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The impact of hindrance-challenge stress on nurses' work engagement: a cross-sectional study

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Abstract

Background Work engagement is vitally crucial in nursing practice. While hindrance-challenge stress significantly influence work engagement across many professions, their specific effects and underlying mechanisms in nursing remain unclear.

Aims To investigate how hindrance-challenge stress affect nurses' work engagement, examining the mediating role of self-regulatory fatigue and the moderating role of self-compassion.

Methods A cross-sectional online survey was conducted among 559 nurses in a public tertiary medical center in Nanjing, China. Standardized measures for hindrance-challenge stress, self-regulatory fatigue, work engagement, and self-compassion were employed, and a moderated mediation model was tested via the PROCESS macro in SPSS software (v22.0).

Results Hindrance stress reduced work engagement both directly and indirectly via self-regulatory fatigue. Challenge stress influenced work engagement only indirectly through self-regulatory fatigue. Self-compassion moderated the direct effect of hindrance stress, weakening its negative impact on work engagement among nurses with high self-compassion.

Conclusions Hindrance and challenge stress diminish nurses' work engagement through self-regulatory fatigue, with self-compassion mitigating the direct detrimental impact of hindrance stress.

Implications for nursing management Nursing leaders can enhance nurses' work engagement by mitigating hindrance-challenge stress and alleviating self-regulatory fatigue. This may be achieved through improved working conditions, optimized workload allocation, and the provision of robust organizational support resources. Furthermore, fostering self-compassion is essential, as it serves to buffer the detrimental effects of hindrance stress on engagement. Nurse managers are encouraged to implement interventions such as compassion-focused therapy or mindful self-compassion training to help maintain nurses' engagement in high-demand clinical environments.

Keywords Hindrance-challenge stress, Self-regulatory fatigue, Self-compassion, Nurses

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Introduction

The persistent nursing workforce shortage and increasing turnover rates have emerged as pressing global challenges, further intensified by rapid population aging and sustained healthcare demands [1] – [2]. According to WHO projections, a global nursing workforce deficit exceeding 7.6 million is anticipated by 2030 [3]. To address workforce sustainability challenges, strategic interventions must extend beyond nurse retention and accelerated novice nurse training to improve nurses' work engagement [4]. Conceptualized as a positive, motivation-driven psychological state manifesting in professional practice, work engagement is characterized by three core components: (1) vigor (the tendency to put persistent effort into occupational tasks), (2) dedication (the magnitude of passion and commitment in one's work), and (3) absorption (the depth of concentration and engrossment in work activities) [5]. This construct holds particular significance given the International Council of Nurses' explicit recognition of work engagement as a critical determinant in advancing global patient safety initiatives [6]. Empirical evidence confirms that professionally engaged nurses demonstrate enhanced organizational citizenship behaviors, greater career resilience, and substantially lower turnover intention than their less-engaged counterparts [1, 7]. However, front-line nurses' work engagement was at a medium-low level [8]. Therefore, investigating modifiable factors enhancing nurses' work engagement is critical in developing evidence-based retention strategies.

The Job Demands-Resources model establishes job stress as a pivotal determinant of work engagement [9]. Job stress is defined as workplace conditions and experiences that result in various psychological and physical outcomes affecting employees [10]. Empirical findings remain contradictory regarding the relationship between job stress and work engagement: while some evidence demonstrates negative associations [11]– [12], other studies report positive effects [13]. For instance, Abou Z et al. reported general job stress among nurses was negatively correlated with work engagement [11]. Similarly, Wang et al. observed that higher levels of job stress were associated with lower work engagement [12]. In contrast, Sarfaraz M et al. reported a positive correlation between job stress and work engagement among employees in medical universities [13]. This discrepancy may stem from methodological approaches treating job stress as a unidimensional construct. Building on Cavanaugh's job stress framework [14], stress can be categorized into challenge stress (developmental demands like time pressures that foster achievement) and hindrance stress (constraining demands including bureaucratic constraints that impede goal attainment). Although some evidence confirms the detrimental effects of job stress on

work engagement across many professions [15–17], other studies suggest that job stress may act as a motivator [16, 18, 19]. Prior investigations in nursing populations have largely overlooked the interpretive and multidimensional nature of job stress, leading to critical knowledge gaps in understanding how different types of stressors uniquely influence nurses' work engagement. Moreover, the psychological mechanisms underlying these relationships remain underexplored. Therefore, the first aim of our study was to explore the relationship between Chinese nurses' challenge-hindrance stress and work engagement.

Understanding the mechanisms linking challenge-hindrance stress to work engagement is crucial for nursing managers to develop effective engagement strategies. An individual's self-regulatory ability determines their stress response. Theoretically, this regulatory process can be explained by the self-control strength model and the conservation of resources (COR) theory, both of which highlight the role of internal resource depletion in stress responses. According to the self-control strength model, individuals possess a limited reservoir of self-regulatory resources, and exerting self-control—whether emotional, cognitive, or behavioral—gradually depletes this capacity [20]. When these internal resources are exhausted, individuals enter a state of self-regulatory fatigue, characterized by reduced motivation, diminished attention, and impaired goal-directed behavior [21]. The COR theory, proposed by Hobfoll, posits that resources—including both external and internal—are the key determinants of whether events or stimuli are perceived as stressful [22]. The theory emphasizes that external stressors, regardless of whether they are perceived as challenges or hindrances, can serve as catalysts for internal resource depletion, thereby compounding the strain on individuals' self-regulatory systems [22]. Such excessive resource depletion can impair work performance [21]. A study among medical postgraduates found that emotional exhaustion mediated the relationship between challenge-hindrance stress and academic engagement [19]. Building on these frameworks and empirical findings, the current study proposes that self-regulatory fatigue mediates the impact of challenge and hindrance stress on nurses' work engagement. However, this mediating pathway remains largely unexamined in nursing populations. Thus, the study's second objective was to examine the mediating role of self-regulatory fatigue in the challenge-hindrance stress–work engagement relationship.

Not all individuals exposed to stressful experiences exhibit equally low work engagement. Self-compassion, a positive emotional stance toward oneself that mitigates negative psychological effects and adverse chain reactions, has been suggested to explain differential responses to stress [23]. In the context of the COR theory, self-compassion functions as a personal resource

that may buffer against resource depletion [22]. According to Neff's widely accepted definition, self-compassion comprises three key elements: common humanity (distress and adversity are universal human experiences), self-kindness (responding to oneself with comfort, kindness, and understanding during periods of adversity), and mindfulness (maintaining balanced awareness of negative emotions without overidentification) [24]. Empirical evidence indicated that individuals with stronger self-compassion employ more adaptive coping strategies when stressed, favoring cognitive restructuring over avoidance [24]. Studies involving nurses have demonstrated that self-compassion attenuates stress-induced burnout [25, 26]. Given that job burnout represents the antithesis of work engagement [27], this evidence suggests that self-compassion may moderate the relationship between challenge-hindrance stress and work engagement. Nevertheless, few studies have explicitly tested the moderating role of self-compassion in the stress-work engagement relationship within nursing populations. Consequently, our study's third objective was to investigate how self-compassion moderates the direct pathway linking challenge-hindrance stress to work engagement.

The present study advances existing research in two key respects. First, while prior investigations have predominantly examined general job stress-work engagement linkages, they have overlooked that distinct job stress types may affect nurses' work engagement differently. Second, although evidence suggests self-regulatory fatigue mediates and self-compassion moderates the relationship between challenge-hindrance stress and work engagement, these mechanisms remain unverified in nursing populations.

To address these gaps, this study examined the dual roles of self-regulatory fatigue (as a mediator) and self-compassion (as a moderator) in the relationship between challenge-hindrance stress and work engagement among nurses. We hypothesized that: (1) higher levels of hindrance stress would be associated with lower work engagement; (2) higher levels of challenge stress would be associated with higher work engagement; (3) self-regulatory fatigue would mediate the relationship between challenge-hindrance stress and work engagement; and (4) self-compassion would moderate the direct association between challenge-hindrance stress and work engagement.

Methods and materials

Design

This study used a cross-sectional design, adhering to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines and methodology for cross-sectional studies.

Study population and data collection

Through convenience sampling, registered nurses from a public tertiary medical center in Nanjing, China, were recruited for this study in June 2023. The eligibility criteria required participants to (i) work full-time, (ii) have at least one year of nursing experience, (iii) hold a patient care position, (iv) have no prior or present diagnosis of mental health disorders or substance abuse, and (v) possess the capability to complete online questionnaires. Trainee nurses were not eligible to participate. The sample size was estimated using the PASS 15.0.5 software, applying a linear multiple regression framework. To identify the minimum sample size, the parameters included a two-sided significance level (α) of 0.05, an expected effect size of 0.10, and a statistical power of 0.90. The calculation accounted for ten predictors: challenge-hindrance stress, self-regulatory fatigue, self-compassion, and demographic variables. Using these inputs, a sample size of 226 was established to ensure adequate statistical power for the study.

A website-based questionnaire was employed to minimize response biases, such as social desirability. The survey was conducted using Questionnaire Star, a widely utilized electronic platform for collecting questionnaires in China. Three members of the research team (heads of nursing departments) were responsible for distributing the link to an online survey hosted on Questionnaire Star to all head nurses via a WeChat group. This preliminary step allowed for thorough discussions to ensure clarity regarding the survey's objectives, procedures, and precautions. The head nurses were then instructed to forward the link to all eligible nurses in their respective departments through departmental WeChat groups, emphasizing the survey's voluntary and anonymous nature. Before beginning the survey, the purpose, significance, instructions, and confidentiality principles were clearly explained on the first page of the questionnaire. Each participant was allowed to submit only one response. A pilot study involving 20 nurses was conducted prior to the official survey to assess the clarity, reliability, validity, and completion time of the questionnaire. Based on participant feedback, minor revisions were made to improve the wording and layout of several items. The Cronbach's alpha coefficients for all scales exceeded 0.70, indicating good internal consistency. The survey took approximately ten to fifteen minutes to complete. Any questionnaires with identical responses were excluded. Finally, 554 valid questionnaires were obtained.

Study tools

Data on sociodemographic characteristics, challenge and hindrance stress, self-regulatory fatigue, self-compassion, and work engagement were gathered through accessible online self-report surveys.

The challenge and Hindrance-Related stress scale (C-HSS)

Originally developed by Cavanaugh et al. to assess challenge and hindrance stress, the C-HSS was cross-culturally adapted into Chinese by Guo et al. [14, 28]. This tool contains 11 items: six assessing challenge stress and five evaluating hindrance stress. Participants rate these items on a 5-point scale (1 = “no pressure” to 5 = “extreme stress”), where higher scores reflected increased job stress. The Chinese version of the scale has been validated among Chinese nurses, demonstrating good internal consistency, with Cronbach’s alpha coefficients ranging from 0.816 to 0.964 for both subscales [28]. In the present study, the Cronbach’s alpha coefficients were 0.928 for the Challenge-Related Stress subscale and 0.877 for the Hindrance-Related Stress subscale, indicating excellent reliability. The confirmatory factor analysis was conducted to examine the construct validity of this scale and the results indicated a good fit: $\chi^2/df=3.480$, GFI=0.963, AGFI=0.929, TLI=0.970, CFI=0.981, RMSEA=0.067, SRMR=0.0391.

Self-regulatory fatigue scale (SRF-S)

The SRF-S measures levels of self-regulatory fatigue through 16 items spanning three key areas: cognition, emotion, and behavior [29]–[30]. Originally developed by Nes et al., the scale was translated into Chinese by Wang Li-gang et al. [29]–[30]. Responses to each item are recorded on a 5-point rating, ranging from one for “strongly disagree” to five for “strongly agree.” The total score reflects the degree of fatigue, with lower scores indicating less fatigue. The Chinese version of the SRF-S has demonstrated good reliability among Chinese nurses, with a reported Cronbach’s alpha of 0.868 [31]. In the present study, the SRF-S yielded a Cronbach’s alpha of 0.838, indicating good internal consistency. To further verify the construct validity of SRF-S, the confirmatory factor analysis with the same sample was performed. The results indicated an excellent model fit: $\chi^2/df=2.989$, GFI=0.948, AGFI=0.913, TLI=0.939, CFI=0.959, RMSEA=0.060, SRMR=0.0624.

Self-Compassion Scale-Short form (SCS-SF)

The SCS-SF was employed to assess the level of self-compassion [32]. This 12-item scale was adapted by Gong et al. from the original Self-Compassion Scale developed by Neff [32, 33]. The SCS-SF consists of three dimensions: common humanity, self-kindness, and mindfulness. Participants rate their responses on a 5-point scale, ranging from “rarely” (one point) to “almost always” (five points). Noteworthy, five SCS-SF items had their grades reversed. The overall score is derived by adding the individual item responses, with higher values reflecting greater self-compassion. In our study, Cronbach’s α of the SCS-SF was 0.647. Construct validity of SCS-SF

was tested by confirmatory factor analysis and the good model fit indexes were found: $\chi^2/df=3.817$, GFI=0.947, AGFI=0.914, TLI=0.948, CFI=0.962, RMSEA=0.071, SRMR=0.073.

Utrecht work engagement scale (UWES)

We used the UWES to evaluate nurses’ work engagement. This tool was developed by Schaufeli et al. and revised by Zhang et al. [34]–[35]. The 17-item UWES includes three dimensions: vigor, dedication, and absorption [34]. Higher scores represent higher work engagement. Every item is provided with a seven-point rating, with zero representing “never” and six representing “always.” Among Chinese nurses, this instrument has demonstrated exceptional psychometric qualities, with the overall Cronbach’s α reaching 0.93 [36]. The Cronbach’s alpha for overall UWES in the current study was 0.962. The acceptable model fit indexes were observed: $\chi^2/df=4.256$, GFI=0.928, AGFI=0.874, TLI=0.950, CFI=0.967, RMSEA=0.077, SRMR=0.0369.

Ethical considerations

Ethical approval This study was granted by the Ethics Committee of the First Affiliated Hospital with Nanjing Medical University (Approval No. 2023-SR-942). All procedures strictly complied with the Declaration of Helsinki to protect participants’ rights, privacy, and welfare. Informed consent was obtained from every participant after comprehensive disclosure of the study purpose, procedures, potential risks/benefits, and the voluntary nature of participation with explicit emphasis on their unconditional right to withdraw at any time without repercussions to employment or professional standing. To ensure data confidentiality, all personally identifiable information was permanently deleted during initial processing, with collected data anonymized through unique coding identifiers. These anonymized datasets were stored on password accessible exclusively to the research team. These protocols rigorously implemented international ethical standards for human subject research, particularly safeguarding informed consent autonomy and data security.

Data analysis

All of the analyses were performed with the program SPSS v22.0. To ensure data quality and the validity of statistical analyses, rigorous procedures were employed to process and validate the questionnaire data. As an initial step, skewness and kurtosis, supplemented by Q-Q plots, were examined to assess the normality of the variables. Harman’s single-factor analysis was conducted to detect potential common method bias, which could threaten the reliability of subsequent analyses. Multicollinearity was assessed using variance inflation factors (VIF) to ensure the absence of multicollinearity among predictors. Next,

means and standard deviations (SDs) were provided for continuous variables, while frequencies and percentages were used for categorical or ordinal variables. Descriptive analyses, ANOVA, and independent t-tests were conducted to summarize sociodemographic characteristics and explore their associations with nurses' work engagement and self-regulatory fatigue. Sociodemographic variables that showed significant associations were controlled for in subsequent mediation and moderation analyses. Scatterplots were inspected to assess the linearity of relationships among challenge-hindrance stress, self-compassion, work engagement, and self-regulatory fatigue. Subsequently, partial correlation analysis was conducted to explore associations among these variables while adjusting for demographic covariates. Finally, we used hierarchical multiple regression models to test the mediating effect of self-regulatory fatigue and the moderating effect between challenge-hindrance stress and work engagement. Furthermore, Model 4 and Model 5 in PROCESS macro in SPSS v22.0 were utilized to validate the mediating model and moderated and mediating model, respectively. Bootstrapping with 5,000 resamples was implemented for mediation analysis due to its higher statistical power and not assuming normality of the sampling distribution of the indirect effect [37]. This approach is particularly suitable for complex models and relatively small to moderate sample sizes, as it provides more accurate confidence intervals than traditional methods such as the Sobel test [38]. In order to investigate the moderating influence of self-compassion in more detail, a simple slope analysis was finally used. The lack of a zero in the confidence intervals indicated statistical significance for all analyses.

Results

Assessment of normality, common method bias and variance inflation factors

Q-Q plots demonstrated close conformity of continuous variables to normal distributions. The results showed that the absolute values of kurtosis ranged from 0.127 to 0.598, and the absolute values of skewness was between 0.240 and 0.547. As Drezner Z et al. [39] pointed out, the strict assumptions of normality are rarely satisfied in practical applications. Generally, if the absolute value of kurtosis is less than 10 and the absolute value of skewness is less than 3, the data can be considered approximately normal [40]. Therefore, the current data meet these relaxed normality criteria. In addition, the VIF values for these variables are far below the threshold of 5.0.

Harman's single-factor analysis was employed to assess common method bias. The results indicated ten factors with eigenvalues exceeding 1, with the first factor accounting for 27.93% of the variance. This value falls

below the 40% threshold, suggesting no substantial common method bias in this study [41].

Participants characteristics

Five hundred fifty-four registered nurses participated in our study. The participants' average age was 32.59 ± 6.78 years, with 67.15% being married. Most participants were female (97.47%), and 93.32% held a bachelor's degree or higher. Over half of the respondents (63.18%) had a primary professional title, and 92.42% had three or more years of nursing experience. Regarding night shifts, 44.22% of the nurses had at least five-night shifts monthly. An overview of the participants' sociodemographic and clinical characteristics of the patients is given in Table 1.

Additionally, Table 1 also shows the distribution of work engagement and self-regulatory fatigue. Significant differences in work engagement were based on sex, age, marital status, and the amount of night shifts worked per month (all $p < 0.05$). Additionally, the number of monthly night shifts was associated with self-regulatory fatigue ($p < 0.05$).

Covariate-adjusted partial correlation analysis

After controlling for variables such as sex, age, marriage, education, professional title, years of service, the number of monthly night shifts, covariate-adjusted partial correlation analyses indicated significant pairwise correlation between variables, as displayed in Table 2. The results demonstrated that challenge-hindrance stress was positively associated with self-regulatory fatigue (all $p < 0.01$). Contrary to expectations, both challenge stress and hindrance stress presented significant negative associations with work engagement ($p < 0.01$). Self-compassion was negatively related to challenge-hindrance stress and positively linked to work engagement (all $p < 0.01$).

Mediation analysis

The mediating role of self-regulatory fatigue in the relationship between hindrance stress and work engagement was examined through hierarchical linear regression analyses (Table 3). In the first step, a regression model (Model 1) assessed the link between hindrance stress and self-regulatory fatigue, controlling for the number of monthly night shifts. The analysis revealed that hindrance stress positively predicted self-regulatory fatigue ($B = 1.02, p < 0.001$), indicating that greater levels of hindrance stress are associated with more intense self-regulatory fatigue. In Model 2, the effect of hindrance stress on work engagement was examined after adjusting for sex, age, marital status, and the number of monthly night shifts. The results showed a significant negative association ($B = -1.34, p < 0.001$), suggesting that higher hindrance stress may undermine nurses' work engagement.

Table 1 Sociodemographic characteristic differences in response to self-regulatory fatigue and work engagement among nurses ($N = 554$)

Characteristics	N (%)	Self-regulatory fatigue	Work engagement
Sex			
Male	14 (2.53)	45.29 (5.41)	53.14 (19.98)
Female	540 (97.47)	42.99 (8.21)	66.31 (22.35)
<i>p</i> -value		0.145	0.030
Age			
<30	219 (39.53)	43.27 (8.19)	64.56 (22.25)
30~40	240 (43.32)	43.51 (7.87)	64.80 (22.79)
≥40	95 (17.15)	41.40 (8.64)	72.23 (20.66)
<i>p</i> -value		0.09	0.011
Marriage			
Single	182 (32.85)	43.37 (8.33)	61.30 (23.55)
Married	372 (67.15)	42.90 (8.07)	68.27 (21.43)
<i>p</i> -value		0.524	<0.001
Education			
Junior college	37 (6.68)	43.27 (8.85)	65.89 (21.55)
Bachelor's degree	496 (89.53)	42.99 (8.16)	66.24 (22.27)
Master's degree or above	21 (3.79)	44.10 (7.10)	59.86 (26.13)
<i>p</i> -value		0.820	0.440
Professional title			
Senior	52 (9.39)	40.79 (7.53)	72.48 (17.77)
Intermediate	152 (27.43)	42.68 (8.45)	66.26 (23.73)
Primary	350 (63.18)	43.55 (8.07)	64.89 (22.26)
<i>p</i> -value		0.059	0.072
Years of service			
<3	42 (7.58)	40.95 (8.88)	62.31 (23.96)
3~8	189 (34.12)	43.75 (7.90)	65.28 (21.72)
>8	323 (58.30)	42.92 (8.17)	66.86 (22.54)
<i>p</i> -value		0.120	0.403
The number of monthly night shifts			
0	78 (14.08)	41.24 (7.94)	73.97 (19.00)
<5	231 (41.70)	42.62 (8.70)	67.63 (22.14)
5~10	202 (36.46)	43.94 (7.79)	63.26 (22.80)
>10	43 (7.76)	44.49 (6.46)	55.37 (22.62)
<i>p</i> -value		0.041	<0.001

Thus, Hypothesis 1 was supported. Model 3 introduced self-regulatory fatigue into the regression equation. The effect of hindrance stress on work engagement was attenuated ($B = -0.53$, $p < 0.001$), implying that self-regulatory fatigue partially mediated this relationship. In other words, hindrance stress may reduce work engagement in

part by depleting individuals' self-regulatory resources. To further validate the mediating effect, Model 4 of the PROCESS macro was applied. The analysis confirmed a significant indirect effect of hindrance stress on work engagement via self-regulatory fatigue, with a bootstrapped estimate of -0.81 , accounting for 60.45% of the total effect. The 95% confidence interval for the indirect effect was $[-1.13, -0.52]$, excluding zero and confirming statistical significance (Fig. 1; Table 4). These findings identify the mediating role of self-regulatory fatigue in the challenge-hindrance stress to work engagement pathway, which supports Hypothesis 3.

Similarly, the mediating effect of self-regulatory fatigue in the relationship between challenge stress and work engagement was examined. Contrary to our initial assumptions (Hypothesis 2), hierarchical linear regression analyses revealed that negative relationship between challenge stress and work engagement ($B = -0.68$, $p < 0.001$). Further analysis showed that self-regulatory fatigue fully mediated this association (Table 5; Fig. 2). This result was supported by the PROCESS macro analysis, which indicated a significant indirect effect ($B = -0.64$, 95% CI $[-0.87, -0.44]$, Table 4), consistent with Hypothesis 3. This finding highlights that even challenge stress, which is often viewed as more positive or motivating, may negatively affect work engagement if it leads to excessive self-regulatory depletion.

Moderation analysis

The moderating role of self-compassion in the relationship between hindrance stress and work engagement was also tested using hierarchical regression analysis. After controlling for relevant covariates (sex, age, marital status, number of night shifts per month, hindrance stress, and self-regulatory fatigue), self-compassion was found to significantly influence work engagement ($B = 1.71$, $p < 0.001$; Table 3, Model 4). In Model 5, a significant interaction effect between self-compassion and hindrance stress was observed ($B = 0.09$, $p = 0.031$), indicating that self-compassion may buffer the detrimental effects of hindrance stress on work engagement.

The PROCESS macro (Model 5) further supported this moderating effect. Simple slope analysis showed that hindrance stress was a significant negative predictor of work engagement when self-compassion was low (one SD below the mean; $B_{simple} = -1.17$, $p = 0.002$). However, this

Table 2 Covariate-adjusted partial correlation analysis among variables ($N = 554$)

Variable	Range	Mean (SD)	1	2	3	4	5
1. Hindrance stress	5~25	15.87 (3.93)	1				
2. Challenge stress	6~30	20.19 (4.76)	0.663***	1			
3. Self-regulatory fatigue	16~80	43.05 (8.15)	0.506***	0.423***	1		
4. Self-compassion	12~60	42.37 (4.59)	-0.183***	-0.109*	-0.389***	1	
5. Work engagement	17~102	65.98 (22.37)	-0.234***	-0.144***	-0.337***	0.433***	1

Table 3 Hierarchical regression examining the mediating role of self-regulatory fatigue and the moderating role of self-compassion in the pathway from hindrance stress to work engagement among nurses

Control variables	Self-regulatory fatigue		Work engagement							
	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta (SE)	p	Beta (SE)	p	Beta (SE)	p	Beta (SE)	p	Beta (SE)	p
Sex										
Male			7.44 (5.81)	0.201	7.49 (5.61)	0.182	7.09 (5.27)	0.179	6.99 (5.25)	0.183
Female			(omitted)		(omitted)		(omitted)		(omitted)	
Age										
<30			1.48 (3.43)	0.667	2.19 (3.32)	0.510	1.81 (3.11)	0.561	1.26 (3.11)	0.686
30~40			-2.46 (3.01)	0.415	-1.50 (2.91)	0.606	-2.12 (2.73)	0.438	-2.78 (2.74)	0.311
>40†			(omitted)		(omitted)		(omitted)		(omitted)	
Marriage										
Single			-6.01 (2.46)	0.015	-6.79 (2.38)	0.005	-5.34 (2.24)	0.018	-5.05 (2.24)	0.025
Married†			(omitted)		(omitted)		(omitted)		(omitted)	
The number of monthly night shifts										
0	-3.52 (1.40)	0.012	14.62 (4.46)	0.001	12.82 (4.32)	0.003	9.86 (4.06)	0.016	9.27 (4.06)	0.023
<5	-2.35 (1.23)	0.056	10.78 (3.56)	0.003	9.53 (3.44)	0.006	7.46 (3.24)	0.022	7.17 (3.23)	0.027
5~10	-1.18 (1.24)	0.342	7.72 (3.58)	0.032	6.99 (3.47)	0.044	5.33 (3.26)	0.102	5.14 (3.25)	0.114
>10†	(omitted)		(omitted)		(omitted)		(omitted)		(omitted)	
Independent variable: hindrance stress	1.02 (0.07)	< 0.001	-1.34 (0.23)	< 0.001	-0.53 (0.26)	0.041	-0.57 (0.24)	0.018	-0.74 (0.25)	0.004
Mediator: self-regulatory fatigue					-0.78 (0.12)	< 0.001	-0.39 (0.13)	0.002	-0.40 (0.12)	0.001
Moderator: self-compassion							1.71 (0.20)	< 0.001	1.74 (0.20)	< 0.001
Interaction: hindrance stress × self-compassion									0.09 (0.04)	0.031
	$R^2 = 0.256$		$R^2 = 0.117$		$R^2 = 0.177$		$R^2 = 0.277$		$R^2 = 0.283$	
	Adjusted $R^2 = 0.251$		Adjusted $R^2 = 0.104$		Adjusted $R^2 = 0.163$		Adjusted $R^2 = 0.264$		Adjusted $R^2 = 0.269$	
	$F(4, 549) = 47.337$		$F(8, 545) = 9.057$		$F(9, 544) = 12.970$		$F(10, 543) = 20.814$		$F(11, 542) = 19.472$	
	$p < 0.001$		$p < 0.001$		$p < 0.001$		$p < 0.001$		$p < 0.001$	

Note: Beta, unstandardized effect estimate. SE, standard error. Model 1 uses Self-regulatory fatigue as the dependent variable, whereas the other models use Work engagement

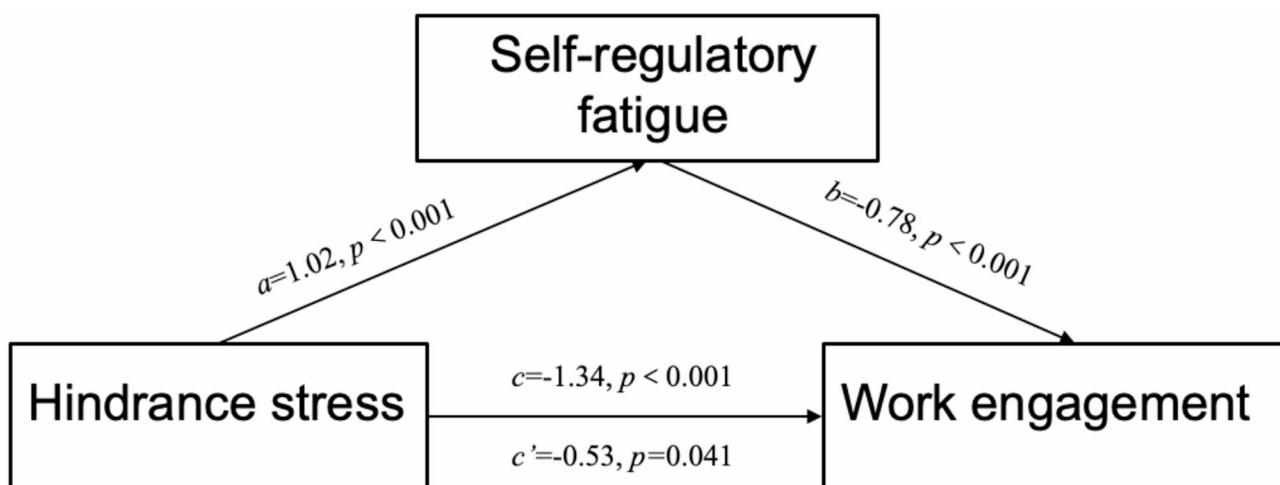
**Fig. 1** The mediation model of hindrance stress, self-regulatory fatigue, and work engagement. a : The effect of hindrance stress on self-regulatory fatigue; b : The effect of self-regulatory fatigue on work engagement; c : The total effect of hindrance stress on work engagement; c' : The direct effect of hindrance stress on work engagement; Unstandardized beta coefficients were reported

Table 4 The bootstrap results of mediation and moderated mediation analysis ($N=554$)

	Effect	SE	95%CI
Mediation effect (mediator: self-regulatory fatigue)			
Path 1: Hindrance stress → work engagement			
Total effect	-1.34	0.23	(-1.79, -0.88)
Direct effect	-0.53	0.26	(-1.03, -0.02)
Indirect	-0.81	0.16	(-1.13, -0.52)
Path 2: Challenge stress → work engagement			
Total effect	-0.68	0.19	(-1.06, -0.30)
Direct effect	-0.04	0.20	(-0.44, 0.36)
Indirect	-0.64	0.11	(-0.87, -0.44)
Moderation effect			
Hindrance stress → work engagement			
Low self-compassion	-1.17	0.37	(-1.90, -0.45)
High self-compassion	-0.32	0.27	(-0.85, 0.21)

relationship was no longer significant when self-compassion was high (one SD above the mean; $B_{simple} = -0.32$, $p = 0.242$; Table 4). These results suggest that individuals with higher levels of self-compassion may maintain higher levels of work engagement even under stressful conditions. To further clarify the boundary conditions of this moderating effect, a Johnson–Neyman analysis was conducted. The analysis identified that the negative association between hindrance stress and work engagement

became non-significant when self-compassion scores exceeded 45.17 (Fig. 3). This threshold may serve as a useful benchmark for identifying individuals who are more protected from the adverse effects of hindrance stress, and underscores the potential value of cultivating self-compassion in workplace interventions.

Discussion

This study first examined four key aspects: (1) the relationship between hindrance stress and work engagement, (2) the association between challenge stress and work engagement, (3) the mediating role of self-regulatory fatigue, and (4) self-compassion's moderating function in this association. After relevant covariates, our results revealed that hindrance stress directly reduced work engagement and indirectly affected it through self-regulatory fatigue. Notably, challenge stress negatively affected work engagement, with its influence operating exclusively through self-regulatory fatigue. Furthermore, self-compassion buffered the direct pathway from hindrance stress to work engagement. These findings offer valuable insights into the mechanisms that elucidate how challenge-hindrance stress influences work engagement.

After adjusting for sex, age, marital status, and the number of monthly night shifts, the negative association between hindrance stress and work engagement in our

Table 5 Hierarchical regression examining the effect of challenge stress on self-regulatory fatigue and work engagement among nurses

	Self-regulatory fatigue		Work engagement		Model 3	
	Model 1		Model 2		Model 3	
Control variables	Beta (SE)	<i>p</i>	Beta (SE)	<i>p</i>	Beta (SE)	<i>p</i>
Sex						
Male			8.32 (5.91)	0.160	8.08 (5.63)	0.152
Female			(omitted)		(omitted)	
Age						
<30			1.49 (3.49)	0.670	2.27 (3.33)	0.496
30~40			-1.81 (3.07)	0.556	-1.29 (2.93)	0.658
>40†			(omitted)		(omitted)	
Marriage						
Single			-6.40 (2.51)	0.015	-7.25 (2.40)	0.003
Married†			(omitted)		(omitted)	
The number of night shifts per month						
0	-3.52 (1.40)	0.012	15.68 (4.55)	< 0.001	12.64 (4.35)	0.004
<5	-2.35 (1.23)	0.056	11.49 (3.63)	0.002	9.39 (3.47)	0.007
5~10	-1.18 (1.24)	0.342	7.81 (3.65)	0.033	6.73 (3.48)	0.054
>10†	(omitted)		(omitted)		(omitted)	
Independent variable: challenge stress	0.72 (0.07)	< 0.001	-0.68 (0.20)	< 0.001	-0.04 (0.20)	0.855
Mediator: self-regulatory fatigue					-0.90 (0.12)	< 0.001
	$R^2 = 0.189$		$R^2 = 0.084$		$R^2 = 0.170$	
	Adjusted $R^2 = 0.183$		Adjusted $R^2 = 0.071$		Adjusted $R^2 = 0.157$	
	$F(4, 549) = 31.948$		$F(8, 545) = 5.298$		$F(9, 544) = 12.414$	
	$p < 0.001$		$p < 0.001$		$p < 0.001$	

Note: Beta, unstandardized effect estimate. SE, standard error

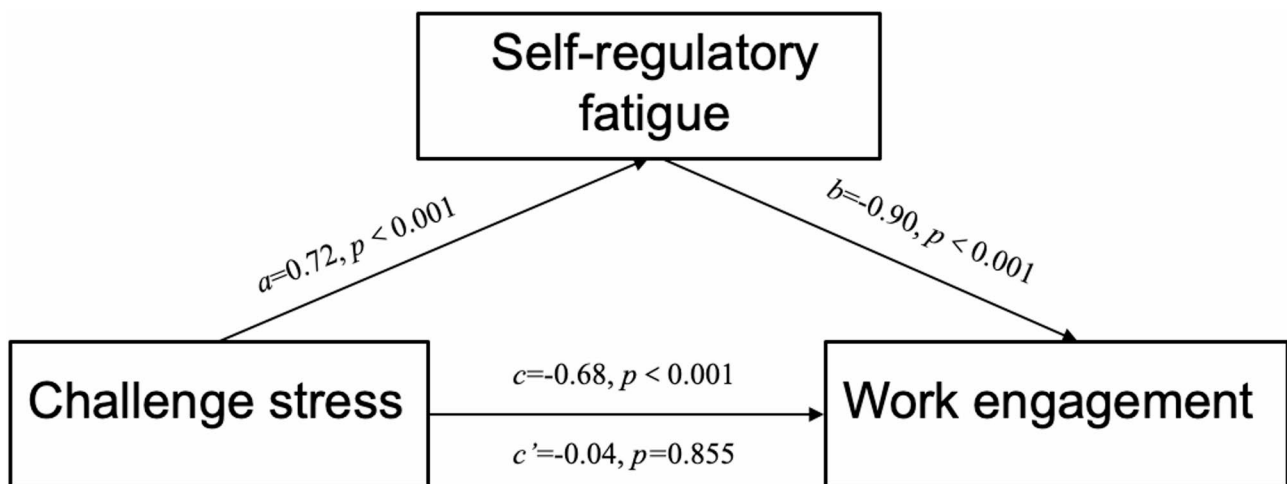


Fig. 2 The mediation model of challenge stress, self-regulatory fatigue, and work engagement. a: The effect of challenge stress on self-regulatory fatigue; b: The effect of self-regulatory fatigue on work engagement; c: The total effect of challenge stress on work engagement; c': The direct effect of challenge stress on work engagement; Unstandardized beta coefficients were reported

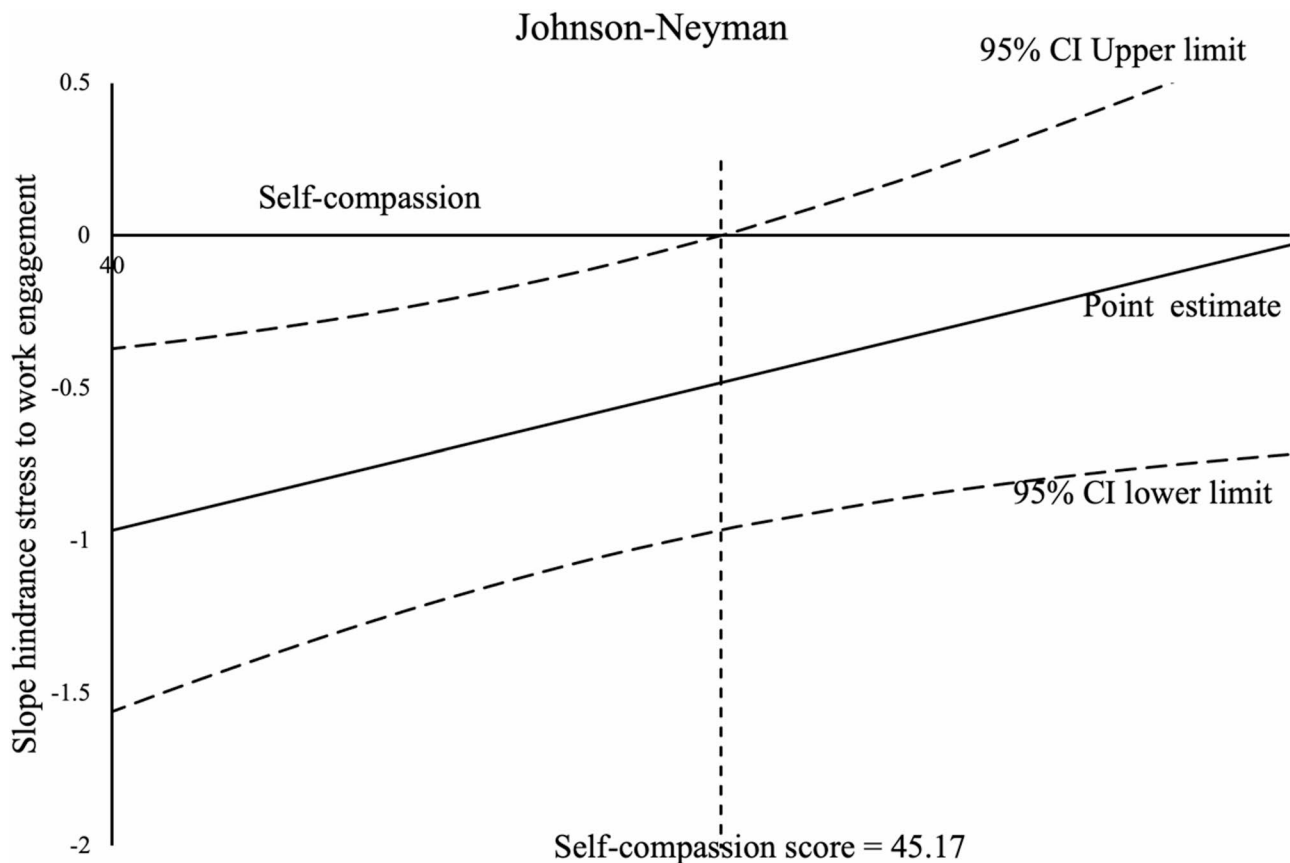


Fig. 3 Estimated effect of hindrance stress on work engagement moderated by self-compassion with Johnson–Neyman confidence bands

study aligns with previous research across diverse populations [19, 42, 43]. For instance, Inoue et al. identified a strong negative relationship between hindrance stress—specifically role ambiguity—and work engagement ($\beta = -0.429, d = 1.011$) among employees in 12 Japanese

companies, even after controlling for demographic variables [42]. Similarly, a study among preschool teachers observed that daily hindrance stress negatively impacted work engagement when controlling for age, work experience, educational level [43]. Bao et al. also reported a

comparable pattern among Chinese medical postgraduates, showing that hindrance stress significantly reduced academic engagement after adjusting for gender, age, grade, and work experience [19]. One plausible explanation is that individuals who perceive hindrance stress as offering no potential rewards may engage in avoidance or disengagement behaviors, which subsequently lowers their work engagement [44]. However, it is important to consider alternative explanations. For example, unmeasured variables such as job resources (e.g., supervisor support and decision-making autonomy) may have influenced the observed relationship. Inoue et al. further demonstrated that after additionally adjusting for job resources—including decision latitude, supervisor support, co-worker support, and extrinsic rewards—the effect size of hindrance stress on work engagement was reduced but remained moderate ($\beta = -0.242$, $d = 0.609$), suggesting that job resources may decrease the adverse effects of hindrance stress [42]. This underscores the multifaceted nature of the hindrance stress–engagement relationship and suggests that more factors should be considered in future research.

Interestingly, our study also identified an adverse effect of challenge stress on work engagement, which contrasts with several previous studies reporting a positive relationship. Existing literature shows mixed findings regarding this relationship. For instance, Inoue et al. found that challenge stress—such as workload and time pressure—was positively associated with work engagement, though the effect size was small ($\beta = 0.102$, $d = 0.240$) [42]. Zhang et al. observed that daily challenge stress was positively related to preschool teachers' work engagement, controlling for age, work experience, and education level [43]. Similarly, Bao et al. also reported a positive association among Chinese medical postgraduates [19]. However, other studies suggest that the relationship between challenge stress and work engagement may not be always positive. Kim et al. found that while moderate levels of challenge stress can enhance motivation and engagement, excessive challenge stress may surpass individuals' coping capacity and lead to adverse outcomes [45]. In line with this, a German study revealed that challenge stress—specifically time pressure—could relate to both higher and lower work engagement depending on mediating mechanisms such as loss of time control and reduced sense of meaning at work [46]. These divergent findings may stem from differences in occupational context, stress intensity, or individual coping capacity. In our study, conducted within the context of China's rapidly evolving healthcare system, nurses are facing intensified demands due to wide-ranging public hospital reforms. These reforms—such as the implementation of diagnosis-related group (DRG) payment systems and performance-based evaluations—have significantly shortened inpatient

stays, while increasing workloads and expectations for nursing staff [47]. Under such conditions, challenge stress may no longer be perceived as an opportunity for growth or achievement, but rather as a chronic burden, especially when personal resources (e.g., time, energy) are insufficient. When challenge stress exceeds personal coping resources, it may be appraised as a hindrance, thereby diminishing work engagement [18]. This alternative explanation may account for the negative association observed in our sample of Chinese nurses.

The results demonstrated that self-regulatory fatigue partially mediated the relationship between hindrance stress and work engagement, and fully mediating the relationship between challenge stress and work engagement. This finding is consistent with a study by Bao et al., which concluded that emotional exhaustion serves as a mediator between challenge-hindrance stress and academic engagement among Chinese medical students [19]. Previous studies have shown that the sustained arousal and cognitive effort required to cope with ongoing stressors—whether categorized as challenge or hindrance—can trigger negative emotions, ultimately depleting self-regulatory resources [48]–[49]. Li et al. also verified that both hindrance and challenge stress were positively related to emotional exhaustion [50]. When individuals experience self-regulatory fatigue, they become more susceptible to negative affect and tend to focus on immediate, low-effort rewards rather than long-term goals [51]. Consequently, this fatigued state may undermine motivation and reduce work engagement. Notably, there may be additional mechanisms beyond self-regulatory fatigue that explain how challenge and hindrance stress affect work engagement. For example, Kim et al. found psychological empowerment and organization-based self-esteem were important intrinsic motivational pathways through which some stressors (especially hindrance demands) can promote employees' favourable work behaviours [52]. Taken together, these findings suggest that the relationship between challenge-hindrance stress and work engagement is complex, potentially influenced not only by self-regulatory fatigue, but also by individual appraisals, motivational resources, and the broader organizational context. Future research would benefit from incorporating these alternative explanatory pathways to develop a more comprehensive understanding of how challenge-hindrance stress influences work engagement.

Our finding was the first to find that self-compassion moderated the direct pathway from hindrance stress to work engagement. Specifically, hindrance stress predicted lower work engagement among nurses with low self-compassion, whereas this association was non-significant among those with high self-compassion. As noted by Neff et al., individuals with high levels of self-compassion tend to respond to adversity with self-kindness,

accept difficult experiences without excessive self-criticism, and maintain positive cognitive appraisals—all of which support effective behavioral self-regulation [32]. Moreover, neuroimaging studies have shown that self-compassionate individuals exhibit increased activation in brain regions associated with emotional processing and regulation [53]. This evidence helps explain why nurses with greater self-compassion are better able to maintain their work engagement even when facing hindrance stress. Since challenge stress did not show a significant direct effect on work engagement in our model, the moderating role of self-compassion in this pathway was not examined. However, future research should explore the interrelationships among self-compassion, challenge stress, and work engagement to further advance comprehensive theoretical frameworks.

Limitations

Careful interpretation of the current findings is necessary due to several limitations. First, the cross-sectional design of this study constrains the ability to infer causal relationships among variables. To address this, future research should adopt longitudinal designs that can track changes over time and establish temporal precedence. For example, panel studies conducted at multiple time points could clarify the directionality of the relationships among these four variables. Second, the sample was drawn from a single hospital, which may limit the generalization of the findings. Future studies should recruit larger and more diverse samples across different hospitals, regions, and healthcare systems, possibly including rural and urban settings, to improve external validity and explore contextual influences on the studied variables. Third, the use of a web-based questionnaire, while efficient and convenient, may have introduced certain methodological limitations. For instance, participants were limited to those with internet access to participate, potentially leading to selection bias and affecting the generalizability of the findings. Moreover, self-report measures via online platforms are susceptible to social desirability bias. To address these concerns, future studies should consider adopting multi-center sampling, combining web-based and offline data collection methods, and utilizing random sampling or anonymization strategies to enhance data quality and representativeness. Fourth, the study focused only on challenge-hindrance stress, self-regulatory fatigue, and self-compassion, potentially overlooking other individual and contextual factors that influence work engagement. Future studies should explore additional relevant variables, such as psychological empowerment, organization support, and organization-based self-esteem, to develop a more comprehensive understanding of the mechanisms influencing nurses' engagement at work.

Relevance to clinical practice

First, nursing managers should implement regular screenings to assess nurses' levels of challenge-hindrance stress and self-regulatory fatigue. These assessments can be incorporated into routine performance evaluations or monthly psychological check-ins, helping managers identify staff who may be at risk of disengagement and require timely support. Second, targeted interventions should be introduced by nursing managers to address challenge-hindrance stress. These may include organizing structured stress management workshops, promoting peer support groups, and fostering a positive team climate through leadership training and recognition of nursing efforts. Drawing on the conservation of resources theory and prior empirical evidence [22, 24], managers should also consider establishing on-site psychological counseling services or partnerships with mental health professionals, as well as forming interdisciplinary support teams to provide emotional and professional guidance during high-stress periods. Moreover, the moderating role of self-compassion should be emphasized, particularly when nurses encounter intense hindrance stress. Nursing managers can facilitate this by incorporating compassion-focused training programs (e.g., mindful self-compassion workshops) into continuing education curricula [24]. Additionally, mentorship programs that encourage self-reflection and emotional awareness can help nurses build self-compassion over time. Finally, when designing interventions to enhance work engagement, nursing managers should take a holistic approach that integrates the assessment and management of challenge-hindrance stress, self-compassion and self-regulatory fatigue. This comprehensive strategy can maximize the impact of engagement initiatives and contribute to sustainable workforce wellbeing.

Conclusion

The findings revealed that hindrance stress not only directly reduced work engagement but also indirectly affected it through increased self-regulatory fatigue. In contrast, challenge stress influenced work engagement solely through self-regulatory fatigue. Importantly, self-compassion buffered the negative impact of hindrance stress on work engagement, highlighting its protective function. These results offer evidence-based guidance for nursing managers seeking to improve nurse' engagement at work. Specifically, integrating self-compassion training into interventions for nurses facing high hindrance stress may be a critical strategy for mitigating self-regulatory fatigue and sustaining engagement. Future research should further investigate the causal relationships among these variables by employing longitudinal designs, which could provide stronger evidence for temporal dynamics. Additionally, exploring the effectiveness of specific

self-compassion interventions (e.g., mindful self-compassion programs or compassion-focused therapy) in real-world clinical settings would help translate these findings into practice. Finally, expanding research to include diverse populations and healthcare contexts, such as community nurses, or international samples, could offer a broader understanding of how challenge-hindrance stress operates across different environments.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12912-025-03676-8>.

Supplementary Material 1

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Author contributions

MJZ and LC designed the study, conducted data analysis, and wrote the manuscript. FL and ZL contributed to overseeing project management and revising the original manuscript. JJX, QW, and WXB played a role in data collection and the study's execution. All authors participated in reviewing and editing the manuscript and approved the final version.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval for this study was granted by the Ethics Committee of the First Affiliated Hospital with Nanjing Medical University (Approval No. 2023-SR-942). All procedures strictly complied with the Declaration of Helsinki to protect participants' rights, privacy, and welfare. Informed consent was obtained from every participant after comprehensive disclosure of the study purpose, procedures, potential risks/benefits, and the voluntary nature of participation with explicit emphasis on their unconditional right to withdraw at any time without repercussions to employment or professional standing. To ensure data confidentiality, all personally identifiable information was permanently deleted during initial processing, with collected data anonymized through unique coding identifiers. These anonymized datasets were stored on password accessible exclusively to the research team. These protocols rigorously implemented international ethical standards for human subject research, particularly safeguarding informed consent autonomy and data security.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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