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Impact of effort-reward imbalance, emotional labour, and nurse-patient relationship on physical and mental health of registered nurses in China: a structural equation modeling

Fanfan Lv[1], Longti Li[1], Na Wang[1], Kefei Yu[1], Xiaofei Nie[2], Li Ke[2] and Jia Jia[2*]

Abstract

Background Currently, the physical and mental health of nursing staff in China is not optimistic and cannot be ignored. Meanwhile, the tense nurse-patient relationship imposes higher demands on the emotional labor of nursing staff. How to maintain a balance between the contributions and rewards of nursing staff, guide them to engage in moderate emotional labor, and improve their physical and mental health has become an important and urgent issue that medical institutions and the entire society need to address. The purpose of this study was to explore the effect of effort-reward imbalance on the physical and mental health of nurses, focusing on the mediating role of emotional labor and nurse-patient relationship, and to provide a basis for formulating strategies and measures to improve the health status of nursing staff.

Methods A cross-sectional design was employed.Using convenience sampling methods, 2191 new nurses were surveyed in 7 hospitals in Hubei Province, China, from June to October 2024. Data were collected using demographic characteristics questionnaire, the Short Form-12(SF-12) scale, the Effort-reward imbalance Scale, the Emotional labour Scale for Nurses, while the nurse-patient relationship was assessed using single items. AMOS 26.0 was used for model drawing and mediation path testing, and SPSS 26.0 was used for data analysis.

Results The mediation model shows a good fit (χ^2/df = 2.747, CFI = 0.981, AGFI = 0.971, IFI = 0.982, GFI = 0.990, TLI = 0.961, and RMSEA = 0.056). In this study, we found emotional labour is a mediating variable between effort-reward imbalance and physical and mental health of nurses (β = 0.009, P = 0.019), nurse-patient relationship is a mediating variable between effort-reward imbalance and physical and mental health of nurses (β = 0.126, P < 0.01) and emotional labour and nurse-patient relationship play a chain mediating role in effort-reward imbalance and physical and mental health (β = 0.011, P = 0. 023).

*Correspondence:
Jia Jia
1215850473@qq.com

Full list of author information is available at the end of the article

Conclusions The study emphasizes the significance of enhancing the physical and mental health of nurses. Policymakers and hospital administrators should devise policies and strategies that encourage nurses to demonstrate an appropriate level of dedication, balance effort and reward, establish a safe working environment, and improve emotional labor to promote harmonious nurse-patient relationships, thereby improving the physical and mental health of nurses.

Keywords Nurse, Effort-reward imbalance, Emotional labour, Nurse-patient relationship, Health

Introduction

Currently, the challenges faced by the global health sector are becoming increasingly severe, especially with the aging of the population and the increasing demand for chronic disease and mental health care, highlighting the importance of the nursing profession [1–2]. According to data from the International Council of Nurses, the global nurse population is estimated to be between 28 and 29 million, with China having over 5.6 million registered nurses, accounting for approximately 20% of the total global nursing workforce [3]. Clinical nurses are a vital professional group in healthcare institutions and play a crucial role in providing medical and health services [4]. As frontline medical personnel, nurses undertake a significant amount of treatment and nursing tasks. Due to the unique characteristics of nursing work, such as high stress levels, heavy workloads, extensive emotional labor, high risk of occupational exposure, and shift work [5–8], nurses' health is threatened, making them a high-risk group for sub-health. Previous studies [9] have shown that 74.21% of nurses in China are in a state of sub-health. A systematic review and meta-analysis included 401 studies, representing 458,754 healthcare workers across 58 countries suggested that the prevalence of depression was 28.5%, anxiety was 28.7%, and insomnia was 24.4% [10]. While, a study by Guo X [11] involving 23,234 Health care workers from 100 health institutions in 5 provinces/autonomous regions/municipalities across China, shows that 22.45% of Health care workers reported having chronic diseases, which was significantly higher than the national average for young and middle-aged people (20%) [12]. It is evident from this that the physical and mental health of nursing staff urgently needs attention. The poor physical and mental health status of nurses not only exposes them to a higher risk of illness, but may also increase the risk of nursing shortages and error occurrences, leading to higher levels of burnout and intention to leave, reducing the quality of nursing care, and threatening patient safety and the stability of the nursing workforce [13–14]. Therefore, amidst the backdrop of an aging population and a growing shortage of nursing staff, protecting the physical and mental health of nurses is a crucial prerequisite for safeguarding the health of the people.

According to effort-reward imbalance model (ERI model), effort-reward imbalance could affect final physical and mental health of individuals. In addition, physical and mental health among nursing staff has been proved closely related to their work effort, work rewards emotional labor and nurse-patient relationship among previous surveys. However, few studies have focus on the impact of effort-reward imbalance on physical and mental health among nursing staff as complex individuals with social attributes and explore the relationships among the four elements and their interaction mechanisms. Therefore, to promote the physical and mental health of nurses, the present study aimed to explore the mediating effect of emotional labor and nurse-patient relationship in the association between effort-reward imbalance and physical and mental health among nursing staff, this is of great significance for maintaining the stability of the health workforce and promoting the development of the human health cause.

Background

The World Health Organization (WHO) defines health as a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity [15]. Nurses represent a special occupational group; on the one hand, they have a better understanding of diseases, theoretically making it more advantageous for them to maintain their own health. On the other hand, the nature of their work may have adverse effects on their health. Previous research has mostly focused on services to promote the physical and mental health of patients [16–17], often neglecting the nurse population that is equally in need of assistance. The "Report on the Current Development Status of the Nursing Workforce in China" indicates that 90.4% of nurses work more than 40 h per week, with about 9.8% working more than 60 h per week, and 51.2% of nurses experience severe psychological trauma [18]. Previous studies have found that compared to the general population, nursing personnel face more health risk factors [19–20]. Nursing work is characterized by high work pressure, high job risks, inadequate staffing, nurse-patient disputes, alternating night shifts, and poor job substitutability, which can have certain impacts on the physical and mental health of nursing staff. Considering the unique nature of the nursing profession, when nurses' physical and mental health declines, especially when psychological issues arise, it can easily lead to nurse-patient disputes, medical accidents, and subsequently affect the

quality of nursing care and patient safety. Wu YN conducted a survey on the health status of medical staff in 144 tertiary public hospitals in China, and the results showed that only 28.92% of nurses rated themselves as "healthy," which is a lower proportion compared to the general population and healthcare workers in developed countries, indicating that the health status of nurses in China is more severe [21].

The Effort-Reward Imbalance Model (ERI), proposed by psychologist Siegrist in 1996, includes extrinsic effort, reward, and overcommitment, and effectively predicts individual physical and mental health [22]. It suggests that when individuals are in a state of high effort and low reward, they often experience stressful consequences that harm their health. Studies have reported high incidences of ERI among nurses, with 72.5% [23], 57% [24], and 64.9% [25] of nurses in Egypt, Japan, and Switzerland experiencing ERI, respectively. A Chinese study found that 64.7% of healthcare workers are in a state of effort-reward imbalance [26]. According to the ERI theory [27], this imbalanced state may decrease nurses' physical and mental health, leading to diseases like myocardial infarction, migraines, coronary heart disease, anxiety, depression, and burnout. Thus, this study proposes Hypothesis 1: There is a negative correlation between nurses' work effort-reward imbalance and their physical and mental health status.

Nursing is not just a task-oriented job, but also an emotional one that requires not only a significant amount of physical and mental labor but also a substantial amount of emotional labor [28]. Emotional labor is considered an essential component of the role of healthcare professionals, particularly in the nursing field [29]. Numerous studies [30–32] further define nurses' emotional labor as the process of constantly regulating their own emotions during interactions with patients, developing and maintaining harmonious relationships, and ensuring that they provide care that patients perceive as genuine and effective. Previous research has consistently demonstrated the connection between emotional labor and mental health concerns like anxiety and depression [33–35]. Therefore, this study proposes Hypothesis 2: Emotional labor mediates the relationship between nurses' work effort-reward imbalance and their physical and mental health status.

The nurse-patient relationship is a care-oriented relationship formed between nurses and patients and their families, which influences patients' psychological state, treatment, and rehabilitation outcomes [36–37]. Currently, most research on the nurse-patient relationship is conducted from the patient's perspective, with limited studies exploring the nurse's viewpoint [38]. Previous studies have indicated that tense nurse-patient relationships can exacerbate nurses' occupational stress, leading to symptoms such as nervousness, anxiety, and insomnia, thereby diminishing their mental health levels [39]. From the ERI model perspective, when nurses' emotional labor receives positive feedback from patients, the nurse-patient relationship becomes more harmonious, promoting the health of both parties. Therefore, this study proposes Hypothesis 3: The nurse-patient relationship mediates the relationship between nurses' work effort-reward imbalance and their physical and mental health status, and Hypothesis 4: The nurse-patient relationship mediates the relationship between nurses' emotional labor and their physical and mental health status.

Based on the reasoning and literature review above, the existing literature on nurses' health primarily focuses on exploring the relationship between two variables. However, research into the potential influencing mechanisms of nurses' health remains inadequate. Therefore, this study employs chain mediation analysis to delve into the mediating roles of emotional labor and nurse-patient relationships in the association between effort-reward imbalance and physical and mental health among nurses from all departments. The aim is to provide management recommendations for healthcare institutions to improve the physical and mental health of nursing staff. Specifically, these recommendations will not only guide nursing staff to better display appropriate emotions and improve nurse-patient relationships in the short term but also, in the long run, facilitate the professional development of nursing staff, enhance the physical and mental health standards of the nursing workforce, and improve the quality of nursing services in healthcare institutions. The theoretical framework is illustrated in Fig. 1.

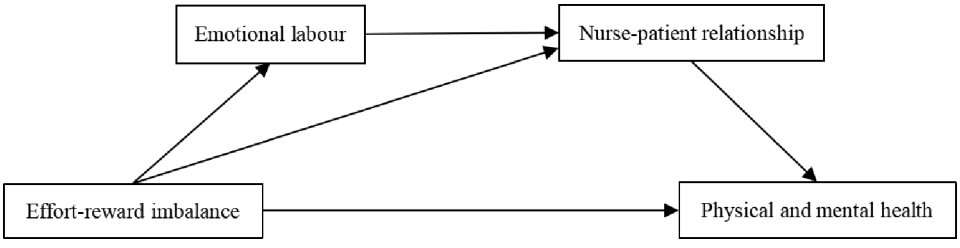

Fig. 1 Basic architecture diagram

Methods

Study design and participants

This research was structured as a multi-site, cross-sectional study employing convenience sampling strategies to acquire an adequate sample size for model development. From June to October 2024, an anonymous questionnaire survey was administered to nurses employed at seven hospitals located in Hubei Province, China. The inclusion criteria encompassed (a) nurses possessing a valid nursing qualification certificate, (b) nurses with at least one year of experience providing patient care, (c) nurses willing to voluntarily participate in the study, and (d) nurses actively working in clinical frontline settings. Nurses enrolled in departmental studies during the investigation period were excluded. Furthermore, those absent from duty during the study period due to reasons including maternity leave, illness, or overseas education were also excluded from the research cohort.

The sample size was calculated using current survey formula [40]: $n = \mu_{\alpha}{}^{2} P(1-P)/\delta^{2}$, P is the expected prevalence rate, referring to the overall sub-health detection rate of 68.1% in China [41], allowable P was set to 0.681, α was set to 0.05, μ_{α} was set to 1.96 and error δ was set to 0.03, so $N = 1.96^2 \times 0.681 \times (1-0.681)/0.03^2$ = 927. The study considered a 10% non-response rate and the final sample size was 1020. With 2191 questionnaires included in the data analysis, the sample size was deemed sufficient to facilitate a robust data analysis.

Measures

Social demographic characteristics

The social-demographic information of the participants was collected using a self-designed questionnaire, which comprised 10 variables, including age, gender, years of work, marital status, education background, and professional title.

Physical and mental health

Physical and mental health was surveyed using the 12-Item Short Form Health Survey (SF-12) developed by Ware [42], which is a concise version of the MOS 36-Item Short-Form Health Survey (SF-36), reduced to 12 items. The scale consists of 12 items and contains two dimensions: physical health and mental health. Participants respond using a five-point Likert scale with reverse scoring, where higher total scores indicate better physical and mental health. The SF-12 has demonstrated validity in Chinese populations, with a Cronbach's alpha of 0.914 [43], confirming its reliability and measurement accuracy. In this study, the Cronbach's alpha was 0.970, reinforcing the survey's strong internal consistency.

Emotional labour

Emotional labour was gauged using the emotional labour scale for nurse (ELS), originally formulated by Hong J [44], which was adapted to the nursing context. The Chinese version of the ELS was validated by Yao [45]. The scale included three dimensions: professional emotion regulation (7 items), patient-centered emotion suppression (5 items), and standardized emotion acting (4 items), with a total of 16 items. The three dimensions indicated respectively: when the emotion felt was inconsistent with the emotion needed to be expressed, nurses actively regulated and expressed the true emotion; Suppress real emotions and try to adjust disharmonious emotions; Using emotional camouflage to change what you say and do to meet organizational requirements. Each item adopts Likert 5-level scoring method, with 1 point representing "strongly disagree" and 5 points representing "strongly agree". The total score is 16–80 points. The higher the score, the higher the emotional labor level of nurses. The Cronbach's α coefficient and content validity index of the Chinese version were 0.862 and 0.969 respectively. In this study, the Cronbach's α coefficient of this scale was 0.865.

Effort-reward imbalance

The balance between job efforts and rewards was evaluated by an effort-reward ratio (ERR), which was measured using the Chinese version of the effort-Reward Imbalance scale (ERI), which originated from Siegrist in 1996 [22]. The Chinese version of the ERI questionnaire has good reliability and validity in Chinese medical staff, and the Cronbach's alpha of the effort and reward subscales is 0.78 and 0.81, respectively [46]. This survey uses two sub-scales of work effort and work return in the scale, and adopts 5-level Likert scoring method. The work effort scale contains 6 items, with 1–5 points indicating "strongly disagree" to "strongly agree", and the total score is 6–30 points. The Job Reward Scale contains 11 items, with a score of 1 to 5 indicating "strongly agree" to "strongly disagree", and a total score of 11 to 55. The disequilibrium between Effort and reward was described by calculating the effort-reward ratio (ERR). ERR index > 1.0 indicates that there is a payback imbalance, and the higher the ERR index is, the higher the imbalance is. In this study, the Cronbach's alpha values of efforts and rewards were 0.82 and 0.92, respectively.

Nurse-patient relationship

The evaluation of the nurse-patient rapport was conducted using a general inquiry: "How do you perceive the existing nurse-patient relationship in terms of harmony?" This approach aligns with previous research in the field [47–48]. Respondents were asked to express their perceptions on a five-point Likert scale, ranging from 1 (indicating a "very disharmonious" relationship)

to 5 (representing a "very harmonious" one), with intermediate options of 2 ("disharmonious"), 3 ("fair"), and 4 ("harmonious").

Data collection

Firstly, with the consent of hospital leaders and the nursing department, we conducted a pre-survey of 50 nurses. Statistical analysis of the 50 data obtained from the preliminary survey showed that the scale used in this study had good reliability and validity. Secondly, the general leader of the subject contacted the nursing department of 7 tertiary hospitals to obtain informed consent, and explained the questionnaire filling method, the investigation purpose, the inclusion and exclusion criteria of the survey objects, and the precautions for questionnaire filling. Then the nursing department of each hospital will send the QR code of the electronic questionnaire to the nurses of the hospital to fill it out anonymously through wechat. Set the IP address limit, one IP address can only fill in the questionnaire once, and set all questions as required. After retrieving questionnaires, the exported Excel data were checked one by one to eliminate invalid questionnaires. In this study, invalid questionnaires are defined as those with the same options or logical questions in the whole questionnaire, such as contradictions and inconsistencies in the answers. The study included 2310 nurses from 7 tertiary hospitals across 4 cities in Hubei Province, and 2191 questionnaires were deemed eligible for analysis, yielding an effective response rate of 94.8%.

Statistical analysis

Data analysis was performed using SPSS 26.0 and AMOS 26.0. Initially, descriptive statistics were employed to characterize the demographic attributes of the participants. Specifically, means ± standard deviations (SD) were utilized to delineate the scores of each scale, while independent samples t-tests and one-way ANOVA were implemented to assess differences in physical and mental health scale scores across categorical variables. Subsequently, upon confirming that the collected data adhered to normal distribution and exhibited linear correlations among variables, we opted for Pearson's correlation analysis to explore the relationships among the four variables of interest. Additionally, AMOS 26.0 was utilized to visualize the model and delve into the interconnections and parameters among these variables. To ascertain the statistical significance of the mediation model, we applied the bootstrapping procedure with 5000 resamples, considering an effect to be significant if the 95% confidence interval excluded zero [49]. Two-tailed tests were conducted to determine P values. For model validation, we employed several fit indices, including the $\chi 2$ test ($P < 0.05$), a $\chi 2$/df ratio less than 3, a comparative fit index (CFI) greater than 0.90, an adjusted goodness of fit index (AGFI) greater than 0.90, an incremental fit index (IFI) greater than 0.90, a goodness of fit index (GFI) greater than 0.90, a Tucker-Lewis index (TLI) greater than 0.90, and a root mean square error of approximation (RMSEA) less than 0.08 [50].

Ethics statement

This study adhered to the principle of the Declaration of Helsinki. Ethical approval was granted by the Medical Ethics Committee of Shiyan Taihe Affiliated Hospital of Hubei University of Medicine (Approval No.2024KS53). Before the commencement of the investigation, participants were given an informed consent form. They were thoroughly informed of the voluntary and confidential nature of their involvement in this study. Emphasis was placed on the fact that their participation was entirely optional and that they had the unconditional right to withdraw from the study at any point without consequences or explanation. Additionally, they were assured that all collected data would remain anonymous and that their privacy would be strictly protected throughout the research process.

Results

Characteristics of the nurse participants

A total of 2191 nurses were included in this study, with a slightly higher proportion of young and middle-aged individuals. Most participants held a bachelor's degree or higher (88.5%), and they work more than 51 h a week (15.1%). The proportion of nurses working in the internal medicine department, surgery department, obstetrics and gynecology, pediatric department, emergency and intensive care unit, and other departments was 21.3%, 20.2%, 19.0%, 14.7%, 15.6% and 9.2%, respectively. The other details are presented in Table 1.

Pearson's correlation analysis

The median, standard deviation, sig (two-tailed), and correlation coefficient of each of the variables in this study are shown in Table 2. The nurses' physical and mental health average score was 100.02 ± 14.30. In the research variables, physical and mental health fit was significantly positively correlated to emotional labour ($r = 0.243$, $p < 0.01$) and nurse-patient relationship ($r = 0.476$, $p < 0.01$), and negatively correlated to effort-reward imbalance (r=-0.352, $p < 0.01$). The above results indicate that effort-reward imbalance, emotional labour, nurse-patient relationship are all important factors affecting physical and mental health of nurses.

Mediating effect analysis

Firstly, according to the mediation effect testing procedure [51], this study applied the structural equation

Table 1 Characteristics and univariate analysis of survey results($n = 2191$)

Variables		*n* (%)	SF12 (Mean ± SD)	t/F	*P*
Age(Years)	≤ 25	208(9.5)	103.46 ± 12.47	7.936[1)]	< 0.001
	26–35	1078(49.2)	100.27 ± 14.29		
	36–45	667(30.4)	98.23 ± 14.97		
	≥ 46	238(10.9)	100.25 ± 13.21		
Gender	Male	139(6.3)	101.96 ± 15.46	1.662[2)]	0.097
	Female	2052(93.7)	99.88 ± 14.21		
Working years (Years)	≤ 5	420(19.2)	103.06 ± 13.70	5.218[1)]	0.006
	6–10	554(25.3)	100.03 ± 14.30		
	11–15	618(28.2)	99.04 ± 14.34		
	16–20	223(10.2)	98.01 ± 14.62		
	≥ 21	376(17.2)	99.39 ± 14.23		
Marital status	Unmarried	449(20.5)	101.92 ± 14.06	5.347[1)]	0.005
	Married	1717(78.4)	99.49 ± 14.29		
	Divorced or widowed	25(1.1)	101.01 ± 14.30		
Education background	College degree or under	253(11.5)	100.70 ± 13.39	0.656[1)]	0.519
	Bachelor's degree	1727(78.9)	99.89 ± 14.42		
	Master's degree or above	211(9.6)	101.98 ± 14.14		
Professional title	Primary or below	760(34.7)	101.52 ± 13.80	0.637[1)]	0.529
	Medium	952(43.5)	98.89 ± 14.63		
	Professor or above	479(21.8)	101.06 ± 13.60		
Sleep over the past week	Bad	357(16.3)	89.07 ± 13.32	324.128[1)]	< 0.001
	Fair	1094(49.9)	97.80 ± 12.44		
	Good	740(33.8)	108.57 ± 12.36		
Average working hours per week (hours)	≤ 40	379(17.3)	104.57 ± 14.53	36.693[1)]	< 0.001
	41–50	1481(67.6)	99.8513.80		
	≥ 51	331(15.1)	95.54 ± 14.71		
The number of nurses matches the working level	Very unsatisfied	50(2.3)	87.80 ± 12.06	117.758[1)]	< 0.001
	Not satisfied	264(12.0)	91.76 ± 14.23		
	Average	516(23.6)	95.70 ± 13.46		
	Satisfied	980(44.7)	100.98 ± 12.53		
	Very satisfied	381(17.4)	110.69 ± 12.63		

Notes: 1) one-way ANOVA analysis; 2) T-tests analysis; SF12 = Physical and mental health Scale

Table 2 Means, standard deviations, and correlations among the variables

Variables	M	SD	Physical and mental health	Emotional labour	Effort-reward imbalance	Nurse-patient relationship
Physical and mental health	100.02	14.30	1	-	-	-
Emotional labour	69.15	9.42	0.243**	1	-	-
Effort-reward imbalance	1.08	0.74	-0.352**	-0.234**	1	-
Nurse-patient relationship	3.86	0.82	0.476**	0.312**	-0.368**	1

Note: M = Mean, SD = standard deviation, ** $p < 0.01$(two-tailed)

model of AMOS 26.0 to analyse the relationship of four variables. The model fitting indexes were $\chi^2/df = 2.747$, CFI = 0.981, AGFI = 0.971, IFI = 0.982, GFI = 0.990, TLI = 0.961, and RMSEA = 0.056, which indicated that the model could be successfully established. In the mediation effect model, effort-reward imbalance has a negative predictive effect on emotional labour, nurse-patient relationship, and physical and mental health (β=-0.050, $P < 0.01$; β=-0.203, $P < 0.01$ and β=-0.292, $P < 0.01$, respectively); emotional labour positively predicted nurse-patient relationship and physical and mental health (β = 0.339, $P < 0.01$; β = 0.183, $P < 0.01$); nurse-patient relationship positively predicted physical and mental health (β = 0.618, $P < 0.01$). The mediating effect model is depicted in Fig. 2.

Secondly, this study was sampled 5000 times from the raw data to calculate a 95% confidence interval. Table 3 presented bootstrapping effects and 95% confidence interval for the total effect model and indirect

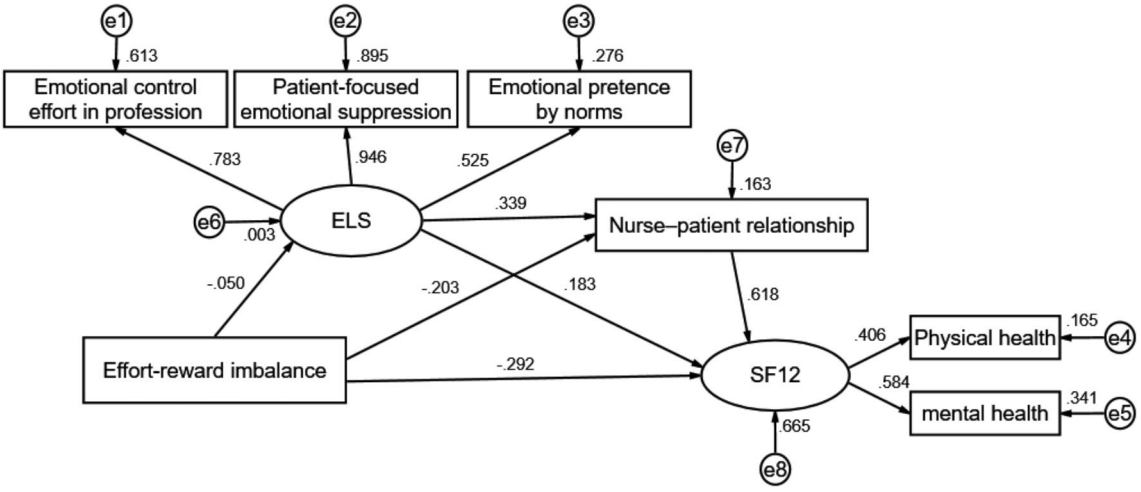

Fig. 2 Model of the relationships among the latent variables of effort-reward imbalance, emotional labour, nurse-patient relationship and physical and mental health among nurses

Table 3 Direct and indirect effects and 95% confidence intervals

Effect	Pathways	β	SE	95%CI		*P*
				Lower	Upper	
Total effects	Effort-reward imbalance → SF12	0.438	0.224	-2.527	-1.636	< 0.001
Direct effects	Effort-reward imbalance → SF12	0.292	0.177	-1.743	-1.045	< 0.001
Indirect effects	Effort-reward imbalance → ELS → SF12	0.009	0.023	-0.097	-0.006	0.019
	Effort-reward imbalance → Nurse-patient relationship → SF12	0.126	0.082	-0.765	-0.440	< 0.001
	Effort-reward imbalance → ELS → Nurse-patient relationship → SF12	0.011	0.024	-0.102	-0.006	0.023

Notes:β = standardised regression coefficient, SE = standard error, ELS = Emotional labour, SF12 = Physical and mental health

effect model. From effort-reward imbalance to physical and mental health, bootstrap 95%CI is (-1.743, -1.045), $P < 0.001$, thus confirms hypothesis 1; from effort-reward imbalance to emotional labour to physical and mental health, bootstrap 95% CI is (-0.097, -0.006), $P = 0.019$, thus confirms hypothesis 2; from effort-reward imbalance to nurse-patient relationship to physical and mental health, bootstrap 95% CI was (-0.765, -0.440), $P < 0.001$, thus confirms hypothesis 3; from effort-reward imbalance to emotional labour, effort-reward imbalance to emotional labour, the chain of mediating role of 95% CI was (-0.102, -0.006), $P = 0.023$, thus confirms hypothesis 4.

Discussion

Summary of main results

The results of this study indicate that the health status of nurses is at a moderate level, which is consistent with the findings of scholars from Taiwan, China [34], and slightly higher than the research conducted by Wen J [52] on the physical and mental health of Wuhan healthcare workers two years after a public health emergency. The results of the univariate analysis reveal that nurses in the 36–45 age group have the lowest scores for physical and mental health, indicating poorer health status among this age group. Nursing staff in the middle-age bracket are typically the backbone of their departments and are in the midst of their career advancement stage, bearing relatively heavier workloads and pressures related to career progression, as well as numerous family responsibilities and life stresses. These factors may influence their health outcomes. Furthermore, the poorer the perceived sleep quality of nursing staff, the longer their average weekly working hours, and the inadequate nurse-to-patient ratio, the worse their health status. This survey found that nurses with better self-perceived sleep quality have higher levels of health. Previous studies have shown that sleep quality is a significant factor affecting the physical and mental health of nursing staff. Research by Alameri RA [53] indicates that nurses' sleep status is related to their chronic disease conditions; studies by Feng HL [54] and others demonstrate that the longer nurses' sleep duration, the better their mental health status. Other research [55] shows that sleep deprivation due to work-life imbalance among healthcare workers may act as a catalyst for the onset of sub-health states or physical and mental illnesses. In this survey, 15.1% of nurses worked an average of more than 51 h per week, and 14.3% believed that the number of nurses in their department was insufficient to meet daily work demands, highlighting

the need to address the excessive workload of nursing staff. Studies have shown that healthcare workers who work more than 8 h a day have higher rates of anxiety and depression, and as continuous working hours increase and the nurse-to-patient ratio becomes inadequate, the prevalence of anxiety and depression among healthcare workers tends to rise. Long working hours, poor sleep quality, and heavy workloads can easily lead to physical and mental exhaustion among nurses, contributing to the occurrence and exacerbation of various health issues. Therefore, the physical and mental health problems of nursing staff urgently require attention from the whole society, and measures should be taken to improve them. It is recommended that healthcare institutions pay more attention to nursing staff in the mid-career stage, increase their career development opportunities, enhance their work confidence and enthusiasm, improve the working environment, boost their professional identity, adjust resource allocation, establish scientific scheduling systems and job settings, reasonably arrange working hours and content, appropriately reduce the work intensity and load of nursing staff, and alleviate sleep issues, thereby improving their health status.

Model results

The results of this study indicate that effort-reward imbalance among nursing staff has a negative effect on their physical and mental health ($\beta = 0.292$, $p < 0.001$), with the direct effect comprising 66.7% of the total effect. This suggests that the higher the degree of effort-reward imbalance among nursing staff, the poorer their health status, which supports Hypothesis 1 of our study. Many scholars have pointed out that ERI is a common issue among the medical staff [56]. According to the ERI model, when effort exceeds reward, individuals psychologically feel unfairness and unreasonableness, indicating an imbalance. This imbalance leads to work-related stress that affects individuals' physical, mental, and behavioral aspects. High effort, low reward, and long-term high workload can have negative impacts on nursing staff's mental health [57]. Danish scholars have found that nursing staff with poorer health status are characterized by over-investment in work and low job rewards, and work stress is a predictor of their poor health status [58]. Research by Bonzini et al. [59], shows that nurses with somatic pain report a significantly higher incidence of ERI than those without somatic pain in the same work environment. Siegris [60] conducted a retrospective analysis of multiple studies and found that when both external and internal effort levels are high, the risk of stress-related diseases increases. In particular, employees with high external effort and a sense of reward imbalance are more prone to hypertension, hypercholesterolemia, heart disease, anxiety/depression, and other stress-related illnesses. Therefore, it suggests that health administration departments and healthcare institutions need to further analyze the causes of ERI in nurses' work. It is recommended to improve the work rewards for nursing staff, refine the performance evaluation mechanism for nursing in healthcare institutions, establish a long-term salary growth mechanism and promotion path, and fully reflect the technical and labor value of nursing staff. At the same time, more attention should be paid to the needs of nursing staff for self-improvement, improve the in-service continuing education and training system, increase opportunities for training, exchange, and learning, so that nursing staff can gain more beyond salary and benefits, alleviate the effort-reward imbalance, thereby improving their health status and ensuring the high-quality delivery of nursing care.

In exploring ways to enhance nurses' health status, the mediation effects in this study revealed that emotional labour and nurse-patient relationship serve as mediating variables between nurses' effort-reward imbalance and their physical and mental health. The total indirect effect accounts for 43.63% of the total effect, with the pathway of effort-reward imbalance → nurse-patient relationship → physical and mental health demonstrating the most significant mediation effect ($\beta = 0.126$, $p < 0.001$), consistent with Hypothesis 3. Previous research [61–62] has also highlighted that a good nurse-patient relationship has a protective effect against effort-reward imbalance and is closely associated with individual mental health, similar to the results of this study. This study confirms that the effort-reward disparity experienced by nurses can influence the establishment of nurse-patient relationships, thereby impacting their physical and mental health. When nurses are in a state of effort-reward balance, they are more proactive in adopting positive measures to build harmonious nurse-patient relationships and alleviate work stress. Moreover, a good nurse-patient relationship not only reduces role conflict, alleviates work pressure, and mitigates job burnout among nursing staff but also stimulates their work enthusiasm and sense of responsibility, fostering a sense of occupational value and satisfaction, which, to a certain extent, offsets the effort-reward imbalance at work. This reciprocal interaction and influence contribute to promoting the physical and mental health of individual nurses. It suggests that medical institutions should attach great importance to the impact of nurse-patient relationships on the health of nursing staff and take targeted measures to improve nurse-patient relationships. Specifically, they can strengthen communication skills training for nurses, enhance their empathy and patience to ensure smoother and more empathetic communication with patients; optimize hospital service processes to reduce patient waiting times, improve the healthcare environment, and provide patients with

a more comfortable and convenient service experience; and establish regular patient satisfaction surveys and feedback mechanisms to promptly understand patient needs and opinions and respond and make improvements accordingly. Through the implementation of these measures, the harmonious development of nurse-patient relationships can be promoted, thereby enhancing the health level of nurses.

In addition, this study has made new discoveries. Nurses' effort-reward imbalance can not only affect their health levels through emotional labor ($\beta = 0.009$, $p = 0.019$), thus verifying Hypothesis 2; it can also influence their health levels through the chain mediation of emotional labor and nurse-patient relationship ($\beta = 0.011$, $p = 0.023$), which was consistent with Hypothesis 4. Studies have shown that effort-reward imbalance has a negative direct impact on emotional labor [63]. When nurses perceive higher efforts and lower rewards in their work, this may increase negative psychological reactions, resulting in low levels of emotional labor. Furthermore, the findings of this study further illustrate that when clinical nurses are exposed to stressors for prolonged periods (such as an adverse occupational environment, nursing human resource shortages, promotion pressure, work-family conflict, and complex interpersonal relationships), they may experience effort-reward imbalance. Higher levels of emotional labor can help nurses control and manage their emotions to display those suitable for nursing work requirements, thereby promoting the harmonious development of nurse-patient relationships. Therefore, this enables them to approach difficulties and pressures at work with a positive mindset, reducing the intensity of the threat of effort-reward imbalance to their health. This further reduces the likelihood of anxiety and depressive symptoms and helps maintain stable physical and mental health. This research finding, to a certain extent, further validates the applicability of the effort-reward imbalance model in the field of nurse health research. Moreover, the results of this study have certain guiding implications for the prevention and intervention of nurses' physical and mental health.

In conclusion, managers should pay close attention to nurses who experience effort-reward imbalance and low emotional labor. It is recommended that hospitals take the following measures: Firstly, establish a comprehensive physical and mental health monitoring system to accurately identify such nurses and provide data support for subsequent interventions. Secondly, implement multiple targeted support plans, including: (1) Setting up specialized emotional support groups to offer nurses phased and systematic emotional labor support; (2) Launching standardized nurse-patient communication training courses to assist nurses in mastering effective communication skills and enhancing the quality of nurse-patient relationships; and (3) Inviting industry experts to share experiences and practical techniques for stress management, and developing personalized stress-reduction plans based on the actual situations of nurses, thereby enhancing their ability to cope with stress. Through the coordinated implementation of these measures, the physical and mental health of nurses can be effectively promoted.

Limitation and future research direction

Firstly, although our study was conducted across multiple centers, it was confined to seven hospitals within a single province.Consequently, the generalizability of our findings to other regions or countries may be questioned. Future research should replicate this study in diverse regions to assess the consistency and broader applicability of the findings. Secondly, despite utilizing a theoretical model for data analysis, the cross-sectional design of our study restricted our ability to infer causality. Therefore, additional longitudinal studies and interventions are essential to validate our findings. Thirdly, data collection in this study was reliant on subjective questionnaire responses, using a single item to measure the nurse-patient relationship compromises both construct validity and reliability, which may have led to overestimation, underestimation, or deviation in the results. Therefore, future research should adopt more objective methods by selecting more robust, validated multi-item instruments and employing multivariate or moderation analysis to investigate from multiple perspectives, ensuring the accuracy and reliability of study findings.

Conclusion

The present study confirmed a significant association between effort-reward and physical and mental health among nurses based on the ERI (effort-reward imbalance) model, with emotional labor and the nurse-patient relationship playing a mediating role, which filled the gap in the Chinese cultural context. Specifically, this could contribute an important empirical reference value for promoting measures to improve physical and mental health among nurses. In particular, reducing effort-reward imbalance, enhancing emotional labor, and promoting the nurse-patient relationship, might be entry points for subsequent research and interventions to improve the physical and mental health of nurses.

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Author contributions

JJ and LFF finished the manuscript of the article. JJ, LFF, and NXF provided the study design. LFF, LLT, WN, JJ and YKF conducted data collection and data processing. NXF and KL proposed key revisions. All authors read and approved the final manuscript.

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Data availability
Data sets generated during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study adhered to the principle of the Declaration of Helsinki. The study obtained the informed consent of all study participants and passed the ethical review by the Medical Ethics Committee of Shiyan Taihe Affiliated Hospital of Hubei University of Medicine (Approval No.2024KS53). Before filling out the questionnaire, we informed the participants about the purpose and importance of the study, and they were able to drop out at any time. We will not disclose information about the participants, and the data and information collected were only used for this study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]TaiHe Hospital, Affiliated Hospital of Hubei University of Medicine, Shiyan, Hubei Province, China
[2]School of Nursing, Hubei University of Medicine, Shiyan , Hubei Province, China

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