the index hospitalization ( $n = 32$ ), lacked information about all 4 SES indicators ( $n = 144$ ), or were lost to follow-up at 1 year after discharge

( $n = 6$ ), leaving 4725 patients for analysis. All enrolled patients signed an informed consent form.

The China PEACE 5p-HF Study was approved by the ethics committees of Fuwai Hospital and all collaborating hospitals. The study was registered at [www.clinicaltrials.gov](http://www.clinicaltrials.gov) (NCT02878811).

### Socio-economic data

We collected information about socio-economic characteristics with a standardized questionnaire during an in-person interview conducted by trained local clinicians during the index hospitalization.

Socio-economic status was measured by income (most recent annual household income in renminbi; low income was defined as  $<¥10\ 000$ , middle income was defined as  $¥10\ 000–49\ 999$ , high income was defined as  $≥¥50\ 000$ ; patients who reported 'do not know the household income' were considered to have unknown income), employment status [employed was defined as non-manual or manual work (including patients who are not working for a short time and will be reinstated, e.g. people on parental leave or sick leave for a short time); unemployed was defined as previously employed (including retirement, lay-off, unable to work due to permanently sick or disability, unwilling to work and the need to take care of family) or never employed], educational level (low educational level was defined as primary school or below; middle educational level was defined as junior high school; high educational level was defined as senior high school, college, or postgraduate degree), and partner status (having a partner was defined as married; unpartnered status was defined as divorced, separated, widowed, and unmarried).

We defined low level of income, unemployed status, low educational level, and unpartnered status as socio-economic risk factors (SERFs). The individual SERF scores were graded according to the number of coexistent SERFs, ranging from 0 to 4. The higher the SERF score was, the more socio-economically deprived a patient was.

### Data collection

Detailed information on demographics, clinical characteristics, comorbidities, and discharge medications was obtained from abstraction of medical charts and in-person interviews conducted during the index hospitalization. Chart abstraction was performed centrally according to a standardized procedure, and the accuracy of abstraction exceeded 98%. Left ventricular ejection fraction (LVEF) was measured during the index hospitalization by trained physicians with a standard protocol. Blood samples of enrolled patients were

collected within 48 h of admission for analysis in the central laboratory.

## Outcome

The primary outcome of the study was all-cause mortality within 1 year after discharge. We also included cardiovascular (CV) death and HF hospitalization as secondary outcomes. CV death included sudden cardiac death, death due to HF, cerebrovascular events, acute coronary syndrome, aortic vascular disease, peripheral arterial disease, pulmonary heart disease, or presumed/unknown CV death. Information regarding patient survival status and hospitalization events during the 1 year follow-up was collected from interviews, medical documents, and the national death cause database. All the data were centrally adjudicated at the national coordinating centre by trained clinicians.

## Statistical analysis

Continuous variables are expressed as the medians with interquartile ranges (IQRs) due to a non-normal distribution. Categorical variables are presented as frequencies with percentages. To evaluate patient characteristics that were independently associated with higher SERF score, multivariable ordinal logistic regression was conducted, and univariate models that were  $P < 0.05$  (Table 1) were selected for subsequent analysis. The correlations between all pairs of SES indicators were assessed using Cramer's  $V$  [weak ( $<0.30$ ), moderate ( $0.30$ – $0.50$ ), strong ( $\geq 0.50$ ) association] and Spearman's correlation [weak ( $<0.30$ ), moderate ( $0.30$ – $0.60$ ), strong ( $\geq 0.60$ ) association].<sup>18</sup>

Survival estimates were calculated using the Kaplan–Meier method and compared across groups with log-rank tests. Hazard ratios (HRs) with 95% confidence intervals (CIs) for clinical outcomes were calculated using Cox proportional hazard models. Firstly, we evaluated the independent effects of income, employment status, education, and partner status. Secondly, we explored the association between the SERF score and outcomes. In the multivariable models, the candidate covariates were those that were considered clinically relevant or that showed a univariate relationship with the outcome. Separate Cox models were constructed as follows: (1) no adjustment in Model 1; (2) adjustment for demographics (age and sex) in Model 2; (3) further adjustment for clinical characteristics [systolic blood pressure at admission, heart rate at admission, New York Heart Association (NYHA) class, LVEF, serum sodium, serum albumin, high sensitivity cardiac troponin T (hs-cTnT), N-terminal brain natriuretic peptide precursor (NT-proBNP), estimated glomerular filtration rate (eGFR), and current smoking] and comorbidities (coronary heart disease, chronic obstructive pulmonary

disease, anaemia, valvular heart disease, diabetes mellitus, and atrial fibrillation) in Model 3; (4) further adjustment for treatments [use of angiotensin-converting enzyme inhibitors (ACEIs)/angiotensin receptor blockers (ARBs), beta-blockers, and mineralocorticoid receptor antagonists (MRAs)] in Model 4. (5) To account for the potential interrelations among these SES indicators, we further mutually adjusted for SES indicators in Model 5. For outcome of HF hospitalization, we performed the Fine–Gray analysis with death as competing risk.<sup>19</sup> When assessing the outcome of CV death, non-CV death was considered as competing risk.

To further examine additional prognostic information provided by the SES beyond traditional risk factors (all variables in Model 4), we compared models with and without SES using the differences in Harrell  $c$  statistic,<sup>20</sup> and continuous net reclassification improvement (NRI) and integrated discrimination improvement (IDI) were calculated.<sup>21,22</sup> The NRI quantifies the amount of correct reclassified patients introduced by SES. The IDI represents the average improvement in predicted probabilities for mortality after the addition of SES to the baseline model.

In the sensitivity analysis, because non-manual workers  $> 65$  years of age are above the mandatory retirement age, while there is no retirement age limit for manual workers, we included patients aged 18–65 years to obtain a more homogenous study population and re-examined the association between employment status and outcome. In addition, because 1158 patients reported an unknown household income, to assess the robustness of the relation between income and mortality, these 1158 patients were all included in high-income group/low-income group, and we re-evaluated the relation.

In this study, missing rates for selected variables in the model (LVEF, serum sodium, serum creatinine, serum albumin, hs-cTnT, and NT-proBNP) ranged from 0.1% to 5.7% and were imputed by multiple imputation, taking the average of 20 imputed values as the final value. Two-sided  $P$  values  $< 0.05$  were considered significant and were not adjusted for multiple comparisons. Statistical analyses were performed using the SAS statistical software package, Version 9.4 (SAS Institute, Cary, NC, USA).

## Results

### Baseline characteristics

The baseline characteristics based on the SERF score and each SES indicator are illustrated in Table 1 and Supporting Information, Table S1. A total of 10.1%, 30.5%, 29%, 23.8%, and 6.6% of patients had 0, 1, 2, 3, and 4 SERFs, respectively. Patients with higher SERF scores were more likely to be older and female, to have a higher ejection fraction, to have more

Table 1 Baseline characteristics stratified by the number of socio-economic risk factors

	Total	Number of SERFs					P value
		0 (n = 359, 10.1%)	1 (n = 1088, 30.5%)	2 (n = 1036, 29.0%)	3 (n = 850, 23.8%)	4 (n = 234, 6.6%)	
<b>Demographic factors</b>							
Age, years (IQR)	67 (57, 75)	48 (41, 54)	66 (58, 74)	67 (59, 75)	69 (63, 77)	77 (69, 81)	<0.001
Female, n (%)	1306 (36.6)	50 (13.9)	240 (22.1)	400 (38.6)	453 (53.3)	163 (69.7)	<0.001
<b>Clinical factors</b>							
LVEF, % (IQR)	43 (33, 56)	35 (27, 45)	42 (33, 56)	44 (33, 56)	46 (36, 58)	47 (38, 57)	<0.001
NYHA, n (%)							<0.001
NYHA II	450 (12.6)	51 (14.2)	180 (16.5)	124 (12.0)	73 (8.6)	22 (9.4)	
NYHA III	1573 (44.1)	163 (45.4)	488 (44.9)	478 (46.1)	363 (42.7)	81 (34.6)	
NYHA IV	1535 (43.0)	143 (39.8)	418 (38.4)	432 (41.7)	411 (48.4)	131 (56.0)	
Unknown	9 (0.3)	2 (0.6)	2 (0.2)	2 (0.2)	3 (0.4)	0 (0)	
HR, b.p.m. (IQR)	85 (72, 100)	89 (77, 102)	82 (70, 98)	84 (72, 100)	87 (75, 101)	86 (75, 98)	<0.001
SBP, mmHg (IQR)	130 (115, 148)	126 (111, 144)	130 (115, 147)	130 (115, 147)	130 (117, 150)	134 (120, 153)	<0.001
Albumin, g/L (IQR)	38.9 (35.9, 41.9)	39.4 (35.9, 42.6)	39.1 (35.9, 42.3)	38.7 (36.0, 41.5)	38.6 (35.6, 41.4)	38.4 (35.6, 41.9)	0.02
hs-cTnT, ng/L (IQR)	21.0 (12.7, 39.6)	19.6 (11.9, 37.0)	20.6 (12.3, 38.3)	21.5 (13.2, 42.1)	21.3 (12.9, 39.4)	22.6 (13.7, 43.3)	0.09
NT-proBNP, pg/mL (IQR)	1486 (613, 3248)	976 (476, 2141)	1281 (510, 2820)	1661 (688, 3419)	1821 (752, 3645)	1818 (775, 3600)	<0.001
Na, mmol/L (IQR)	140 (137, 142)	141 (138, 143)	140 (137, 142)	140 (137, 142)	140 (137, 142)	140 (137, 143)	0.02
eGFR, mL/min/1.73 m <sup>2</sup> (IQR)	68.6 (53.4, 84.4)	84.1 (69.3, 96.2)	67.3 (52.9, 84.0)	69.2 (52.5, 83.0)	65.9 (52.7, 80.5)	63.2 (48.5, 75.5)	<0.001
Current smoking, n (%)	908 (25.5)	179 (49.9)	279 (25.6)	242 (23.4)	168 (19.8)	40 (17.1)	<0.001
<b>Comorbidities, n (%)</b>							
Hypertension	2049 (57.4)	181 (50.4)	677 (62.2)	586 (56.6)	474 (55.8)	131 (56.0)	<0.001
Coronary heart disease	2062 (57.8)	129 (35.9)	668 (61.4)	594 (57.3)	513 (60.4)	158 (67.5)	<0.001
Prior revascularization	557 (15.6)	41 (11.4)	250 (23.0)	153 (14.8)	92 (10.8)	21 (9.0)	<0.001
Atrial fibrillation	1300 (36.4)	85 (23.7)	395 (36.3)	369 (35.6)	364 (42.8)	87 (37.2)	<0.001
Valvular heart disease	584 (16.4)	52 (14.5)	164 (15.1)	177 (17.1)	153 (18.0)	38 (16.2)	0.37
Diabetes mellitus	1110 (31.1)	111 (30.9)	407 (37.4)	307 (29.6)	226 (26.6)	59 (25.2)	<0.001
Stroke	725 (20.3)	23 (6.4)	267 (24.5)	210 (20.3)	166 (19.5)	59 (25.2)	<0.001
COPD	674 (18.9)	29 (8.1)	198 (18.2)	207 (20.0)	182 (21.4)	58 (24.8)	<0.001
Anaemia	825 (23.1)	38 (10.6)	261 (24.0)	261 (25.2)	215 (25.3)	50 (21.4)	<0.001
<b>Medications at discharge, n (%)</b>							
ACEI/ARB	1849 (51.8)	236 (65.7)	574 (52.8)	517 (49.9)	412 (48.5)	110 (47.0)	<0.001
Beta-blocker	2111 (59.2)	275 (76.6)	675 (62.0)	605 (58.4)	437 (51.4)	119 (50.9)	<0.001
MRA	2263 (63.4)	260 (72.4)	688 (63.2)	647 (62.5)	522 (61.4)	146 (62.4)	0.006

ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration rate; HR, heart rate; hs-cTnT, high sensitivity cardiac troponin T; IQR, interquartile range; LVEF, left ventricular ejection fraction; MRA, mineralocorticoid receptor antagonist; NT-proBNP, N-terminal brain natriuretic peptide precursor; NYHA, New York Heart Association; SBP, systolic blood pressure; SERFs, socio-economic risk factors.

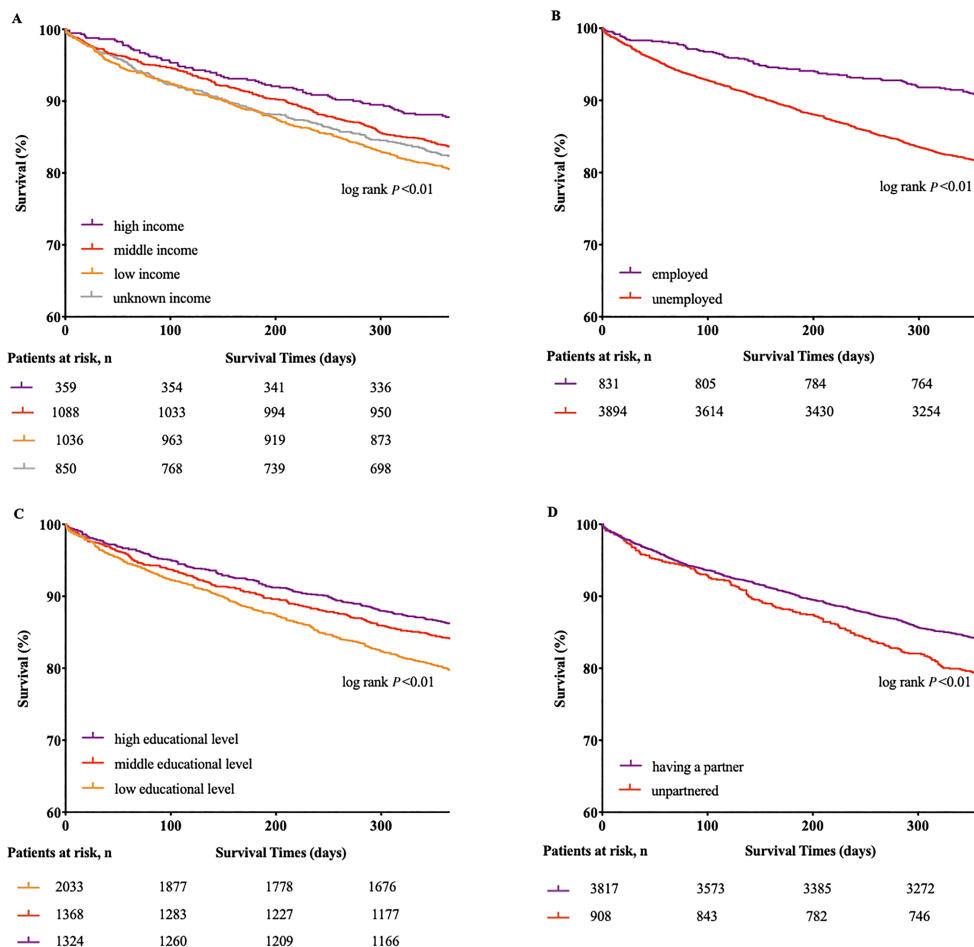
severe HF (i.e. a higher proportion of NYHA functional classes III to IV and higher NT-proBNP and hs-cTnT levels), and to have a higher comorbidity burden (i.e. a medical history of coronary heart disease and chronic obstructive pulmonary disease). Patients with higher SERF scores were less likely to use ACEIs/ARBs, beta-blockers, and MRAs. Similar results were shown when analyses were conducted by each SES indicator (Supporting Information, *Table S1*). Variables that were independently associated with higher SERF score were older age, female sex, more severe HF (higher NYHA class and higher NT-proBNP), and the presence of coronary heart disease and chronic obstructive pulmonary disease. In contrast, the history of revascularization, the presence of diabetes mellitus, and the use of beta-blockers were associated with lower SERF score (Supporting Information, *Table S2*). We evaluated the correlations between these four SES indicators using Cramer’s *V* and Spearman’s correlation, education level correlated moderately with income (Cramer’s *V* = 0.30, Spearman’s  $\rho$  = 0.41), while the strength of relationship be-

tween other pairs of SES indicators were weak (Supporting Information, *Table S3*).

### Socio-economic status indicators and mortality

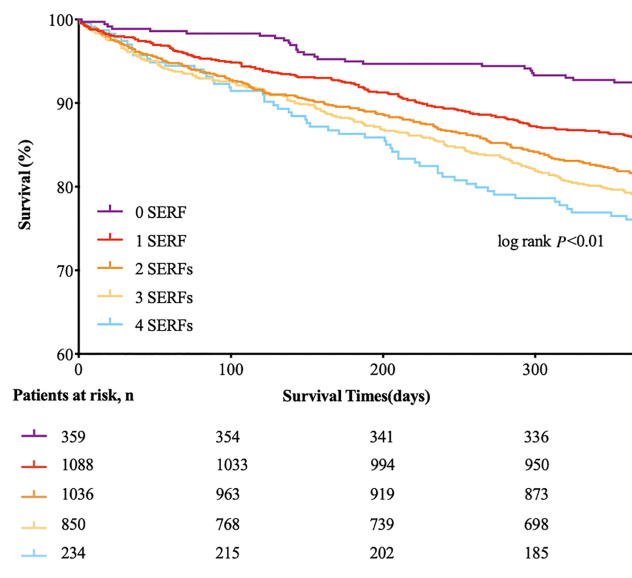
During the 1 year follow-up, 810 (17.1%) patients died. For secondary outcomes, 523 (11.1%) died of CV causes and 1506 (31.9%) were hospitalized for HF. The cumulative incidence of death by each SES indicator and SERF score are described using the Kaplan–Meier method in *Figures 1* and *2*. A significantly higher 1 year mortality was observed in the low-income (19.5%) group than in the middle-income (16.4%) and high-income (12.2%) groups. The mortality rates were 9.4% and 18.8% in the employed and unemployed groups ( $P < 0.01$ ), respectively, and 20.2%, 15.9%, and 13.7% in the low, middle, and high educational level groups ( $P < 0.01$ ), respectively. The mortality difference in patients who were living with a partner compared with those

**Figure 1** Kaplan–Meier survival curves for 1 year all-cause mortality by socio-economic status indicators in patients hospitalized for heart failure. (A) One year all-cause mortality by income level; (B) 1 year all-cause mortality by employment status; (C) 1 year all-cause mortality by educational attainment; (D) 1 year all-cause mortality by partner status.





**Figure 2** Kaplan–Meier survival curves for 1 year all-cause mortality by the number of socio-economic risk factors (SERFs) in patients hospitalized for heart failure.



unpartnered was 4.5% (16.3% vs. 20.8%,  $P < 0.01$ ). Additionally, the mortality increased with an increasing number of coexisting SERFs: 7.2% for 0 SERFs, 14.1% for 1 SERF, 18.3% for 2 SERFs, 20.8% for 3 SERFs, and 23.5% for 4 SERFs.

*Table 2* shows the relationship between SES indicators and mortality after sequentially adjusting for covariates. In the unadjusted analysis, patients with low/middle income, unemployed status, low educational level, or unpartnered status had a higher risk of death than their counterparts. After adjustment for covariates, socio-economic inequalities in mortality were attenuated but still significant. The multivariate analysis confirmed that low income (HR 1.61, 95% CI 1.21–2.14) and middle income (HR 1.32, 95% CI 1.00–1.74), unemployed status (HR 1.43, 95% CI 1.10–1.86), low educational level (HR 1.25, 95% CI 1.03–1.53), and unpartnered status (HR 1.22, 95% CI 1.03–1.46) were all associated with a higher risk of death than high income, employed status, high educational level, and having a partner. In the secondary outcome analysis, the income, employment status, and education level were associated with CV death. And only employment status was associated with HF readmission (Supporting Information, *Table S4*).

*Table 3* shows the combination of the four SES indicators in relation to mortality. The multivariable Cox models showed that the risk of death increased with increasing SERF score. Compared with the no SERF group, the HRs for 1 SERF were 1.52 (95% CI 0.99–2.33), 2.01 (95% CI 1.31–3.09) for 2 SERFs, 2.45 (95% CI 1.57–3.83) for 3 SERFs, and 3.20 (95% CI 1.91–5.35) for 4 SERFs, with a  $P$  for trend of  $< 0.01$ . The overall pattern remained when stratifying the analyses according to age or sex (Supporting Information, *Table S5*).

## Improvement of predictive performance by adding socio-economic status

*Table 4* demonstrates that the SES is associated with an improvement in the prediction of death. In the fully adjusted model considering demographics, clinical characteristics, comorbidities, and treatments, the  $c$  statistic was 0.727, and the addition of the SERF score to this model resulted in a statistically significant increase in the  $c$  statistic (+0.01,  $P < 0.01$ ). The NRI and IDI analyses were consistent with the  $c$ -statistic results.

## Sensitivity analyses

The first analyses that excluded patients who were older than 65 years yielded consistent findings when compared with the results of the primary analyses (Supporting Information, *Table S6*). The second analyses related to the income classification for patients with unknown income. Regardless of whether the unknown income data were categorized as low or high income, low income was still associated with a higher risk of death (Supporting Information, *Tables S7* and *S8*).

## Discussion

In this national HF cohort in China, we observed that patients with low income, unemployed status, low educational level, or unpartnered status had an increased risk of death in the 1 year period following hospitalization for HF. The risk of mortality increased with the increasing number of coexisting SERFs. In addition, incorporating the SES into a clinical-based model improved mortality risk prediction.

Our study extends the literature in two major ways. Firstly, our study, based on data from a large cohort of HF patients with 1 year follow-up, is the first study to assess SES-related prognostic differences in China. In this study, we examined SES as a multidimensional construct and showed the strong role of SES indicators in influencing mortality in HF patients. Additionally, this is the first study to incorporate SES in a prediction model for mortality among hospitalized HF patients, and we demonstrated that greater discrimination can be achieved by adding easily obtained individual socio-economic information.

## Association between socio-economic status indicators and mortality

Although increased burden of comorbidities, more severe HF, and less use of evidence-based medications might partly explain the increased mortality risk in deprived patients, the

**Table 2** Hazard ratios for 1 year mortality according to socio-economic status indicators

	Model 1		Model 2		Model 3		Model 4		Model 5	
	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P	HR (95% CI)	P
<b>Income level</b>	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
High level	1.35	0.03	1.33	0.04	1.40	0.02	1.39	0.02	1.32	0.05
Middle level	1.75	<0.01	1.74	<0.01	1.84	<0.01	1.82	<0.01	1.61	<0.01
Low level	1.44	0.01	1.39	0.02	1.53	<0.01	1.50	<0.01	1.39	<0.01
Unknown										
<b>Employment status</b>	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
Employed	2.17	<0.01	1.86	<0.01	1.53	<0.01	1.50	<0.01	1.43	<0.01
Unemployed										
<b>Education level</b>	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
High level	1.20	0.07	1.21	0.07	1.16	0.15	1.16	0.16	1.05	0.62
Middle level	1.53	<0.01	1.43	<0.01	1.45	<0.01	1.42	<0.01	1.25	0.03
Low level										
<b>Partner status</b>	1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)		1.00 (Reference)	
Having a partner	1.35	<0.01	1.25	0.01	1.25	0.01	1.24	0.02	1.22	0.02
Unpartnered status										

CI, confidence interval; HR, hazard ratio. Model 1, unadjusted; Model 2, adjusted for demographic characteristics; Model 3, Model 2 plus adjustment for clinical characteristics and comorbidities; Model 4, Model 3 plus adjustment for treatments; Model 5, Model 4 plus mutual adjustment for socio-economic status indicators.

persisting difference after full adjustment for these factors suggests other factors might be having an effect.

The present study and prior studies consistently found that a lower income level was associated with a higher mortality risk.<sup>7,9,10,14</sup> Low-income patients face numerous challenges after discharge. Firstly, those patients may have limited access to high-quality health care services and HF ambulatory-based care, hence, experience higher mortality.<sup>23</sup> Secondly, poor medication adherence due to unaffordability of drug regimens could be an explanation for the higher mortality risk.<sup>24</sup> Additionally, studies have reported that patients with low income are more likely to engage in risky behaviours (i.e. low level of physical activity and unhealthy diet), less likely to make behavioural changes after hospitalization, more likely to delay medical assistance seeking, and have poor psychological well-being, which all contributes to worse survival rates.<sup>25</sup>

Our study found that unemployed patients were at higher risk of death than their employed counterparts. Employment could influence survival through income differences. In addition, in China, a resident’s ability to enrol in a particular medical insurance scheme, mainly including urban employee basic medical insurance, urban resident basic medical insurance, and new rural cooperative medical scheme, depends on the employment status and rural/urban residency.<sup>26</sup> These medical insurance schemes offer different inpatient and outpatient reimbursement rates and different coverage for medical care and medicines. Hence, insurance type has an impact on health care accessibility and quality, which is known to be linked to health outcomes.<sup>27</sup> Dedicated studies would need to delineate the role of medical insurance schemes in understanding employment status-based mortality differences in China.

Our study confirmed a distinct mortality disadvantage among patients with a low education level. Patients with a low education level are considered to have low health literacy<sup>28</sup>; thus, these patients may have difficulty managing their disease due to lack of understanding of instructions from health care providers (such as up-titration of medication and usage of diuretics), poor treatment adherence, and poor self-care.<sup>29</sup> A study from Denmark did not find education-related differences in HF mortality.<sup>14</sup> A possible explanation may be that the universal health care coverage could result in closer follow-up and optimal treatment, and the prognostic role of education is attenuated because the need for self-care is relatively low. The findings suggested that patients with a low education level should alert physicians to health literacy issues and that these deprived patients may benefit from rigorous follow-up, therapeutic monitoring, and additional support to enhance self-management (such as creating disease-related educational materials appropriate for a patient’s literacy level).

Unpartnered status was associated with a 22% higher mortality risk than partnered status in our study. Theories relating

**Table 3** Hazard ratios for 1 year all-cause mortality of heart failure patients according to the number of coexisting socio-economic risk factors

Number of coexistent SERF	Model 1			Model 2			Model 3			Model 4		
	HR (95% CI)		P	HR (95% CI)		P	HR (95% CI)		P	HR (95% CI)		P
0	1.00	(Reference)		1.00	(Reference)		1.00	(Reference)		1.00	(Reference)	
1	2.01	1.33–3.03	<0.01	1.69	1.10–2.60	0.02	1.56	1.01–2.39	0.04	1.52	0.99–2.33	0.06
2	2.72	1.81–4.09	<0.01	2.38	1.55–3.65	<0.01	2.11	1.37–3.23	<0.01	2.01	1.31–3.09	<0.01
3	3.27	2.17–4.94	<0.01	2.87	1.84–4.46	<0.01	2.61	1.68–4.05	<0.01	2.45	1.57–3.83	<0.01
4	3.89	2.43–6.22	<0.01	3.36	2.02–5.61	<0.01	3.34	2.00–5.58	<0.01	3.20	1.91–5.35	<0.01
P value for trend			<0.01			<0.01			<0.01			<0.01

CI, confidence interval; HR, hazard ratio; SERF, socio-economic risk factor.

Model 1, unadjusted; Model 2, adjusted for demographic characteristics; Model 3, Model 2 plus adjustment for clinical characteristics and comorbidities; Model 4, Model 3 plus adjustment for treatments.

**Table 4** Improvement of predictive performance by adding the socio-economic risk factor score

	Harrell c statistic		NRI analysis		IDI analysis	
	c statistic	P value	Change in NRI% (95% CI)	P value	Change in IDI% (95% CI)	P value
Model 1	0.727	Reference	Reference	Reference	Reference	Reference
Model 2	0.738	0.002	15.5 (6.8, 24.2)	<0.001	0.7 (0.4, 1.1)	<0.001

CI, confidence interval; IDI, integrated discrimination improvement; NRI, net reclassification improvement.

Model 1: adjusted for demographic characteristics, clinical characteristics, comorbidities, and treatments (including age, sex, systolic blood pressure at admission, heart rate at admission, New York Heart Association class, left ventricular ejection fraction, serum sodium, serum albumin, high sensitivity cardiac troponin T, N-terminal brain natriuretic peptide precursor, estimated glomerular filtration rate, current smoking, coronary heart disease, chronic obstructive pulmonary disease, anaemia, valvular heart disease, diabetes mellitus, atrial fibrillation, and prescription of angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, beta-blocker, and mineralocorticoid receptor antagonist); Model 2: Model 1 plus the socio-economic risk factor score.

spousal contributions to improved outcomes involve assistance in maintaining healthy lifestyle habits, emotional support, and post-hospital care.<sup>30,31</sup> The extent of the impact of unpartnered status on the risk of death was less than that in Western countries,<sup>30–32</sup> where patients with no partner had an increased mortality risk, with HRs ranging from 2.00 to 3.86. Three generations living together is the main living arrangement in China, and as shown in our study, 63% of unpartnered patients lived with other family members, while the proportion was 20–30% from Western countries.<sup>33,34</sup> Hence, unpartnered patients might obtain support from other family members,<sup>30</sup> which resulted in a limited effect of the spouse.

### Combined effect of socio-economic status indicators on mortality

We found that the risk of death was greater when several SERFs coexisted. The addition of the SERF score has the potential to improve the identification of patients at risk of death. One study reported that adding non-clinical information (including employment status and marital status) could improve the predictive ability of 30 day readmission or death,<sup>35</sup> which is consistent with our findings. A systematic review of HF prediction models showed that previous

well-established mortality prediction models mainly include demographic and clinical characteristics<sup>36</sup>; therefore, these models might not adequately account for the risk conveyed by a low SES. Further studies should be designed to develop and test prognostic models that include the SES in other countries.

### Clinical implications

The results of the present study indicate that a low SES should be considered an adverse prognostic factor, helping to identify HF patients at high risk for death. To reduce mortality, attention should also be focus on patients with socio-economic disadvantage rather than poor clinical feature only. Improving the prognosis of deprived patients requires a collaborative approach that addresses upstream socio-economic deprivation, as well as the downstream pathways by which deprivation affects health. Because socio-economic determinants are hard to modify, a much more efficient way is to address easily modifiable risk factors, such as HF-related educational interventions, affordable medication regimens, more rigorous discharge follow-up, and psychosocial evaluation and treatment. High-quality studies are needed to test the efficacy of these downstream clinical interventions in reducing mortality.



## Limitations

Several limitations should be acknowledged. Firstly, 1158 patients that reported unknown income were excluded when we evaluated the association between the SERF score and mortality, which might lead to selection bias. However, we showed that patients considered in this analysis had similar characteristics and 1 year mortality to those in the full cohort; hence, the impact of bias may be limited. Secondly, this was an observational study; we cannot define cause–effect relationships. There may be unobserved or unmeasured confounders that explain the relationship between SES and outcomes. Thirdly, partner status was assessed based on current marital status; we categorized the patients who are never married but cohabiting with a partner into unpartnered group. Therefore, taking the definition of partner status in our study might not accurately reflect the survival benefit of having a partner. Because patients who are cohabiting could also benefit from emotional support, post-hospital care, and greater financial resources from their partner,<sup>37</sup> our study might underestimate the benefit of having a partner. Finally, a SERF score derived from the sum of the number of SERFs assumed that all SERFs had equal effects on mortality, which might not be true. Future studies with more accurate assessments of SERF scores are preferred.

## Conclusions

In this national Chinese cohort of patients hospitalized for HF, we found that low income, unemployment status, low educational level, and unpartnered status were associated with worse survival, and the SES measures improved mortality risk prediction. Continuous efforts are warranted to explore interventions aimed at mitigating the excess risk experienced by those with socio-economic deprivation.

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## Conflict of interest

None declared.

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## Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table S1.** Baseline characteristics of patients hospitalized with HF according to SES indicators.

**Table S2.** Independent associations between patient characteristics and SERF score.

**Table S3.** Correlation analysis between SES indicators by Cramer's V and Spearman correlation.

**Table S4.** Hazard ratios for CV death and HF readmission according to SES indicators.

**Table S5.** Association between number of SERFs and 1-year mortality stratified by age or sex.

**Table S6.** Employment status and 1-year mortality among patients with HF aged 18–65 years.

**Table S7.** Income and 1-year mortality (categorizing patients with unknown income information as high-income group).

**Table S8.** Income and 1-year mortality (categorizing patients with unknown income information as low-income group).

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