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EVALUATING THE ASSOCIATION BETWEEN EFFORT-REWARD IMBALANCE AND SUBOPTIMAL HEALTH STATUS AMONG HOSPITAL NURSES: A CROSS-SECTIONAL STUDY

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Abstract

Objectives: Occupational stress is a common complaint in nurses, who perceived more sense of effort-reward imbalance (ERI). Suboptimal health status (SHS) is a state between health and disease. However, the correlation between ERI and SHS is unclear. Therefore, the aim of this study was to examine the prevalence of SHS and ERI and evaluate the relationship between ERI and SHS in clinical nurses by a cross-sectional study. **Material and Methods:** The current cross-sectional study was conducted through an online survey at Dongping People's Hospital in China. A total of 633 completed surveys were received. Effort-reward imbalance was measured by subscales of the ERI questionnaire. The SHS was measured by the *Suboptimal Health Status Questionnaire – 25* (SHSQ-25). The relationship between ERI and SHS in nurses was subsequently assessed by Spearman's

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correlation coefficient and logistic regression model. **Results:** The mean age of the optimal health status (OHS) group (M±SD 26.3±7.3 years) was younger than the SHS group (M±SD 30.3±6.9 years). The prevalence of SHS was 54.5% (345/633). Female nurses aged ≥30 years, a junior college or university graduate educational level, smokers, and nurses without regular exercise were at a higher risk of SHS. In Spearman's correlation analysis, ERI reflected by the effort-reward ratio was correlated with SHSQ-25 score ($r = 0.662$, $p < 0.001$). In logistic regression, ERI was strongly associated with SHS after potential confounding factors adjusting (OR 27.924, 95% CI 22.845–34.132). **Conclusions:** The prevalence of SHS was significantly high in clinical nurses. Administrators should pay more attention to health status of female nurses aged ≥30 years, with a junior college or bachelor's degree, smoking, and without regular exercise to reduce the SHS and ERI. Int J Occup Med Environ Health. 2024;37(2):166–75

Key words:
stress, nurses, occupational health, hospital, effort-reward imbalance, suboptimal health status

INTRODUCTION

Nurses are the pivotal components of the healthcare system, who dedicate the most time to direct patient care [1], and the quality of patients' care and nursing is greatly affected by nurses' performance in the hospital. The nursing profession is characterized by a fast pace, large workloads, and high work intensity [2]. The increases in nurses' burnout levels and stress [3,4] can compromise productivity and performance, as well as affect the quality of patient care [5]. Therefore, investing more effort to maintain nurses' psychological and physical health is warranted.

The effort-reward imbalance (ERI) model, proposed by Siegrist [6], is a main-stream measure of the psychosocial work environment to explain job stress, described as a failed state of reciprocity with high effort spent but low rewards received [7,8]. Compared with other occupations, nurses have reported higher ERI [9]. In previous studies, 93% [10] and 59.7% [11] of the emergency department nurses from the USA and China had an ERI; in Egypt, nurses reported high levels of ERI (72.5%) [12]; and 20.7% in Germany [13]. Previous research has demonstrated that ERI is associated with hypertension, physical diseases, and mental disorders [14], such as hypertension [15], cardiovascular disease [16,17], depression [18], and sleep disorder [19,20]; ERI negatively affected the quality of working life [21], and ERI was positively associated with insomnia and productivity lost [22]. Additionally, ERI could lead to an increase in withdrawal behavior and turnover intentions [23].

Suboptimal health status (SHS) is a moderate state between health and disease without a diagnosable condition, which is characterized by chronic fatigue, weakness, decreased adaptability and physical function [24,25]. Nurses are exposed to multifarious professional challenges and bear the double pressure of mind and body due to the patient safety concerns and personal factors, which cause nurses to have SHS. A study reported the SHS prevalence of nurses was 35.1% in hospitals during the coronavirus disease 2019 (COVID-19) [26]. Accordingly, SHS may affect nurses' physical and mental health, patient safety, and the quality of hospital and healthcare. As a major global public health challenge, SHS has attracted growing concern from healthcare practitioners. The concept of SHS has led to the development of a robust scanning tool, the *Suboptimal Health Status Questionnaire – 25* (SHSQ-25), which is a self-report non-invasive tool for SHS measurement based on the perspective of predictive, preventive, and personalized medicine, covering 5 domains and consisting of 25 items [27]. The SHSQ-25 has been identified to be a reliable and valid measure tool for people's health in large-scale health condition surveys in 3 major ethnic groups (African, Asian, and Caucasian) [28–30]. Previous studies have focused on examining the prevalence of ERI or SHS. A study has revealed that ERI showed associations with suboptimal self-rated health in Swedish [31]. However, the knowledge concerning the association between ERI and SHS in clinical nurses is limited. Therefore, the authors of this study aimed to explore hospital nurses' current situation with ERI and evaluate the relationship between ERI and SHS in Dongping People's Hospital in China via a cross-sectional survey.

MATERIAL AND METHODS

Study design

A cross-sectional study was conducted to explore the association between ERI and SHS among nurses at Dongping People's Hospital, which is a tertiary hospital in China. This study was approved by the Clinical Ethics Review Committee of Dongping People's Hospital (No. DPH-24082021). Participants were informed of the study purpose and approach in the invitation online and had their consent for recruitment at the start of the survey.

Participants

Participants were nurses aged ≥18 years, working in the hospital currently, and able to proceed with the questionnaire. The authors excluded individuals suffering from an uncontrolled physical and psychiatric disorder.

Recruitment

From June to August 2022, an online questionnaire survey was undertaken to collect data. The survey was developed using Wenjuanxing, a recognized online survey platform in China. At the start of the survey, the participant information letter was provided, indicating that completing and submitting the questionnaire is considered informed consent. The recruitment was conducted as following strategy:

- The method of convenient sampling was applied to recruit nurses working in Dongping People's Hospital.
- Initially, invitations were sent via WeChat to hospital nurses. The support nurses answered the questionnaire with either QR code or link by their mobile devices.
- Moreover, nurses were encouraged to share the survey by their networks to extend the pool of potential respondents.
- All questions were mandatory, to ensure the completeness of the questionnaire survey.
- Seven hundred questionnaires were received. The screening measures were implemented and duplicates and responses that out of the eligible criteria were excluded.
- Finally, a total of 633 completed surveys were identified, resulting in a response rate of 90.4%.

Measurements

In this study, the content of the structured anonymous questionnaire included 3 parts: demographic characteristics, the ERI questionnaire, and the SHSQ-25. The participant's characteristics included age, sex, educational level, smoking, drinking, whether having a regular exercise habit, and daily sleep hours.

The ERI was assessed based on the effort-reward ratio, which was measured by subscales of the ERI questionnaire. This questionnaire includes 23 items divided into 3 domains: effort (including 6 items), reward (including 11 items), and overcommitment (including 6 items). The effort and reward scales were 5-point Likert-type scales, and the option of "1" represented a non-respective stressful experience and the option of "5" represented a state of extreme high stress. The over commitment scale was a 4-point Likert-type scale, in which the option of "1" represented fully disagree and the option of "4" represented fully agree. The scores of the effort, reward, and overcommitment scales ranged 6–30, 11–55, and 6–24, respectively. The effort-reward ratio is designed to evaluate the imbalance between effort and reward, and it was calculated as:

$$E/(R \times C) \quad (1)$$

where:

E – the effort scores,

R – the reward scores,

C – the correction factor which was the ratio of the number of effort items and the number of reward items (6/11).

An E/R >1 indicated that the participants' invested efforts cannot match the received rewards. Additionally, participants whose scores were in the upper one-third were considered in the "overcommitment" parameters.

The SHSQ-25 was created to time-efficiently and cost-effectively to evaluate SHS. It has been validated and represented high reliability and validity in 3 major ethnic groups – African, Asian, and Caucasian in this questionnaire in health measures [30,32,33]. The SHSQ-25 is a self-reported instrument, including 5 domains of fatigue, cardiovascular system, digestive tract, immune system, and mental status, with 25 items [27]. The SHSQ-25 items are scored on a 5-point Likert-type scale according to the frequency of specific complaints: 1 – never or almost never, 2 – occasionally, 3 – often, 4 – very often, and 5 – always. The raw scores of items 1–5 on the questionnaire were subsequently recoded as 0–4, and the total of the 25 items constitutes the SHSQ-25 score. There are 2 classifications to present participant's health status: optimal health status (OHS) with the SHSQ-25 score <35, and suboptimal health status (SHS) with SHSQ-25 score ≥35.

Statistical analysis

The authors used SPSS v. 27.0 for Windows (IBM Corp., Armonk, NY) and the R program (v. 4.2.1) for statistical analyses. Categorical variables were represented as frequencies and percentages. Pearson's χ^2 test was applied to compare the differences in sociodemographic and effort-reward variables between OHS and SHS groups. Continuous variables were reported as mean (M) ± standard deviation (SD). The student's t-test was applied to compare the differences in ERI scores between OHS and SHS groups. The associations of the independent variables with SHS were conducted using a binary logistic regression model with a stepwise selection algorithm. Correlations between ERI and SHSQ-25 scores were analyzed using Spearman's test. All reported p values were 2-tailed, and $p < 0.05$ was considered statistically significant.

RESULTS

Participants' characteristics

The characteristics of the hospital nurses are presented in Table 1. A total of 633 (90.4% response rate) completed surveys were received for data analysis. The age of the OHS group (M±SD 26.3±7.3 years) was younger than the SHS group (M±SD 30.3±6.9 years). The prevalence of SHS was 54.5%, and the prevalence was significantly higher ($p < 0.05$) among female nurses (59.6%) than among male nurses (38.0%). The respective prevalence rates were 36.1%, 61.1%, 67.8%, and 41.7% among nurses who held the educational level of polytechnic school, junior college, university graduate, and master or above. In this sample, 7.0% of SHS nurses were smokers, and 43.5% SHS nurses did regularly exercise.

Comparison between OHS and SHS nurses in ERI

As shown in Table 1, there were significant differences in statistics between the OHS and SHS groups in the effort score, reward score, overcommitment score, ERI ratio and distribution of overcommitment. Correspondingly, the effort score, reward score, and overcommitment score in OHS group were higher SHS group. Additionally, the prevalence of ERI (E/R >1) in the SHS group was higher (87.0%) than OHS; and SHS nurses perceived more overcommitment. In addition, as shown in Figure 1, the scores of SHSQ-25, including each domain and total score, in E/R >1 group were statistically higher than that of E/R ≤1.

Correlation between ERI questionnaire scores and SHSQ-25 scores

The associations between SHSQ-25 scores, including scores for each domain, and ERI scores were shown in Figure 2. Spearman's correlation analysis revealed that the effort ($r = 0.431$, $p < 0.001$), reward ($r = 0.088$, $p = 0.026$), overcommitment ($r = 0.179$, $p < 0.001$) score and E/R ratio ($r = 0.662$, $p < 0.001$) were significantly correlated with SHSQ-25 score. Regarding respective domains of SHSQ-25, the effort score was significantly correlated with fatigue ($r = 0.433$, $p < 0.001$), mental status ($r = 0.384$, $p < 0.001$), digestive tract ($r = 0.247$, $p < 0.001$), and immune system

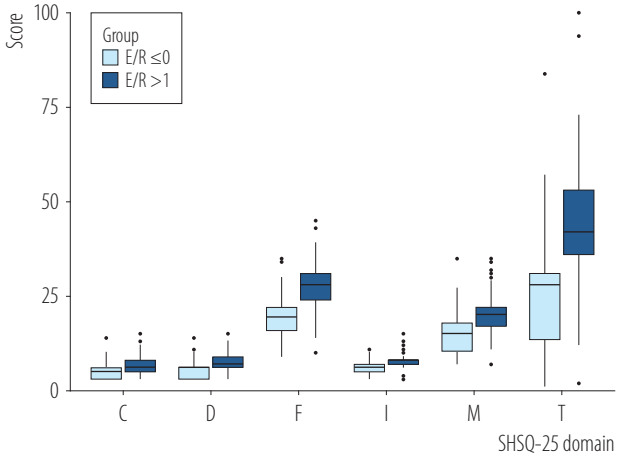
Table 1. Characteristics and proportions with suboptimal health status among 633 hospital nurses in a cross-sectional survey conducted at Dongping People's Hospital, China, June–August 2022

Variable	Participants (N = 633)		p
	optimal health status[a] (N = 288)	suboptimal health status[a] (N = 345)	
Demographic and socio-economic factor [n (%)]			
age			<0.001
18–29 years	204 (70.8)	150 (43.5)	
≥30 years	84 (29.2)	195 (56.5)	
sex			<0.001
male	90 (31.2)	57 (16.5)	
female	198 (68.8)	288 (83.5)	
education level			<0.001
polytechnic school	117 (40.6)	66 (19.1)	
junior college	42 (14.6)	66 (19.1)	
university graduate	87 (30.2)	183 (53.0)	
master or above	42 (14.6)	30 (8.7)	
Lifestyle factor [n (%)]			
smoking			0.032
yes	9 (3.1)	24 (7.0)	
no	279 (96.9)	321 (93.0)	
drinking			0.437
yes	33 (11.5)	33 (9.6)	
no	255 (88.5)	312 (90.4)	
regular exercise			<0.001
yes	192 (66.7)	150 (43.5)	
no	96 (33.3)	195 (56.5)	
sleep time			0.935
7–9 h	171 (59.4)	207 (60.0)	
<7 h or >9 h	117 (40.6)	138 (40.0)	
Work-related stress			
effort (M±SD)	12.32±5.8	17.93±6.6	<0.001
reward (M±SD)	23.59±8.2	25.77±9.1	0.002
overcommitment (M±SD)	11.99±3.7	13.71±4.3	<0.001
E/R[b] [n (%)]			<0.001
≤1	231 (80.2)	45 (13.0)	
>1	57 (19.8)	300 (87.0)	

Table 1. Characteristics and proportions with suboptimal health status among 633 hospital nurses in a cross-sectional survey conducted at Dongping People's Hospital, China, June–August 2022 – cont.

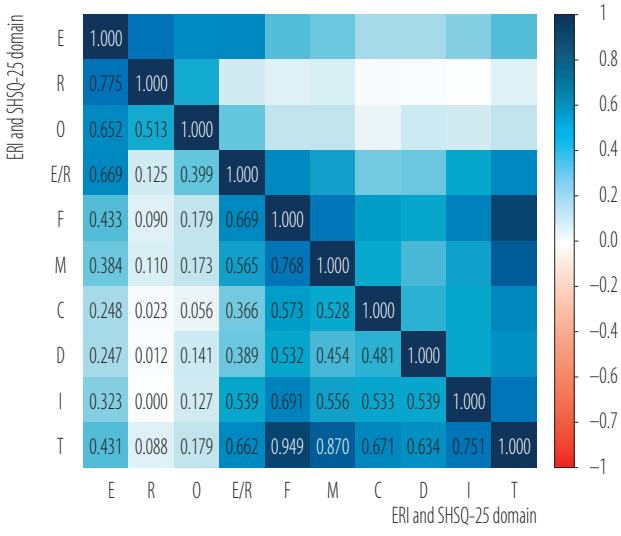
Variable	Participants (N = 633)		p
	optimal health status[a] (N = 288)	suboptimal health status[a] (N = 345)	
Work-related stress – cont.			
distribution of overcommitment [n (%)]			0.019
6–17	255 (47.5)	282 (52.5)	
18–24	33 (34.4)	63 (65.6)	

[a] Health status was assessed by *Suboptimal Health Status Questionnaire* – 25 (SHSQ-25), OHS indicating optimal health status with SHSQ-25 score <35; whereas SHS representing suboptimal health status with SHSQ-25 score ≥35.
[b] E/R is the ratio of "effort scores" and "reward scores", it was evaluated by the effort-reward imbalance (ERI) questionnaire. An E/R >1 indicates the ERI that the participants' invested efforts cannot match the received rewards.



C – cardiovascular system; D – digestive tract; F – fatigue; I – immune system; M – mental status; T – total.
E/R – effort/reward ratio.
Regarding the categorization of 2 groups of E/R ≤1 and E/R >1, E/R indicates effort-reward ratio, it was evaluated by the effort-reward imbalance (ERI) questionnaire. The ERI reflected by the E/R >1, represents that the participant's invested efforts cannot match the received rewards.

Figure 1. Box plot of the distribution of *Suboptimal Health Status Questionnaire* – 25 (SHSQ-25) scores in 2 groups of effort/reward ratio (E/R) ≤1 and E/R >1 in a cross-sectional survey among 633 hospital nurses conducted at Dongping People's Hospital, China, June–August 2022



SHSQ-25: C – cardiovascular system; D – digestive tract; F – fatigue; I – immune system; M – mental status; T – total.
ERI questionnaire: E – effort; R – reward; E/R – effort/reward ratio; O – overcommitment.
Positive correlations were observed between 4 domains of ERI questionnaire and 5 domains of SHSQ-25, which indicates the higher the effort-reward imbalance, the higher SHSQ-25 score (poorer health status).

Figure 2. Correlation between effort-reward imbalance (ERI) questionnaire scores and *Suboptimal Health Status Questionnaire* – 25 (SHSQ-25) scores in a cross-sectional survey among 633 hospital nurses conducted at Dongping People's Hospital, China, June–August 2022

(r = 0.323, p < 0.001); the reward score was significantly correlated with fatigue (r = 0.909, p = 0.024) and mental status (r = 0.110, p = 0.006); the overcommitment score was significantly correlated with fatigue (r = 0.179, p < 0.001), mental status (r = 0.173, p < 0.001), digestive tract (r = 0.141, p < 0.001) and immune system (r = 0.127, p = 0.001).

Table 2. Associations between effort-reward imbalance (ERI) and suboptimal health status (SHS), using the logistic regression model in a cross-sectional survey among 633 hospital nurses conducted at Dongping People's Hospital, China, June–August 2022

Variable	OR	95% CI	p
Model 1			
E/R ≤1 (ref.)			
E/R >1	27.018	17.631–41.402	<0.0001
Model 2			
E/R ≤1 (ref.)			
E/R >1	23.907	19.963–28.632	<0.0001
Model 3			
E/R ≤1 (ref.)			
E/R >1	27.924	22.845–34.132	<0.0001

E/R – effort-reward ratio.
Model 1 – without adjustment; model 2 – adjusting age and sex; model 3 – adjusting age, sex, educational attainment, smoking, alcohol use, physical activity, and sleep hours.

Associations of effort-reward imbalance with SHS, with and without adjustment for potential confounding factors

The logistic regression analysis was conducted to evaluate the associations of effort-reward ratios with SHS. Detailed information was listed in Table 2. In model 3, strong associations of effort-reward imbalance (reflected by E/R >1) and SHS were observed (OR 27.924, 95% CI: 22.845–34.132), after adjusting the potential confounding risk factors of age, sex, educational attainment, smoking, alcohol use, physical activity, and sleep hours. Model 2 and model 1 demonstrated similar patterns of associations.

DISCUSSION

In this study, more than half of the nurses (54.5%) experienced SHS, which showed the hospital nurses are under serious pressure by complex work conditions and pose a threat to nurses' physical and mental health. Such high prevalence was significantly over than the finding in 2760 nurses during the COVID-19 outbreak in 2020 [26], which indicated that the issue of SHS was getting serious gradually. The probable reason might be that the hospital nurses must take good nursing care for patients and face the risk of COVID-19 and bear the double pressure on the body and mind [34] because the epidemic is obviously not over. Nurses performed more risky and intensive work in a worse environment. Higher turnover intention [35] and the occurrence of medical errors [36] also may make them have more stress in their daily work.

Compared to the nurses aged 18–29 years, nurses >30 years had a higher SHS incidence rate. That may be young nurses are usually able to keep a better status of psychological and physical health. With the increase of age, individuals' functions and physical conditions begin to decline gradually, and aging was an independent risk factor for SHS [37]. A previous study [38] has shown that continuing professional development appeared to be more intensive relative to younger nurses; however, female nurse >30 years more often has a huge challenge to balance life and work. This may be the factors that lead nurses aged ≥30 years to have a higher risk of SHS.

There may be a correlation between gender and the occurrence of SHS. Compared with male nurses, female nurses are more likely to experience SHS status, and the difference of physiological and psychological between genders could be the affecting factor. Female nurses have reported more severe degrees of mental health symptoms than males [39]. A previous study also found that it would consume more physical and mental energy for female nurses because they must face the discomfort during periods while wearing protective clothing during COVID-19 [26].

Various factors that were influential to SHS, including age, gender, functions, activities, emotion, dietary habits, social adaptation [40,41]. This study showed that nurses who had a junior college or university graduate educational level were at a higher risk of SHS. The main reason for this is that nurses with junior col-

lege or over educational level are the key force among nurses in a tertiary hospital, with lasting work and intensive labour intensity make them suffer more stress. Meanwhile, individuals with higher education degree reported greater psychological demands [42]. Liang's study [43] reported that clinical practitioners with higher levels of education were more susceptible to work strain, and this psychosocial work stress factors was the factor influencing the risk of suboptimal health among medical staff. Similarly, in this study, the authors found that the prevalence rate of SHS is significantly lower in nurses with regular exercise habits than those who did not. Compared with nurses who are non-smokers, nurses who smoke are more likely to experience SHS. This is consistent with previous reports, unhealth lifestyles were considered as one of the most important factors affecting SHS, such as smoking and physical inactivity [44,45].

There was a close relationship between health status and ERI among clinical nurses. In this study, there were 2 groups based on the SHSQ-25 score: OHS group (SHSQ-25 score <35) and SHS group (SHS ≥35). The findings in this study demonstrated that clinical nurses who perceived a high effort score, reward score, and overcommitment score were at a SHS group. In addition, compared with OHS nurses, the prevalence of ERI in nurses with SHS was 87.0%, which was extremely high. The result showed that SHS is a pivotal contributing factor for ERI. Overall, SHS nurses perceived more overcommitment than OHS nurses; and SHS nurses had a higher risk of ERI. Therefore, high attention to the SHS and ERI of nurses and the relationship between them is warranted.

Limitations

While the findings of this study provide valuable insights into the association between ERI and SHS, several limitations should be considered. The authors designed this study as an observational, cross-sectional survey; this allowed to explore the association between ERI and SHS, but prevented from establishing causality, which should be the purpose of future longitudinal studies. Secondly, the authors obtained all information through self-reported questionnaires, which may introduce potential information bias. Lastly, participants in the current study were from a single centre that was representative of the local population but may limit its generalizability.

CONCLUSIONS

Overall, the current study observed a high prevalence of SHS in clinical nurses. The risk of experiencing ERI and overcommitment was significantly higher in nurses with SHS than among nurses with OHS. Based on the findings, administrators should pay more attention to health status of female nurses aged ≥30 years, with an educational background of a junior college or bachelor's degree, smoking, and without regular exercise take targeted steps to reduce their experience of SHS and ERI. The findings from the current study draw forth suggestions that it is necessary to take measures to reduce nurses' sense of effort (e.g., recruit more medical staff, reduce the quantity of night shifts) and increase their sense of rewards (e.g., increase nurses' income, and create a safe work environment). Additionally, SHSQ-25 and ERI questionnaires are considered as instruments for application in large-scale surveys of the normal people and routine health studies to prevent the predisposition to chronic disease.

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REFERENCES

1. García-Sierra R, Fernández-Castro J. Relationships between leadership, structural empowerment, and engagement in nurses. J Adv Nurs. 2018;74(12):2809-2819. https://doi.org/10.1111/jan.13805.
2. Fradelos E, Tzitzikos G, Giannouli V, Argyrou P, Vassilopoulou C, Theofilou P. Assessment of Burn-Out and Quality of Life in Nursing Professionals: The Contribution of Perceived Social Support. Health Psychol Res. 2014;2(1):984. https://doi.org/10.4081/hpr.2014.984.
3. Patel RS, Bachu R, Adikey A, Malik M, Shah M. Factors Related to Physician Burnout and Its Consequences: A Review. Behav Sci (Basel) 2018;8(11):98. https://doi.org/10.3390/bs8110098.
4. Chesak SS, Cutshall SM, Bowe CL, Montanari KM, Bhagra A. Stress Management Interventions for Nurses: Critical Literature Review. J Holist Nurs. 2019;37(3):288-295. https://doi.org/10.1177/0898010119842693.
5. Khamisa N, Oldenburg B, Peltzer KIlic D. Work related stress, burnout, job satisfaction and general health of nurses. Int J Environ Res Public Health. 2015;12(1):652-666. https://doi.org/10.3390/ijerph120100652.
6. Siegrist J. Adverse health effects of high-effort/low-reward conditions. J Occup Health Psychol. 1996;1(1):27-41. https://doi.org/10.1037//1076-8998.1.1.27.
7. Colindres CV, Bryce E, Coral-Rosero P, Ramos-Soto RM, Bonilla F, Yassi A. Effect of effort-reward imbalance and burnout on infection control among Ecuadorian nurses. Int Nurs Rev. 2018;65(2):190-199. https://doi.org/10.1111/inr.12409.
8. Ge J, He J, Liu Y, Zhang J, Pan J, Zhang X, et al. Effects of effort-reward imbalance, job satisfaction, and work engagement on self-rated health among healthcare workers. BMC Public Health. 2021;21(1):195. https://doi.org/10.1186/s12889-021-10233-w.
9. Hong KJ, Cho SH. Effort-Reward Imbalance and Its Effects on Satisfaction With Working Conditions and Sleep-Related Problems: Comparison of Nurses and Other Occupations. J Nurs Scholarsh. 2021;53(5):595-603. https://doi.org/10.1111/jnu.12666.
10. Bardhan R, Heaton K, Davis M, Chen P, Dickinson DA, Lungu CT. A Cross Sectional Study Evaluating Psychosocial Job Stress and Health Risk in Emergency Department Nurses. Int J Environ Res Public Health. 2019;16(18). https://doi.org/10.3390/ijerph16183243.
11. Tian M, Yang H, Yin X, Wu Y, Zhang G, Lv C, et al. Evaluating effort-reward imbalance among nurses in emergency departments: a cross-sectional study in China. BMC Psychiatry. 2021;21(1):353. https://doi.org/10.1186/s12888-021-03344-6.
12. Salem EA, Ebrahem SM. Psychosocial work environment and oxidative stress among nurses. J Occup Health. 2018;60(2):182-191. https://doi.org/10.1539/joh.17-0186-oa.
13. Schulz M, Damkröger A, Heins C, Wehlitz L, Löhr M, Driessen M, et al. Effort-reward imbalance and burnout among German nurses in medical compared with psychiatric hospital settings. J Psychiatr Ment Health Nurs. 2009;16(3):225-33. https://doi.org/10.1111/j.1365-2850.2008.01355.x.
14. Zhang J, Wang Y, Xu J, You H, Li Y, Liang Y, et al. Prevalence of mental health problems and associated factors among front-line public health workers during the COVID-19 pandemic in China: an effort-reward imbalance model-informed study. BMC Psychol. 2021;9(1):55. https://doi.org/10.1186/s40359-021-00563-0.
15. Boucher P, Gilbert-Ouimet M, Trudel X, Duchaine CS, Milot A, Brisson C. Masked hypertension and effort-reward imbalance at work among 2369 white-collar workers. J Hum Hypertens. 2017;31(10):620-626. https://doi.org/10.1038/jhh.2017.42.
16. Eddy P, Wertheim EH, Kingsley M, Wright BJ. Associations between the effort-reward imbalance model of workplace stress and indices of cardiovascular health: A systematic review and meta-analysis. Neurosci Biobehav Rev. 2017;83:252-266. https://doi.org/10.1016/j.neubiorev.2017.10.025.

17. Dragano N, Siegrist J, Nyberg ST, Lunau T, Fransson EI, Alfredsson L, et al. Effort-Reward Imbalance at Work and Incident Coronary Heart Disease: A Multicohort Study of 90,164 Individuals. Epidemiology. 2017;28(4):619-626. https://doi.org/10.1097/ede.0000000000000666.
18. Li J, Leineweber C, Nyberg A, Siegrist J. Cost, Gain, and Health: Theoretical Clarification and Psychometric Validation of a Work Stress Model With Data From Two National Studies. J Occup Environ Med. 2019;61(11):898-904. https://doi.org/10.1097/jom.0000000000001696.
19. Chao W, Shuang L, Tao L, Shanfa Y, Junming D. Mediation effects of overcommitment on effort, reward, insomnia, and well-being as moderated by gender, age, and job position. Southeast Asian J Trop Med Public Health. 2017;48(1):227-239.
20. Cho E, Chen TY. The bidirectional relationships between effort-reward imbalance and sleep problems among older workers. Sleep Health. 2020;6(3):299-305. https://doi.org/10.1016/j.sleh.2020.01.008.
21. Liang HY, Tseng TY, Dai HD, Chuang JY, Yu S. The relationships among overcommitment, effort-reward imbalance, safety climate, emotional labour and quality of working life for hospital nurses: a structural equation modelling. BMC Nurs. 2023;22(1):204. https://doi.org/10.1186/s12912-023-01355-0.
22. Boren JP, Veksler AE. The stress of nursing: exploring communicatively restricted organizational stress (CROS), effort-reward imbalance, and organizational support among a sample of U.S. working nurses. J Occup Med Toxicol. 2023;18(1):22. https://doi.org/10.1186/s12995-023-00390-6.
23. Leineweber C, Bernhard-Oettel C, Eib C, Peristera P, Li J. The mediating effect of exhaustion in the relationship between effort-reward imbalance and turnover intentions: A 4-year longitudinal study from Sweden. J Occup Health 2021;63(1):e12203. https://doi.org/10.1002/1348-9585.12203.
24. Wang W, Yan Y. Suboptimal health: a new health dimension for translational medicine. Clin Transl Med. 2012;1(1):28. https://doi.org/10.1186/2001-1326-1-28.
25. Yan YX, Dong J, Liu YQ, Zhang J, Song MS, He Y, et al. Association of suboptimal health status with psychosocial stress, plasma cortisol and mRNA expression of glucocorticoid receptor α/β in lymphocyte. Stress. 2015;18(1):29-34. https://doi.org/10.3109/10253890.2014.999233.
26. Liu H, Fan J, Tao X, Zhan Y, Huang LWang G. Suboptimal health status of nurses in Wuhan, China during the COVID-19 outbreak. Rev Assoc Med Bras. 2021;67(7):1010-1014. https://doi.org/10.1590/1806-9282.20210449.
27. Wang W, Yan Y, Guo Z, Hou H, Garcia M, Tan X, et al. All around suboptimal health - a joint position paper of the Suboptimal Health Study Consortium and European Association for Predictive, Preventive and Personalised Medicine. EPMA J 2021;12(4):403-433. https://doi.org/10.1007/s13167-021-00253-2.
28. Adua E, Afrifa-Yamoah E, Frimpong K, Adama E, Karthigesu SP, Anto EO, et al. Construct validity of the Suboptimal Health Status Questionnaire-25 in a Ghanaian population. Health Qual Life Outcomes 2021;19(1):180. https://doi.org/10.1186/s12955-021-01810-z.
29. Yan YX, Liu YQ, Li M, Hu PF, Guo AM, Yang XH, et al. Development and evaluation of a questionnaire for measuring suboptimal health status in urban Chinese. J Epidemiol 2009;19(6):333-341. https://doi.org/10.2188/jea.je20080086.
30. Kupaev V, Borisov O, Marutina E, Yan YX, Wang W. Integration of suboptimal health status and endothelial dysfunction as a new aspect for risk evaluation of cardiovascular disease. EPMA J. 2016;7(1):19. https://doi.org/10.1186/s13167-016-0068-0.
31. Stadin M, Nordin M, Broström A, Magnusson Hanson LL, Westerlund H, Fransson EI. Information and communication technology demands at work: the association with job strain, effort-reward imbalance and self-rated health in different socio-economic strata. Int Arch Occup Environ Health 2016;89(7):1049-1058. https://doi.org/10.1007/s00420-016-1140-8.
32. Anto EO, Roberts P, Coall D, Turpin CA, Adua E, Wang Y, et al. Integration of suboptimal health status evaluation as a criterion for prediction of preeclampsia is strongly recommended for healthcare management in pregnancy:

a prospective cohort study in a Ghanaian population. EPMA J. 2019;10(3):211-226. https://doi.org/10.1007/s13167-019-00183-0.

33. Sun Q, Xu X, Zhang J, Sun M, Tian Q, Li Q, et al. Association of suboptimal health status with intestinal microbiota in Chinese youths. J Cell Mol Med. 2020;24(2):1837-1847. https://doi.org/10.1111/jcmm.14880.
34. Chen Q, Liang M, Li Y, Guo J, Fei D, Wang L, et al. Mental health care for medical staff in China during the COVID-19 outbreak. Lancet Psychiatry. 2020;7(4):e15-e16. https://doi.org/10.1016/s2215-0366(20)30078-x.
35. Lavoie-Tremblay M, Gélinas C, Aubé T, Tchouaket E, Tremblay D, Gagnon MP, et al. Influence of caring for COVID-19 patients on nurse's turnover, work satisfaction and quality of care. J Nurs Manag. 2022;30(1):33-43. https://doi.org/10.1111/jonm.13462.
36. Kaur AP, Levinson AT, Monteiro JFG, Carino GP. The impact of errors on healthcare professionals in the critical care setting. J Crit Care. 2019;52:16-21. https://doi.org/10.1016/j.jcrc.2019.03.001.
37. Zhu J, Ying W, Zhang L, Peng G, Chen W, Anto EO, et al. Psychological symptoms in Chinese nurses may be associated with predisposition to chronic disease: a cross-sectional study of suboptimal health status. EPMA J. 2020;11(4):551-563. https://doi.org/10.1007/s13167-020-00225-y.
38. Pool IA, Poell RF, Berings MG, ten Cate O. Strategies for continuing professional development among younger, middle-aged, and older nurses: a biographical approach. Int J Nurs Stud. 2015;52(5):939-950. https:/doi.org/10.1016/j.ijnurstu.2015.02.004.
39. Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors Associated With Mental Health Outcomes Among Health Care Workers Exposed to Coronavirus Disease 2019. JAMA Netw Open. 2020;3(3):e203976. https://doi.org/10.1001/jamanetworkopen.2020.3976.
40. Wu S, Xuan Z, Li F, Xiao W, Fu X, Jiang P, et al. Work-Recreation Balance, Health-Promoting Lifestyles and Suboptimal Health Status in Southern China: A Cross-Sectional Study. Int J Environ Res Public Health. 2016;13(3). https://doi.org/10.3390/ijerph13030339.
41. Yan YX, Dong J, Liu YQ, Yang XH, Li M, Shia G, et al. Association of suboptimal health status and cardiovascular risk factors in urban Chinese workers. J Urban Health 2012;89(2):329-338. https://doi.org/10.1007/s11524-011-9636-8.
42. Landsbergis PA, Grzywacz JG, LaMontagne AD. Work organization, job insecurity, and occupational health disparities. Am J Ind Med. 2014;57(5):495-515. https://doi.org/10.1002/ajim.22126.
43. Liang YZ, Chu X, Meng SJ, Zhang J, Wu LJ, Yan YX. Relationship between stress-related psychosocial work factors and suboptimal health among Chinese medical staff: a cross-sectional study. BMJ Open. 2018;8(3):e018485. https://doi.org/10.1136/bmjopen-2017-018485.
44. Ma C, Xu W, Zhou L, Ma S, Wang Y. Association between lifestyle factors and suboptimal health status among Chinese college freshmen: a cross-sectional study. BMC Public Health. 2018;18(1):105. https://doi.org/10.1186/s12889-017-5002-4.
45. Xu T, Zhu G, Han S. Prevalence of Suboptimal Health Status and the Relationships between Suboptimal Health Status and Lifestyle Factors among Chinese Adults Using a Multi-Level Generalized Estimating Equation Model. Int J Environ Res Public Health 2020;17(3):763. https://doi.org/10.3390/ijerph17030763.