

# BMJ Open Perceived stress in Chinese patients with coronary heart disease: a cross-sectional study

Yifan Gao ,<sup>1,2</sup> Rong Hu,<sup>1,2</sup> Yingyue Zhang,<sup>1,2</sup> Menghan Yuan,<sup>1,2</sup> Yong Xu,<sup>2</sup> Jing Ma<sup>2</sup>

**To cite:** Gao Y, Hu R, Zhang Y, *et al.* Perceived stress in Chinese patients with coronary heart disease: a cross-sectional study. *BMJ Open* 2022;**12**:e051419. doi:10.1136/bmjopen-2021-051419

► Prepublication history for this paper is available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2021-051419>).

Received 18 March 2021  
Accepted 01 March 2022



© Author(s) (or their employer(s)) 2022. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

<sup>1</sup>Medical School of Chinese PLA, Beijing, China

<sup>2</sup>Senior Department of Cardiology, the Sixth Medical Center, Chinese PLA General Hospital, Beijing, China

## Correspondence to

Dr Jing Ma;  
crystalma@126.com and  
Dr Yong Xu;  
13701141929@163.com

## ABSTRACT

**Objective** Studies have shown that chronic stress is closely linked to the occurrence and development of cardiovascular disease. To date, few studies have focused on perceived stress in coronary heart diseases (CHD) patients and the possible factors influencing the stress. This study aims to investigate the perceived stress of patients with CHD and determine the individual attributes closely associated with it.

**Design** A cross-sectional study.

**Participates** A total of 2215 patients with CHD were enrolled and perceived stress was assessed with the Chinese version Perceived Stress Scale (CPSS). Participants were divided into two groups due to CPSS score and binary logistic regression was applied to analyse the factors that affected perceived stress level.

**Results** The mean CPSS score of Chinese patients with CHD was 27.16±6.35. Compared with participants who received senior middle school education or below, those with a university degree had a higher probability of high perceived stress (OR 1.453, 95% CI 1.206 to 1.750); this difference was more evident in participants with a master or doctoral degree (OR 1.928, 95% CI 1.290 to 2.882). Also engaging in mental labour (OR 1.389, 95% CI 1.144 to 1.686), having children (OR 2.226, 95% CI 1.098 to 4.515) and having a habit of risky alcohol consumption (OR 1.492, 95% CI 1.146 to 1.944) were associated with perceived stress.

**Conclusion** Patients who had higher educational attainment, engaged in mental labour, had children, and had a habit of risky alcohol consumption were much easier to perceive the stress.

## INTRODUCTION

The incidence of coronary heart disease (CHD) has been rising steadily over the past few decades and the resulting burden of disease is an issue faced by developed and developing countries alike.<sup>1</sup> Finding out the potential risk factors of CHD and subsequent targeted treatment is a severe challenge. Recent studies demonstrated that psychological and social factors play an important and independent role in the development of CHD.<sup>2–4</sup>

## Strengths and limitations of this study

- Few studies have focused on perceived stress in patients with coronary heart disease (CHD) and the identification of high perceived stress individuals.
- Utilise the Perceived Stress Scale for the accurate identification of stress-sensitive individuals among patients with CHD.
- Given the cross-sectional nature of the study, we cannot infer causal relationships.

Psychological stress (stress) refers to the psychological challenge or threat caused by various triggering events or adverse life factors and usually manifests as emotional discomfort, pain or anguish.<sup>5</sup> Under normal circumstances, a dynamic equilibrium exists between an organism and its external environment, and stress arises when this equilibrium is upset or is self-perceived as upset.<sup>6</sup> Stress is believed to be closely linked to the occurrence and development of cardiovascular disease, one of the most important psychosomatic diseases.<sup>7,8</sup> Acute mental stress caused by sudden accidents or illness may be a trigger for cardiac events such as myocardial ischaemia or Takotsubo cardiomyopathy.<sup>9,10</sup> The process of seeking medical care for patients with an acute coronary event could be another stressor itself.<sup>11</sup> Meanwhile if certain acute stress becomes persistent, it will change to chronic stress. A meta-analysis<sup>12</sup> suggests that high stress is associated with a moderately increased risk of incident CHD. The current literature suggests that mental stress may cause over-activation of the autonomic nervous system and elicit a stress response from the endocrine system, thereby inducing endothelial dysfunction, ultimately triggering cardiovascular events.<sup>13–15</sup> A latest study<sup>16</sup> revealed that the amygdala, a stress-sensitive structure, may increase the incidence of cardiovascular diseases by improving the activity of the immune system, which might

be a possible mechanism. Stress-induced platelet bioactivity increase and prolongation may also be involved in this process.<sup>17</sup>

It was also found that the process by which stressors exert their effects on an organism is not linear; instead, it arises through interactions.<sup>6</sup> The actual effect of chronic stress on different individuals depends on the stress they perceived. The stress perceived by an individual reflects his/her subjective evaluation of the stressor and will partly depend on individual attributes. Studies have shown that different individuals faced with identical stressors may perceive considerably different levels of stress, with different effects on CHD occurrence and development, resulting in differences in the severity or prognosis of CHD.<sup>18-19</sup> Therefore, the accurate identification of individuals who are more likely to perceive stress is of great significance for the precise assessment and subsequent treatment of CHD.

Assessments of psychological stress are generally performed using standard psychological instruments. Commonly used questionnaires include the Perceived Stress Scale (PSS), Stress Appraisal Measure, and Impact of Event Scale. The PSS is the most widely used scale to assess chronic stress because it is easy to implement and does not require professional intervention during administration. Developed by Cohen *et al*,<sup>20</sup> the PSS measures the dimensions of uncontrollability and stressfulness, and assesses the stress levels of individuals based on their subjective perceptions of stressors. It has been translated into many languages and used widely in diverse populations around the world.<sup>21-27</sup> Blumenthal *et al*<sup>28</sup> have used PSS as a tool to assess the chronic stress of patients with CHD. The version most used in Chinese populations is the Chinese PSS (CPSS), which is a simplified-Chinese version translated by Yang *et al*.<sup>29</sup> The CPSS has demonstrated good validity and reliability in a series of studies in different Chinese populations,<sup>30-32</sup> especially in cardiac patients.<sup>33</sup>

Few studies published to date have used the CPSS for the accurate identification of high perceived stress individuals among patients with CHD, and perceived stress detection in the Chinese mainland population with CHD has not yet been reported. We, therefore, analysed the CPSS scores of patients who visited the cardiac rehabilitation clinic at our hospital with the aim of investigating the self-perceived stress levels of Chinese patients with CHD and determining the individual attributes closely associated with perceived stress. The results of this study might help to stratify patients with CHD according to stress perception level and supply the individualised stress management programmes for Chinese populations with CHD.

## METHODS

### Study participants

A cross-sectional study design was adopted. Using the electronic medical records system of our hospital, we

screened patients referred to the cardiac rehabilitation clinic between 2015 and 2020. All patients in the inpatient department of cardiology were recommended to the rehabilitation clinic regardless of whether they choose to receive the following rehabilitation treatment or not. Only those with a definitive diagnosis of CHD were included in the analysis. Based on the criteria of the CHD 2019 ESC Guidelines for the Diagnosis and Management of Chronic Coronary Syndromes, the inclusions were: one or more lesions with  $\geq 50\%$  stenosis as shown by coronary angiography; stable angina; unstable angina; old myocardial infarction (MI); acute MI; postpercutaneous coronary intervention; postcoronary artery bypass graft; or ischaemic cardiomyopathy. Those who are unwilling to take the scale will be excluded.

### Demographic characteristics and medical history

The demographic characteristics and medical history of the participants were obtained from the cardiac rehabilitation medical records system and collated by a cardiologist. The demographic characteristics analysed included age, sex, region (south / north, divided along the Qinling Mountains-Huaihe River line), educational level, marital status, family structure (with/without children), nature of work (mental/manual labour), the presence/absence of sleep disorders, and the following lifestyle factors: regular exercise, risky alcohol consumption and smoking. The medical history data analysed included a history of cardiac revascularisation and the presence/absence of other chronic diseases requiring long-term medication. Mental labour was defined as professional, managerial, or administrative work generally performed in an office or other administrative environment. Manual labour was defined as strenuous physical work or other types of work demanding physical exertion. Regular exercise was defined as  $\geq 30$  min of low-intensity exercise  $> 5$  times per week or  $\geq 20$  min of moderate-intensity exercise  $> 3$  times per week. Sleep disorders were defined as the occurrence of at least one of the following  $\geq 3$  times per week for at least 1 month: inability to sleep after 30 min in bed, waking up  $\geq 2$  times during the night, wake time  $> 15\%$ , dreamful sleep or total sleep time  $< 6$  hours and waking up  $\geq 2$  hours ahead of schedule and subsequently unable to get back to sleep. Risky alcohol consumption was defined as the consumption of  $\geq 5$  alcoholic drinks on a single occasion  $> 12$  times in the past year.<sup>34</sup>

### Stress assessment

The perceived stress of the study participants was assessed using the CPSS, which comprises 14 items intended to measure the dimensions of uncontrollability and stressfulness. Each item is rated on a 5-point scale (0=never, 1=rarely, 2=sometimes, 3=fairly often, 4=very often), with items 4, 5, 6, 7, 9, 10 and 13 scored in the reverse direction. Total scores range from 0 to 56 points, with higher scores indicating higher psychological stress.

In addition to the CPSS, all the participants were asked to complete the Patient Health Questionnaire (PHQ-9)

scale and the Generalised Anxiety Disorder (GAD-7) scale to assess preexisting mental health comorbidities. The PHQ-9 is a self-rating scale consisting of 9 items. A PHQ-9 score greater than five indicates that the patient may be in a mild or more depressive state. The GAD-7 is a 7-item self-rating scale indicating a mild or more anxiety state when the score is greater than 5.

All the participants were asked to provide responses based on their own perceptions. All patients who visited the cardiac rehabilitation clinic for the first time were requested to complete the scales on their own after receiving instructions on questionnaire completion from a nurse. The responses were collected and collated by a cardiologist.

### Statistical analysis

Statistical analysis was performed using SPSS V.25.0. Quantitative variables were tested for normality. Normally distributed variables were expressed as mean±SD ( $\bar{x}\pm s$ ); variables not normally distributed were expressed as median and IQR. Qualitative data were expressed as ratios or percentages. Factors associated with the CPSS scores of the study participants were analysed from binary logistic regression.

### Patient and public involvement

Public and patient involvement was not applicable in this research.

## RESULTS

### Demographic data of patients with CHD

Of the 3845 patients referred to the cardiac rehabilitation clinic during the study period, 1630 patients were excluded, of which 1428 did not meet the inclusion criteria, and 202 refused to be evaluated by CPSS. Eventually, 2215 patients with CHD were included in the study (figure 1). The mean age of the study participants was  $59.57\pm 10.10$  years, and the majority of the participants were male (79.6%), had a university degree or below (94.13%), married (99.1%), had children (98.0%), engaged in mental labour (69.1%), had sleep disorders

(74.8%) and did not have a risky drinking habit (86.5%). Of the participants, 77.1% had previously undergone stent insertion, 56.2% had concomitant hypertension, 47.4% had concomitant hyperlipidaemia and 27.0% had concomitant diabetes mellitus (see table 1).

### Comparison of characteristics between groups

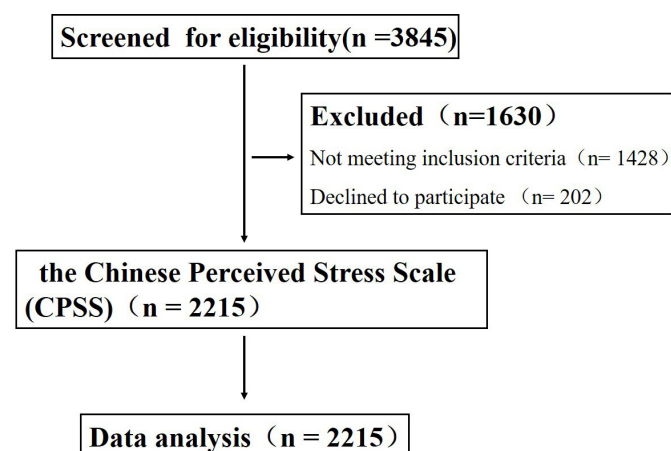
The mean CPSS score of all the patients with CHD was  $27.16\pm 6.35$ . Using the median score of 27 as the cut-off point, the study participants were divided into a low perceived stress group (CPSS score  $\leq 27$ ) and a high perceived stress group (CPSS score  $> 27$ ). Yang *et al*<sup>29</sup> conducted a CPSS assessment of the Chinese general population ( $n=3666$ ), with an average score of  $24.22\pm 5.81$ . A summary independent-sample t-test proves that the CPSS scores of the two groups are statistically different ( $p=0.000$ ). Participants who had children, engaged in mental labour, or had a habit of risky alcohol consumption had a higher probability of experiencing higher stress perception levels (see table 2).

### Logistic regression

Binary logistic regression analysis was performed in model 1 by setting the CPSS score as the dependent variable and the following as the independent variables: age, sex, educational level, marital status, family structure (with/without children), nature of work (mental/manual labour), number of stents, and the presence/absence of sleep disorders, other chronic diseases, and the following habits: regular exercise, risky alcohol consumption and smoking. Our results indicated that study participants who have children had a higher probability of high perceived stress, with the OR being 2.226 (95% CI 1.098 to 4.515). Compared with participants who received middle school education or below, those with a university degree had a higher probability of high perceived stress (OR 1.453, 95% CI 1.206 to 1.750); this was more evident in participants with a master or doctoral degree (OR 1.928, 95% CI 1.290 to 2.882). Participants who engaged in mental labour had a higher probability of high perceived stress than those who engaged in manual labour (OR 1.389, 95% CI 1.144 to 1.686). Compared with participants who did not have a habit of risky alcohol consumption, those who had this habit had a higher probability of high perceived stress (OR 1.492, 95% CI 1.146 to 1.944). Model 2 was adjusted by GAD-7 and PHQ-9 scores, which has no major influence on the conclusion (see table 3).

## DISCUSSION

The relationship between psychological stress and cardiovascular disease has attracted increasing attention in recent years. Considering that perceived stress may play some role in the occurrence and development of CHD, a greater emphasis has been placed on stress management in comprehensive cardiac rehabilitation programmes because it may potentially provide benefits, such as improving the long-term prognosis of patients with



**Figure 1** Flow diagram of the participants.



**Table 1** Social demography factors of the subjects

Social demography factor		n	%
Age	<45	160	7.2
	45–64	1317	59.5
	65–84	727	32.8
	≥85	11	0.4
Gender	Male	1764	79.6
	Female	451	20.4
Region	North	1388	62.7
	South	827	37.3
Education level	Senior high school and below	1107	50.0
	College	978	44.2
	Above college	130	5.9
Having children	Yes	2170	98.0
	No	45	2.0
Marital status	Married	2194	99.1
	Other (single, divorced or widowed)	21	0.9
Occupation	Mental	1530	69.1
	Physical	685	30.9
Regular exercise	Yes	1630	73.6
	No	585	26.4
Risky alcohol drinking	Yes	298	13.5
	No	1917	86.5
Current smoker	Yes	334	15.1
	No	1881	84.9
Comorbidity			
No of stent	0	508	22.9
	1	901	40.7
	2	462	20.9
	≥3	344	15.5
Hypertension	Yes	1245	56.2
	No	970	43.8
Hyperlipaemia	Yes	1049	47.4
	No	1166	52.6
Diabetes	Yes	598	27.0
	No	1617	73.0
Cerebrovascular disease	Yes	39	1.8
	No	2176	98.2
Other diseases	Yes	119	7.1
	No	2096	92.9
Sleep disorder	Yes	1657	74.8
	No	558	25.2
Depressive state	Yes	817	36.9
	No	1398	63.1
Anxiety state	Yes	1113	50.2
	No	1102	49.8

CHD.<sup>28</sup> In this study, we investigated the stress perception level in the Chinese CHD population and explored the possible influencing factors associated with them. Our study suggested that patients with CHD in China had a relatively higher perceived stress level. In addition, we found that patients who had higher educational attainment, engaged in mental labour, had children and had a habit of risky alcohol consumption were much easier to perceive the stress.

Analysis of the demographic characteristics of high-stress individuals among patients with CHD can support the clinical stratified management of patients according to the perceived stress level, which increases the efficiency of rehabilitation treatment and maximises the clinical benefits to each individual. Previous studies have shown that demographic characteristics such as age, sex, educational level, marital status, family structure (with/without children), nature of work (mental/manual labour), the presence/absence of mental health comorbidities, sleep disorders, other chronic diseases and the following habits: regular exercise, risky alcohol consumption and smoking may have an impact on perceived stress,<sup>20 24 26 33 35–37</sup> but the conclusion is not completely consistent. We also observed in the clinic that patients implanted with multiple stents tend to be more stressed.

Our results showed a strong correlation between perceived stress and educational level in Chinese patients with CHD. A higher educational level was associated with higher perceived stress. However, this result is contrary to the findings of studies conducted in other countries,<sup>26 38</sup> which have indicated that individuals with lower educational attainment generally perceive higher stress. This may be attributed to the long-standing, strong emphasis on educational attainment in Chinese society, which has led to the general view that individuals with higher educational levels should attain greater personal achievements and bear greater social responsibilities and expectations. However, it is not clear whether this unique socio-cultural background has caused the aforementioned difference between Eastern and Western countries in the influence of educational level on perceived stress.

The perceived stress level was also found to be strongly related to the nature of work in the Chinese population. Participants who engaged in mental labour had higher perceived stress than did those who engaged in manual labour. Such a result is not in complete agreement with the findings of previous studies. A survey by Lesage *et al.*<sup>24</sup> revealed that differences in perceived stress among administrative, technical and blue-collar workers were statistically insignificant. However, the 501 participants of Lesage's study were selected from individuals who attended occupational health centres in northern France, whereas the participants of our study had a greater diversity of occupations, including teachers, doctors, taxi drivers and gardeners. The greater diversity of occupations included in our study provides a better reflection of the actual range of perceived stress across occupations, thereby helping the occupational factor to reach

**Table 2** Comparison of two groups with different CPSS scores

Characteristics	Categories	High-stress group (n=1190)		Low stress group (n=1025)		X <sup>2</sup>	P value
		n	%	n	%		
Age	< 45	89	7.5	71	6.9	0.358	0.949
	45–64	709	59.6	608	59.3		
	65–84	386	32.4	341	33.3		
	≥85	6	0.5	5	0.5		
Gender	Male	966	81.2	798	77.9	3.750	0.053
	Female	224	18.8	227	22.1		
Education level	Senior high school and below	526	44.2	581	56.7	36.611	0.000
	College	578	48.6	400	39.0		
	Above college	86	7.2	44	4.3		
Having children	Yes	1173	98.6	997	97.3	4.698	0.030
	No	17	1.4	28	2.7		
Marital status	Married	1182	99.3	1012	98.7	2.083	0.149
	Other (single, divorced or widowed)	8	0.7	13	1.3		
Occupation	Mental	881	74.0	649	63.3	29.605	0.000
	Physical	309	26.0	376	36.7		
Regular exercise	Yes	901	75.7	729	71.1	5.975	0.015
	No	289	24.3	296	28.9		
Risky alcohol drinking	Yes	188	15.8	110	10.7	12.141	0.000
	No	1002	84.2	915	89.3		
Current smoker	Yes	182	15.3	152	14.8	0.093	0.760
	No	1008	84.7	873	85.2		
No of stent	0	280	23.5	228	22.2	0.820	0.845
	1	486	40.8	415	40.5		
	2	243	20.4	219	21.4		
	≥3	181	15.2	163	15.9		
Chronic disease	Yes	965	81.1	831	81.1	0.000	0.991
	No	225	18.9	194	18.9		
Sleep disorder	Yes	889	74.7	768	74.9	0.014	0.905
	No	301	25.3	257	25.1		
Depressive state	Yes	626	52.6	487	47.5	5.713	0.017
	No	564	47.4	538	52.5		
Anxiety state	Yes	470	39.5	347	33.9	7.530	0.006
	No	720	60.5	678	66.1		

CPSS, Chinese version Perceived Stress Scale.

significance. Dėdelė *et al*<sup>39</sup> performed a cross-sectional study on perceived stress among 571 full-time workers in Lithuania and found that blue-collar workers who spent relatively more time engaging in physical work had a higher risk of high perceived stress than white-collar workers, which appears to contradict our results. However, the distribution of perceived stress across occupations may depend on the social environment. With China's vast population, Chinese workers are often faced with complicated interpersonal relationships in their workplace. In

general, workplace ecology is more complex among individuals engaged in mental labour than among manual workers, which may have partially contributed to the difference in perceived stress we observed between the two occupational categories.

The drinking habit of patients with CHD has also been identified as a potential factor associated with perceived stress. Our results indicated that participants with a habit of risky alcohol consumption had higher perceived stress. These findings are consistent with those reported by Yoon

**Table 3** Logistics regression of CPSS score

	Model 1*		Model 2†	
	OR (95% CI)	P value	OR (95% CI)	P value
<b>Kid</b>				
Yes	1.000		1.000	
No	2.226 (1.098 to 4.515)	0.027	2.338 (1.258 to 4.345)	0.007
<b>Education level</b>				
Senior high school and below	1.000		1.000	
College	1.453 (1.206 to 1.750)	0.000	1.478 (1.231 to 1.776)	0.000
Above college	1.928 (1.290 to 2.882)	0.001	1.936 (1.306 to 2.870)	0.001
<b>Occupation</b>				
Manual	1.000		1.000	
Mental	1.389 (1.144 to 1.686)	0.001	1.394 (1.149 to 1.690)	0.001
<b>Risky alcohol drinking</b>				
No	1.000	0.003	1.000	0.001
Yes	1.492 (1.146 to 1.944)		1.516 (1.175 to 1.958)	

\*Adjusted by age, sex, educational level, marital status, family structure (with/without children), nature of work (mental/manual labour), number of stents and the presence/absence of sleep disorders, other chronic diseases and the following habits: regular exercise, risky alcohol consumption and smoking.

†Adjusted by age, sex, educational level, marital status, family structure (with/without children), nature of work (mental/manual labour), number of stents and the presence/absence of sleep disorders, other chronic diseases, the following habits: regular exercise, risky alcohol consumption, and smoking, PHQ-9 scores and GAD-7 scores.

CPSS, Chinese version Perceived Stress Scale; GAD-7, Generalised Anxiety Disorder 7; PHQ9, Patient Health Questionnaire 9.

*et al*<sup>36</sup> who showed that the proportion of individuals with adverse drinking habits was higher in the population with high perceived stress than in the population with low perceived stress. Although the study by Yoon *et al* did not investigate possible causal relationships between high stress and at-risk drinking, there is no doubt that patients with a habit of risky alcohol consumption can have higher perceived stress. Therefore, for such individuals, emphasis should be placed on appropriate stress interventions in the formulation of rehabilitation programmes.

Interestingly, we also found that patients with CHD with children were nearly twice as likely to perceive the stress as those without children, which is consistent with the findings of Lesage *et al*.<sup>24</sup>

Our results also showed that the perceived stress of patients with CHD was not correlated with age, sex or marital status. There is no study to investigate the effect of these three factors on perceived stress levels, especially in patients with CHD. For the general population, there are some inconsistent findings. A study by Andreou *et al*<sup>85</sup> indicated that younger individuals, women, and single or divorced individuals may have higher perceived stress. Cohen *et al*<sup>20</sup> reported that perceived stress was higher in women but unrelated to age; similar conclusions were reached in two other studies.<sup>40 41</sup> However, Dédelé *et al*<sup>39</sup> asserted that older individuals had higher perceived stress. A study by Leung *et al*<sup>33</sup> indicated higher levels of perceived stress in women, but a contrary result was reported by Ojard *et al*.<sup>42</sup> In summary, we have to say research on this matter is far from conclusive. And the

inconsistency of our study with other precious ones might attribute to the disease type, difference in environmental and social background.

### LIMITATIONS

This study has several limitations. First, we conducted the study in patients with CHD referred to the cardiac rehabilitation centre in our hospital, which might bring selection bias and the stress levels in the general population only had historical control. Also, a multicentre study to further evaluate the CPSS score in patients with CHD and the general population all over China is ongoing. Second, when screening influencing factors associated with the CPSS score, the variables we included might not cover all the possible factors. The effect size should be interpreted with caution due to the low variation of marital status and other potential missing covariates. Third, our study did not clarify whether the CPSS score would associate with the clinical outcome of patients with CHD, which might be a candidate topic we should investigate further.

### CONCLUSIONS

In conclusion, individuals who had higher educational attainment, engaged in mental labour, had children and had a habit of risky alcohol consumption were much easier to perceive the stress. The results of this study might help to stratify patients with CHD according to stress perception level and supply the individualised stress

management programmes for Chinese populations with CHD.

**Contributors** The study was initiated by JM and YX. YG performed the statistical analysis and drafted the manuscript. RH, YZ and MY were helpful for data collection. JM and YX contributed substantially to its revision. JM is the guarantor of this work.

**Funding** The authors disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This work was supported by the National Key R&D Program of China (2018YFC2000600).

**Competing interests** None declared.

**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study was approved by the ethics committee of the Chinese PLA General Hospital (S2020-382-01).

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data availability statement** Data are available on reasonable request. Given that the data is in Chinese, complete raw data are not available for sharing. Partial data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Open access** This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

#### ORCID iD

Yifan Gao <http://orcid.org/0000-0001-9922-0107>

#### REFERENCES

- Dai H, Much AA, Maor E. Global, regional, and national burden of ischemic heart disease and its attributable risk factors, 1990-2017: results from the global burden of disease study 2017. *Europ Heart J* 2020.
- Rosengren A, Hawken S, Ounpuu S, et al. Association of psychosocial risk factors with risk of acute myocardial infarction in 11119 cases and 13648 controls from 52 countries (the INTERHEART study): case-control study. *Lancet* 2004;364:953-62.
- Iso H, Date C, Yamamoto A, et al. Perceived mental stress and mortality from cardiovascular disease among Japanese men and women: the Japan collaborative cohort study for evaluation of cancer risk sponsored by Monbusho (JACC study). *Circulation* 2002;106:1229-36.
- Rozanski A, Blumenthal JA, Davidson KW, et al. The epidemiology, pathophysiology, and management of psychosocial risk factors in cardiac practice: the emerging field of behavioral cardiology. *J Am Coll Cardiol* 2005;45:637-51.
- Chauvet-Gelinier J-C, Bonin B. Stress, anxiety and depression in heart disease patients: a major challenge for cardiac rehabilitation. *Ann Phys Rehabil Med* 2017;60:6-12.
- Chrousos GP. Stress and disorders of the stress system. *Nat Rev Endocrinol* 2009;5:374-81.
- Gullette EC, Blumenthal JA, Babyak M, et al. Effects of mental stress on myocardial ischemia during daily life. *JAMA* 1997;277:1521-6.
- Esler M. Mental stress and human cardiovascular disease. *Neurosci Biobehav Rev* 2017;74:269-76.
- Pelliccia F, Kaski JC, Crea F, et al. Pathophysiology of takotsubo syndrome. *Circulation* 2017;135:2426-41.
- Hammad M, Sullivan S, Pearce B, et al. Inflammatory response to mental stress and mental stress induced myocardial ischemia. *Brain Behav Immun* 2018;68:90-7.
- Liyanage-Don NA, Edelman DS, Chang BP, et al. Associations between emergency department crowding and perceptions of interpersonal care in patients presenting with suspected acute coronary syndrome. *Emerg Med J* 2022;39:210493.
- Richardson S, Shaffer JA, Falzon L, et al. Meta-analysis of perceived stress and its association with incident coronary heart disease. *Am J Cardiol* 2012;110:1711-6.
- Golbidi S, Frisbee JC, Laher I. Chronic stress impacts the cardiovascular system: animal models and clinical outcomes. *Am J Physiol Heart Circ Physiol* 2015;308:H1476-98.
- Aschbacher K, Milush JM, Gilbert A, et al. Chronic stress is associated with reduced circulating hematopoietic progenitor cell number: a maternal caregiving model. *Brain Behav Immun* 2017;59:245-52.
- Sher LD, Geddie H, Olivier L, et al. Chronic stress and endothelial dysfunction: mechanisms, experimental challenges, and the way ahead. *Am J Physiol Heart Circ Physiol* 2020;319:H488-506.
- Tawakol A, Ishai A, Takx RA, et al. Relation between resting amygdalar activity and cardiovascular events: a longitudinal and cohort study. *Lancet* 2017;389:834-45.
- Koudouovoh-Tripp P, Hüfner K, Egeter J, et al. Stress enhances proinflammatory platelet activity: the impact of acute and chronic mental stress. *J Neuroimmune Pharmacol* 2021;16:500-12.
- Godoy LD, Rossignoli MT, Delfino-Pereira P, et al. A comprehensive overview on stress neurobiology: basic concepts and clinical implications. *Front Behav Neurosci* 2018;12:127.
- Xu X, Bao H, Strait KM, et al. Perceived stress after acute myocardial infarction: a comparison between young and middle-aged women versus men. *Psychosom Med* 2017;79:50-8.
- Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. *J Health Soc Behav* 1983;24:385.
- Mimura C, Griffiths P. A Japanese version of the perceived stress scale: translation and preliminary test. *Int J Nurs Stud* 2004;41:379-85.
- Katsarou A, Panagiotakos D, Zafeiropoulou A, et al. Validation of a Greek version of PSS-14: a global measure of perceived stress. *Cent Eur J Public Health* 2012;20:104-9.
- Almadi T, Cathers I, Hamdan Mansour AM, et al. An Arabic version of the perceived stress scale: translation and validation study. *Int J Nurs Stud* 2012;49:84-9.
- Lesage F-X, Berjot S, Deschamps F. Psychometric properties of the French versions of the perceived stress scale. *Int J Occup Med Environ Health* 2012;25:178-84.
- Lee E-H, Chung BY, Suh C-H, et al. Korean versions of the perceived stress scale (PSS-14, 10 and 4): psychometric evaluation in patients with chronic disease. *Scand J Caring Sci* 2015;29:183-92.
- Klein EM, Brähler E, Dreier M, et al. The German version of the perceived stress scale - psychometric characteristics in a representative German community sample. *BMC Psychiatry* 2016;16:159.
- Kaya C, Tansey TN, Melekoglu M, et al. Psychometric evaluation of Turkish version of the perceived stress scale with Turkish college students. *J Ment Health* 2019;28:161-7.
- Blumenthal JA, Sherwood A, Smith PJ, et al. Enhancing cardiac rehabilitation with stress management training: a randomized, clinical efficacy trial. *Circulation* 2016;133:1341-50.
- Yang TZ, Huang JJ, XJ W. An epidemiologic study among urban residents in social transition period. *Chinese J Behav Med Brain Sci* 2007;16:331-3.
- Huang F, Wang H, Wang Z, et al. Psychometric properties of the perceived stress scale in a community sample of Chinese. *BMC Psychiatry* 2020;20:130.
- She Z, Li D, Zhang W, et al. Three versions of the perceived stress scale: psychometric evaluation in a nationally representative sample of Chinese adults during the COVID-19 pandemic. *Int J Environ Res Public Health* 2021;18:8312.
- Lu W, Bian Q, Wang W, et al. Chinese version of the perceived stress scale-10: a psychometric study in Chinese university students. *PLoS One* 2017;12:e189543.
- Leung DYP, Lam T-hing, Chan SSC. Three versions of perceived stress scale: validation in a sample of Chinese cardiac patients who smoke. *BMC Public Health* 2010;10:513.
- Coups EJ, Ostroff JS. A population-based estimate of the prevalence of behavioral risk factors among adult cancer survivors and noncancer controls. *Prev Med* 2005;40:702-11.
- Andreou E, Alexopoulos EC, Lionis C, et al. Perceived stress scale: reliability and validity study in Greece. *Int J Environ Res Public Health* 2011;8:3287-98.
- Yoon S-J, Kim H-J, Doo M. Association between perceived stress, alcohol consumption levels and obesity in Koreans. *Asia Pac J Clin Nutr* 2016;25:316-25.
- Malik AO, Peri-Okonny P, Gosch K, et al. Association of perceived stress levels with long-term mortality in patients with peripheral artery disease. *JAMA Netw Open* 2020;3:e208741.
- Hernandez R, Allen NB, Liu K, et al. Association of depressive symptoms, trait anxiety, and perceived stress with subclinical atherosclerosis: results from the Chicago healthy aging study (CHAS). *Prev Med* 2014;61:54-60.
- Dèdelè A, Miškinytė A, Andrušaitytė S, et al. Perceived stress among different occupational groups and the interaction with sedentary behaviour. *Int J Environ Res Public Health* 2019;16:ijerph16234595.



- 40 Avila-Palencia I, de Nazelle A, Cole-Hunter T, *et al*. The relationship between bicycle commuting and perceived stress: a cross-sectional study. *BMJ Open* 2017;7:e13542.
- 41 Nitsch KP, Miskovic A, Rodichok B. Measurement characteristics of the perceived stress scale in individuals with spinal cord injury. *Arch Phys Med Rehabil* 2016;97:1219–20.
- 42 Ojard C, Donnelly JP, Safford MM, *et al*. Psychosocial stress as a risk factor for sepsis: a population-based cohort study. *Psychosom Med* 2015;77:93–100.