Risk Management and Healthcare Policy

Dovepress
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ORIGINAL RESEARCH

Physicians' Overwork Impacts Patient Satisfaction via Physician-Nurse Collaboration and Patients' Medical Risk Perception in China

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Background and Objective: To enhance healthcare service quality and foster harmonious doctor-patient relationships, it is necessary to explore the impact of physicians' overwork on patient satisfaction, with the mediating roles of physician-nurse collaboration and patients' medical risk perception in these relationships.

Methods: Using a stratified random sampling method, questionnaire surveys were conducted from June to September 2023 among 90 physicians and 550 inpatients in 13 Grade A tertiary public hospitals across five provinces in China. This survey collected data on physicians' overwork, physician-nurse collaboration, patient's medical risk perception, and patient satisfaction. The data were analyzed using the PROCESS macro (Model 6) in SPSS 23 to examine the chain mediation model.

Results: A total of 81 physicians and 512 inpatients were included. Physicians' overwork had a significant negative effect on patient satisfaction ($\beta = -0.426$, $p < 0.001$). Physician-nurse collaboration ($\beta = 0.463$, $p < 0.001$) and patients' medical risk perception ($\beta = -0.260$, $p < 0.001$) acted as partial mediators, accounting for 24.41% and 5.87% of the total effect, respectively. Furthermore, physicians' overwork indirectly affected patient satisfaction through a chain mediation pathway involving physician-nurse collaboration followed by patients' medical risk perception ($\beta = -0.014$, $p < 0.001$), accounting for 3.29% of the total effect.

Conclusion: Physicians' overwork demonstrates a significant negative predictive effect on patient satisfaction, encompassing both direct and indirect effects mediated by physician-nurse collaboration and patients' medical risk perception. To improve healthcare quality and satisfaction, governments should address physicians' overwork and patient risk perception. Future research could explore physician-patient trust as a mediator or analyze how different dimensions of risk perception influence chain-mediated pathways.

Keywords: medical risk perception, physicians'overwork, patient satisfaction, physician-nurse collaboration

Introduction

The implementation of the Healthy China Strategy has enabled broader access to high-quality medical resources, while healthcare providers (physicians) continue to face challenges of work overload.[1] According to the 2023 Statistical Bulletin of China's Health Development, public hospital physicians handle an average of 7.1 outpatient visits and 2.3 inpatient bed-days daily.[2] The 2018 White Paper on Chinese Physicians' Practice Status revealed that physicians in tertiary hospitals work an average of 51.05 hours weekly. This high-intensity work pattern has demonstrated measurable impacts on both healthcare service quality and patient experience,[3] while posing threats to patient safety.[4] Although existing research suggests that physicians' overwork may impact patient satisfaction, the causal relationship remains unclear. Whether physicians' overwork directly diminishes patient satisfaction or indirectly impacts satisfaction through

Received: 30 May 2025
Accepted: 7 November 2025
Published: 15 November 2025

mediating factors such as healthcare quality or service attitudes remains an unresolved empirical question requiring rigorous investigation.

In addressing physicians' overwork, the quality of physician-nurse collaboration emerges as a critical variable influencing the relationship between work stress and healthcare outcomes. Physician-nurse collaboration is defined as a partnership based on mutual respect and trust, characterized by open communication channels, timely information sharing, and complementary clinical expertise. This collaborative process involves joint strategy development and problem-solving to optimize patient outcomes in patients.[5] Rooted in equality, mutual respect, this patient-centered collaboration integrates multidisciplinary expertise to deliver comprehensive, high-quality care.[6] The impact of physician-nurse collaboration on patient satisfaction may be mediated by factors such as healthcare quality, service attitudes, and patient trust. However, existing studies have not yet fully identified these mediating mechanisms or explored their roles in the relationship between healthcare collaboration and patient satisfaction.

Patients' medical risk perception serves as a key indicator for measuring their healthcare experiences. In the context of health and disease, risk perception refers to individuals' subjective judgments about their susceptibility to illnesses and constitutes a critical factor in understanding their risk awareness and preventive health behaviors. As a specialized service, healthcare inherently involves risk characteristics that create an asymmetric information dynamic between physicians and patients.[7] Elevated medical risk perception among patients often stems from insufficient medical knowledge and anxiety about unexpected clinical outcomes, which may compromise their healthcare experiences.[8] While theoretical discussions and case studies exist, large-scale empirical research validating the specific mechanisms and pathways through which physicians' overwork affects patient satisfaction via patients' medical risk perception remains lacking, thereby limiting the reliability and generalizability of existing findings. Therefore, this study examines physician-nurse collaboration and patients' medical risk perception as mediating variables.

In summary, although previous studies have explored the relationship between physicians' overwork and healthcare collaboration, the underlying mechanisms through which this association influences patients' medical risk perception and ultimately affects patient satisfaction remain underexplored. Most studies focus on relationships between two or three variables, leaving the interconnected mechanisms under-examined. Furthermore, existing research predominantly investigates single stakeholder groups (eg, physicians or patients), with limited integration of dual-perspective analyses. According to Social Cognitive Theory, physicians' overwork leads to diminished self-efficacy, reduced communication with colleagues and patients, and impaired clinical collaboration efficiency. This decline in professional efficacy weakens patients' confidence in treatment, heightens their perception of medical risks, and ultimately deteriorates their healthcare experiences and satisfaction. To address these gaps, this study aims to examine the mediating roles of physician-nurse collaboration and patients' medical risk perception in the relationship between physicians' overwork and patient satisfaction, offering theoretical support for improving healthcare quality and patient experiences. Figure 1 presents the theoretical model of this study.

Research Hypotheses

Overwork not only jeopardizes the physical and mental health of physicians but also adversely affects the overall quality of medical services and patients' healthcare experiences.[9] Tariq et al[10] posit that the rapid increase in patient treatment volumes may be a critical factor contributing to medical errors. Under fatigued conditions, physicians may exhibit delayed responsiveness and impaired concentration, leading to misdiagnosis or missed diagnoses, which directly compromises treatment outcomes and patient satisfaction. Additionally, studies reveal a significant inverse correlation between physician fatigue levels and clinical performance.[11] Fatigue and stress may trigger emotional fluctuations in physicians, potentially resulting in impatient or indifferent attitudes toward patients. Such attitudes can evoke dissatisfaction and disappointment among patients, thereby negatively impacting their healthcare experiences and overall evaluation of healthcare services.[12] Based on the above, this study proposes the following hypothesis:

H1: Physicians' overwork has a significant negative effect on patient satisfaction.

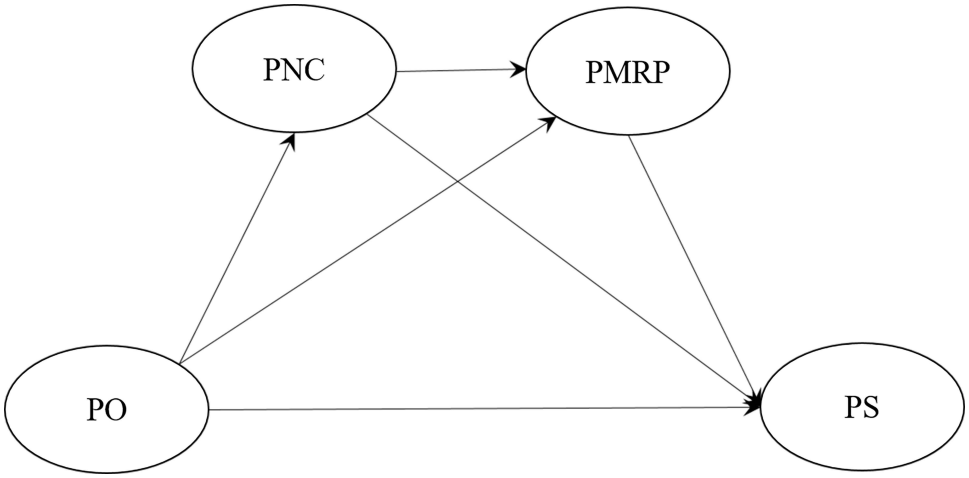

Figure 1 Study Framework.
Abbreviations: PO, physicians' overwork; PNC, physician-nurse collaboration; PMRP, patients' medical risk perception; PS, patient satisfaction.

Physicians' overwork undermines the efficiency of physician-nurse collaboration, thereby negatively impacting patients' healthcare experiences. On one hand, empirical investigation, notably conducted by Kuwaba et al[13] documented instances of physicians dying from overwork. Azhar et al[14] demonstrated that when physicians' experience overwork and sustained stress, manifestations such as inattention and impaired judgment may emerge, thereby adversely affecting coordination and collaboration among healthcare personnel.[13] Pfaff et al[4] identified a correlation between physicians' overwork and surgical safety risks. As the frontline workforce in hospitals, physicians' chronic overwork hinders the optimal functioning of physician-nurse collaboration, thereby compromising coordinated healthcare delivery. On the other hand, Pastores et al[15] argue that enhancing team communication and reducing practice variations are critical factors in improving patient outcomes. In clinical settings, the quality of physician-nurse collaboration directly influences patients' healthcare experiences. Timely information exchange, adaptive treatment strategies, and necessary psychological support between physicians and nurses strengthen patients' confidence and satisfaction during treatment.[16] Based on this, our study proposes the following hypothesis:

H2: Physician-nurse collaboration mediates the relationship between physicians' overwork and patient satisfaction.

Physicians' overwork increases lapses and errors in care delivery, compromising both healthcare quality and operational efficiency while amplifying patients' medical risk perception. Chronic exposure to occupational stress not only induces emotional exhaustion in physicians but also impairs cognitive functions such as attention span and reaction speed, reducing their capacity to detect subtle changes in patient conditions. This state of overwork drives physicians to prioritize expedient solutions during clinical decision-making, often overlooking patient-specific differences and latent risks. Such practices may result in medical errors, heightening the risk of adverse patient events.[17]

Patients' medical risk perception impacts their healthcare experience. Patients' medical risk perception is shaped by physicians' communication skills, treatment transparency, the clinical team's expertise, and healthcare facility conditions.[18] Concerns about medical errors and skepticism toward clinical decisions or treatment plans degrade patients' healthcare experiences.[19] Guan et al[20] found that the greater the workload of physicians, the higher the risk of inappropriate prescribing. Extended weekly working hours (≥60 hours/week) are a significant risk factor for increased medical error rates.[21] Based on this, our study proposes the following hypothesis:

H3: Patients' medical risk perception mediate the relationship between physicians' overwork and patient satisfaction.

Building on the hypotheses H1-H3 proposed earlier, prolonged labor under high-pressure conditions leads to cumulative fatigue among physicians, impairing their judgment and attention. This elevates the risk of medical errors

and heightens patients' risk perception, thereby diminishing their healthcare experience. Studies suggest that excessive physician workload and imbalanced nurse-to-physician ratios negatively impact inter-professional collaboration.[13] When collaboration quality is suboptimal, the probability of medical errors increases, healthcare service quality deteriorates, and therapeutic outcomes are ultimately compromised. From both physiological and psychological perspectives, fatigue reduces physicians' vigilance and decision-making capacity, resulting in deviations during diagnosis and treatment, which further amplifies patients' risk perception.[22] Additionally, mutual supervision among healthcare providers helps prevent medical incidents, alleviates patient concerns, enhances satisfaction, and improves healthcare experience. The specific research methodology is illustrated in Figure 1. Based on the above, the study proposes the following hypothesis:

H4: Physician-nurse collaboration and patients' medical risk perception jointly mediate the relationship between physicians' overwork and patient satisfaction.

Methods

Design and Samples

Employing a stratified random sampling method, this study conducted questionnaire surveys from June 2023 to September 2023, selecting 13 Grade A tertiary public hospitals across five provinces in China: eastern (eg, Shanghai), western (eg, Shaanxi), central (eg, Anhui), northern (eg, Jilin), and southern (eg, Guangdong). Among these, five hospitals were located in Guangdong Province, with two hospitals selected from each of the other four provinces to ensure coverage of diverse clinical specialties. A total of 90 attending physicians and 550 hospitalized patients were surveyed, yielding 81 valid physician questionnaires (90% validity rate) and 512 valid patient questionnaires (93.091% validity rate). Finally, physician and patient data were matched for subsequent analysis. To adhere to stratified random sampling principles, stratification was based on disease categories, with sampling proportions determined by overall population characteristics. Within each stratum, samples were selected using a random number generator (preloaded with patient bed numbers). The stratification proportions were as follows: cardiovascular diseases (30%), respiratory diseases (25%), reproductive system diseases (20%), musculoskeletal disorders (15%), and neurological diseases (10%). These proportions were aligned with disease prevalence to ensure comprehensiveness and representativeness. Additionally, when patients were under the age of 18, all questionnaires were completed under parental accompaniment or other statutory guardians.

Clinical departments involved in the survey included Cardiology, Rheumatology and Immunology, Gynecology, Obstetrics, Urology, General Surgery, Orthopedics, and Neurology, reflecting the scope of the stratified sampling framework. Patient sample inclusion criteria were as follows: (1) Hospitalization duration ≥3 days; (2) Clinically stable condition; (3) Provision of informed consent and willingness to participate in the study. Patient sample exclusion criteria were as follows: (1) Declined participation in the study; (2) Clinically unstable condition; (3) Impaired communication ability (eg, language barriers).

Variable Measurement

Drawing on existing literatures and the practical context of the questionnaire survey, our study identified four core variables, namely physicians' overwork, physician-nurse collaboration, medical risk perception, and patient satisfaction. Internationally recognized and authoritative scales were adopted, with forward-backward translation procedures applied to ensure conceptual equivalence of the Chinese versions. All scales were measured using a Likert 5-point scoring system (1 = "strongly disagree", 5 = "strongly agree").

Physicians' Overwork Scale

This study referenced the fatigue scale developed by Chalder et al[23] which assesses fatigue through two dimensions: physical fatigue and mental fatigue. Building on this, the physicians' overwork scale tailored for Chinese healthcare context by Wei et al[24] was employed. In this study, the scale is single-dimensional and includes six items such as "I work over 10 hours almost every day (including overtime)" and "I often work on holidays".

Physician-Nurse Collaboration Scale

Adapted from the physician-nurse collaboration scale developed by Ushiro,[25] our modified version included 9 items, such as "Our medical team aligns with patients on treatment expectations", "Our team consistently achieve consensus when modifying therapeutic regimens", "Our team collaboratively addresses treatment side effects or complications". Focused on the physician perspective, this study analyzed physician-nurse collaboration as an individual-level variable to assess its practical implementation.

Medical Risk Perception Scale

The patients' medical risk perception scale developed by Liu et al[26] was widely applied in evaluating patients' concerns about treatment outcomes. It included 3 items: "Concerns about treatment efficacy will fail to achieve expected results, potentially worsening physical conditions.", "Anxieties regarding treatment-induced complications (eg, surgical risks) affecting efficacy and prognosis. "Apprehensions of under treatment or overtreatment by physicians".

Patient Satisfaction Scale

Referencing the patient satisfaction scale by Lifshitz et al[27] this study measured satisfaction via 3 items as follows: "Satisfaction with medical costs relative to healthcare services received", "Satisfaction compared to idealized hospital expectations", "Overall satisfaction with the hospital services."

Data Analysis

Data entry, descriptive statistics, and correlation analysis were performed using SPSS 23.0. Furthermore, the PROCESS macro developed by Hayes et al[28] was employed to analyze the chain mediation effects of physician-nurse collaboration and patients' medical risk perception in the relationship between physicians' overwork and patient satisfaction. The Bootstrap method (Model 6, 5000 resamples, 95% confidence intervals) was utilized, with statistical significance defined at $p < 0.05$. Additionally, for missing data in the items, the "series mean" method was employed to impute missing values, followed by the calculation of the mean values for each study variable.

Results

Sample Characteristics

The demographic characteristics of the physician sample are summarized in Table 1. Regarding gender distribution, females accounted for a higher proportion (54.32%) compared to males (45.68%). In terms of age distribution, the sample was predominantly concentrated in the 21–30 years (32.10%) and 31–40 years (37.04%) age groups. For educational attainment, 44 physicians (54.32%) held a master's degree, followed by 24 physicians (29.63%) with a doctoral degree, 10 physicians (12.35%) with a bachelor's degree, and only 3 physicians (3.70%) with a college diploma.

Table 1 Basic Information Description of the Physician Samples (N=81)

Variable	Category	Frequency	Percentage (%)
Gender	Male	37	45.68
	Female	44	54.32
Age (years)	≤20	0	0
	21-30	26	32.10
	31-40	30	37.04
	41-50	15	18.52
	>50	10	12.35
Education level	Junior college	3	3.70
	Bachelor	10	12.35
	Master	44	54.32
	Doctor	24	29.63

https://doi.org/10.2147/RMHP.S537903

Table 2 Basic Information Description of the Patient Sample (N=512)

Variable	Category	Frequency	Percentage (%)
Gender	Male	269	52.54
	Female	243	47.46
Age (years)	<18	11	2.15
	18-33	110	21.48
	34-49	151	29.49
	50-65	172	33.59
	>65	68	13.28
Education level	Junior high school and below	66	12.89
	High school/ Secondary vocational school	87	16.99
	Junior college	154	30.08
	Bachelor	186	36.33
	Master and above	19	3.71
Monthly income (*yuan*)	≤4000	149	29.10
	4001-6000	163	31.84
	6001-8000	119	23.24
	8001-10,000	61	11.91
	>10,000	20	3.91

The demographic characteristics of the patient sample are summarized in Table 2. Females accounted for 243 (47.46%), and males comprised 269 (52.54%). In terms of age distribution, there were 11 patients (2.15%) under 18 years old, 110 patients (21.48%) aged 18–33 years, 151 patients (29.49%) aged 34–49 years, 172 patients (33.59%) aged 50–65 years, and 68 patients (13.28%) over 65 years old. Regarding educational attainment, 186 patients (36.33%) held a bachelor's degree, followed by 154 patients (30.08%) with a junior college diploma, 87 patients (16.99%) with a high school/secondary vocational diploma, and 19 patients (3.71%) with a master's degree, representing the smallest proportion. For monthly income, 431 patients (84.18%) reported earnings below 8,000 Chinese *yuan*.

Common Method Bias

To mitigate common method bias, this study measured independent and dependent variables from multiple sources and time points, with preemptive controls including concealing variable labels to minimize response consistency effects. The Harman single-factor test was conducted using exploratory factor analysis without rotation. Results revealed six factors with eigenvalues >1, with the first factor accounting for 36.260% of variance—below the 40% critical threshold. This indicates no severe common method bias in the study, as variance was distributed across multiple latent constructs rather than dominated by a single method factor.

Reliability and Validity Test

To validate the questionnaire's reliability and effectiveness, a pre-test was conducted using random sampling prior to finalizing the official version. The pilot data underwent rigorous psychometric evaluation, including reliability and validity assessments. For reliability analysis, the widely adopted Cronbach's α coefficient was employed. The results indicated excellent internal consistency, with α values of 0.951 (physicians' overwork), 0.955 (physician-nurse collaboration), 0.936 (medical risk perception), and 0.926 (patient satisfaction), all exceeding the acceptable threshold for measurement precision.

To assess the scale's validity, the research employed a dual-faceted approach: content validity and discriminant validity evaluation. For content validity, the study leveraged well-established scales from prior literature, which had undergone rigorous validation in existing studies. Additionally, three domain experts were consulted to refine the measurement items, further enhancing the instrument's content validity. Regarding discriminant validity, a confirmatory factor analysis (CFA) was performed. The results (Table 3) revealed that the Average Variance Extracted (AVE) values for the four constructs—physicians' overwork (0.662), physician-nurse collaboration (0.563),

Table 3 Confirmatory Factor Analysis

Factors and items		Standardized loadings	AVE	CR
PO	PO1	0.867	0.662	0.966
	PO2	0.797		
	PO3	0.746		
	PO4	0.792		
	PO5	0.812		
	PO6	0.861		
NPC	NPC1	0.688	0.563	0.946
	NPC2	0.731		
	NPC3	0.715		
	NPC4	0.771		
	NPC5	0.712		
	NPC6	0.801		
	NPC7	0.804		
	NPC8	0.821		
	NPC9	0.693		
PMRP	PMRP1	0.882	0.783	0.969
	PMRP2	0.883		
	PMRP3	0.889		
PS	PS1	0.872	0.760	0.966
	PS2	0.865		
	PS3	0.878		

Abbreviations: PO, physicians' overwork; PNC, physician-nurse collaboration; PMRP, patients' medical risk perception; PS, patient satisfaction; AVE, average variance extracted; CR, composite reliability.

medical risk perception (0.783), and patient satisfaction (0.760)—all surpassed the 0.50 threshold, demonstrating satisfactory convergent validity. The Composite Reliability (CR) scores (0.966, 0.946, 0.969, and 0.966) consistently exceeded 0.7, demonstrating robust internal consistency.

The study employed Mplus 8.3 software to conduct CFA to examine the fit between the model and data. A well-fitting model was determined by the following criteria: $\chi^2/df < 5$; RMSEA < 0.08; CFI and TLI ranging between 0 and 1, with values > 0.8 indicating acceptable model fit and > 0.9 indicating good fit. The fit indices for this model were as follows: $\chi^2 = 730.826$, df = 176, $\chi^2/df = 4.152$, CFI = 0.941, TLI = 0.929, RMSEA = 0.078, and SRMR = 0.040. All indices fell within their respective recommended ranges, demonstrating excellent fit standards. The results showed that all fit indices met the threshold values, and the data for each item in the scale aligned well with the theoretical model, indicating satisfactory structural validity of the questionnaire. Collectively, these findings demonstrated that the study's scale exhibits strong reliability and validity, fully meeting the research objectives.

Correlation Analysis

As shown in Table 4, physicians' overwork exhibited significant negative correlations with patient satisfaction (r = −0.423, $p < 0.01$) and physician-nurse collaboration (r = −0.322, $p < 0.01$), while demonstrating a significant positive correlation with patients' medical risk perception (r = 0.156, $p < 0.01$). Physician-nurse collaboration was significantly positively correlated with patient satisfaction (r = 0.467, $p < 0.01$). Conversely, patients' medical risk perception showed significant negative correlations with physician-nurse collaboration (r = −0.209, $p < 0.01$) and patient satisfaction (r = −0.357, $p < 0.01$). Additionally, a low correlation indicates a weak linear association between variables. For instance, while age and patient satisfaction may exhibit a theoretical relationship, the statistical analysis reveals no significant correlation between them (p > 0.05). Subsequently, this study employed Variance Inflation Factor (VIF) values to assess potential multicollinearity within the model. The results indicate that all variance inflation factors (VIF) between variables were below 3, suggesting no issue of multicollinearity.

Structural Equation Model Analysis

The chain mediation effects of healthcare collaboration and patients' medical risk perception in the relationship between physicians' overwork and patient satisfaction were analyzed using the PROCESS macro (Model 6) developed by Hayes,[28] with the Bootstrap method (5,000 resamples, 95% confidence interval). The results (as shown in Tables 5 and 6) revealed that the total effect of physicians' overwork on patient satisfaction was significant ($\beta = -0.426$, $p < 0.001$). After incorporating the mediators, physicians' overwork negatively predicted physician-nurse collaboration ($\beta = -0.224$, $p < 0.001$) and positively predicted patients' medical risk perception ($\beta = 0.095$, $p < 0.05$). The direct effect of physicians' overwork on patient satisfaction remained significant ($\beta = -0.283$, $p < 0.001$). Physician-nurse collaboration significantly negatively predicted patients' medical risk perception ($\beta = -0.243$, $p < 0.001$) while positively predicting patient satisfaction ($\beta = 0.463$, $p < 0.001$). Conversely,

Table 4 Descriptive Statistics and Correlation Analysis

Variable	Mean	SD	1	2	3	4	5	6	7	8
1 Gender	1.47	0.500	1							
2 Age	3.34	1.026	−0.223**	1						
3 Education	3.01	1.095	0.088*	−0.346**	1					
4 MI	2.30	1.125	−0.046	−0.109*	0.158**	1				
5 PO	2.80	1.166	−0.016	0.094*	−0.045	−0.014	1			
6 PNC	3.76	0.816	0.020	−0.045	0.058	0.006	−0.322**	1		
7 PMRP	3.39	1.142	0.071	0.037	−0.114**	−0.015	0.156**	−0.209**	1	
8 PS	3.18	1.165	0.045	−0.012	0.018	−0.069	−0.423**	0.467**	−0.357**	1

Notes:*$p<0.05$, **$p<0.01$.

Abbreviations: MI, monthly income; PO, physicians' overwork; PNC, physician-nurse collaboration; PS, patient satisfaction; PMRP, patients' medical risk perception; PS, patient satisfaction; SD, standard deviation.

Table 5 Chain Mediation Model Analysis

Model	Dependent variable	Independent Variable	R	R^2	*F*	*β*	*SE*	*t*	95% CI	
									LLCI	ULCI
1	PNC	PO	0.325	0.106	11.984	−0.224	0.030	−7.588	−0.282	−0.166
2	PMRP	PO	0.264	0.070	6.313	0.095	0.045	2.121	0.007	0.182
		PNC				−0.243	0.063	−3.820	−0.367	−0.118
3	PS	PO	0.607	0.369	42.082	−0.283	0.038	−7.515	−0.357	−0.209
		PNC				0.463	0.054	8.552	0.357	0.570
		PMRP				−0.260	0.037	−6.945	−0.334	−0.186

Abbreviations: PO, physicians' overwork; PNC, physician-nurse collaboration; PMRP, patients' medical risk perception; PS, patient satisfaction. 95% CI, 95% confidence interval; LLCI, Lower limit confidence interval; ULCI, Upper limit confidence interval.

Table 6 Bootstrap Analysis of the Mediating Effect of Physician-Nurse Collaboration and Patients' Medical Risk Perception

Paths	Effect	Boot SE	BootLL CI	BootUL CI	Effect ratio (%)
Total effect	−0.426	0.040	−0.505	−0.347	100.00
Direct effect	−0.283	0.038	−0.357	−0.209	66.43
Total indirect effect	−0.143	0.025	−0.193	−0.095	33.57
The specific indirect pathways are as follows:					
PO→PNC→PS	−0.104	0.021	−0.146	−0.064	24.41
PO→PMRP→PS	−0.025	0.012	−0.050	−0.002	5.87
PO→PNC→PMRP→PS	−0.014	0.005	−0.026	−0.005	3.29

Abbreviations: PO, physicians' overwork; PNC, physician-nurse collaboration; PMRP, patients' medical risk perception; PS, patient satisfaction; CI, confidence interval.

patients' medical risk perception significantly negatively predicted patient satisfaction ($\beta = -0.260$, $p < 0.001$). The chain mediation effect model of physicians' overwork and patient satisfaction is shown in Figure 2.

The mediation analysis results for physician-nurse collaboration and patients' medical risk perception are presented in Table 6. Both mediation effects reached statistical significance (95% bias-corrected bootstrap confidence intervals excluding zero), demonstrating their roles as mediators between physicians' overwork and patient satisfaction, with a total mediation effect value of −0.143. Specifically, the mediation effects comprised the following three indirect pathways. Path 1: Indirect effect 1 (−0.104) generated through the pathway physicians' overwork→physician-nurse collaboration→patient satisfaction. Path 2: Indirect effect 2 (−0.025) generated through the pathway physicians' overwork→patients' medical risk perception→patient satisfaction. Path 3: Indirect effect 3 (−0.014) generated through the pathway physicians' overwork→physician-nurse collaboration→patients' medical risk perception→patient satisfaction. These three indirect effects accounted for 24.41%, 5.87%, and 3.29% of the total effect, respectively. Figure 2 presents the path coefficients among the variables, and all path coefficients are statistically significant. Based on the analytical results in Table 5 and Table 6, this demonstrates that the hypotheses H1, H2, H3, and H4 proposed in this study have been validated.

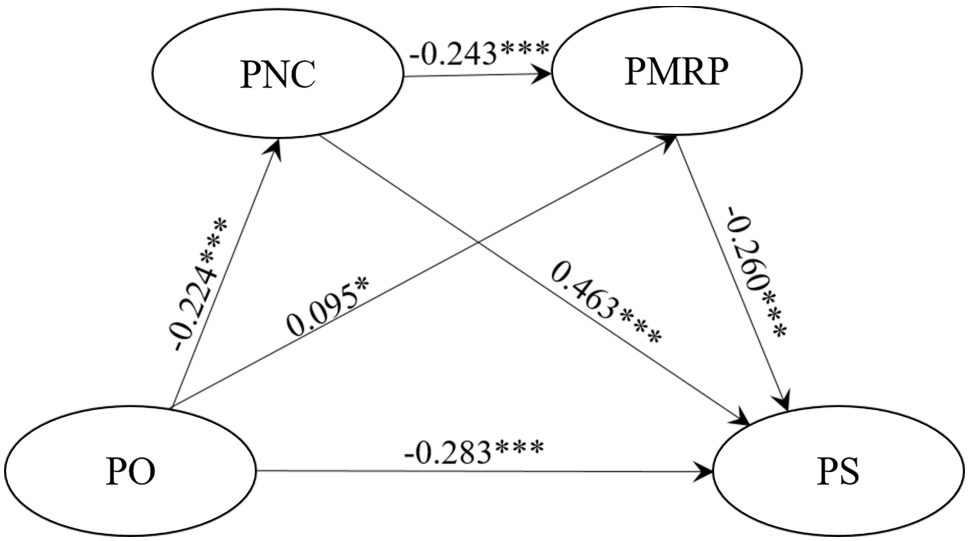

Figure 2 Chain mediation model of physicians' overwork and patient satisfaction.
Notes: All path coefficients are β. *p<0.05; ***p<0.001.
Abbreviations: PO, physicians' overwork; PNC, physician-nurse collaboration; PMRP, patients' medical risk perception; PS, patient satisfaction.

https://doi.org/10.2147/RMHP.S537903

Discussion

This study aims to elucidate the mechanism through which physicians' overwork affects patient satisfaction by introducing physician-nurse collaboration and patients' medical risk perception as mediating variables. Grounded in Social Cognitive Theory, our research provides a dual-perspective (physician-patient) analysis of this process. Empirical validation of the mediation effects between physicians' overwork and patient satisfaction was conducted using the Bootstrap method. The results demonstrated that physicians' overwork exerts a significant negative impact on patient satisfaction, with physician-nurse collaboration and patients' medical risk perception serving as independent mediators between these variables. Furthermore, physician-nurse collaboration and patients' medical risk perception exhibited a chain mediation effect in the relationship between physicians' overwork and patient satisfaction.

First, this study revealed that the direct effect hypothesis between physicians' overwork and patient satisfaction, consistent with findings from Watson et al.[11] Prior literature has extensively explored patient satisfaction through dimensions such as declining service quality [1], insufficient communication,[20] emotional contagion, and uneven healthcare resource allocation. While existing study establish a negative correlation between physicians' overwork and patient satisfaction.[29] Our study quantifies the significant negative influence between physicians' overwork and patient satisfaction ($\beta = -0.426$, $p < 0.001$). At the micro-level, this effect may adversely impact individual health outcomes, revisit intentions, and medical compliance.[3] At the macro-level, it may potentially threaten institutional reputation, physician-patient relationships, and healthcare system stability.[30]

Second, our study indicated the mediating role of physician-nurse collaboration between physicians' overwork and patient satisfaction. Unlike prior work limited to theoretical frameworks[31] or scale development.[25] Previous studies on physicians' overwork and patient satisfaction have predominantly adopted a single-perspective approach, while neglecting the exploration of mediating variables.[32] This study bridges this gap by examining the issue from both physician and patient perspectives, empirically demonstrating the positive mediating role of physician-nurse collaboration between the two. Specifically, integrating the dual perspectives of physicians and patients enables a more comprehensive analysis of antecedent variables and outcome variables centered on interprofessional collaboration. This approach contributes to addressing the limitations in existing literature on healthcare teamwork. Matthys et al[33] further corroborates that physician-nurse collaboration positively influences diverse patient outcomes and clinical management of various diseases. Furthermore, grounded in Social Cognitive Theory, physicians' overwork diminishes self-efficacy, thereby reducing the frequency of physician-nurse collaboration. Inadequate interprofessional communication subsequently impedes the enhancement of patient satisfaction.

Third, this study empirically validated the mediating role of patients' medical risk perception in the relationship between physicians' overwork and patient satisfaction, revealing a chain effect of social cognitive processes in healthcare settings: physicians' overwork, as an environmental factor, shapes patients' risk perception through observational learning, ultimately reshaping their satisfaction evaluation within the individual-behavior-environment interaction framework. Additionally, this research extends the research by Krok[34] on the antecedents of patient-perceived medical risk, incorporating additional predictive variables and methodological refinements to address gaps in prior literature. Previous studies on antecedents to patients' medical risk perception primarily focused on individual differences, physician-related factors, and organizational environments.[35–37] Scholars have predominantly interpreted the mechanisms underlying patients' medical risk perception through theoretical lenses such as health belief models, and attribution theory.[38,39] Notably, Topçu et al[40] has advocated moving beyond identifying influencing factors and instead exploring the generative mechanisms of patients' medical risk perception from information asymmetry perspective. This study employs a quantitative research approach to develop and interpret a model of patients' perceived medical risk, thereby complementing the qualitative findings of Alqahtani[39] et al. However, regarding the low R^2 values in Table 5, it is hypothesized that the variability of the dependent variable may be attributed to unmodeled factors, thereby limiting the model's explanatory power to only a portion of the observed variance. Future studies could incorporate additional variables and expand the sample size to enhance both the model's stability and its explanatory capacity.

Finally, this study reveals that physicians' overwork impacts patient satisfaction through the mediating effects of physician-nurse collaboration and patients' medical risk perception. Our prior research[41] predominantly focused on

moderating individual psychological processes of patients, emphasizing real-time policy interventions and constructing single-path transmission models to analyze the impact of patients' subjective cognition on service evaluations. Building on prior studies, this research designs a chain mediation model that highlights dual perspectives of both physicians and patients, underscores systemic mechanisms, and systematically explores the intrinsic pathways through which physicians' overwork affects patient satisfaction via chain mediation, thereby transcending traditional behaviorist paradigms. The theoretical framework of this study integrates physician-nurse collaboration and patients' medical risk perception into a unified analytical system. This integration not only broadens the scope of related research but also elucidates the specific pathways through which physicians' overwork ultimately impacts patient satisfaction via chain mediation, offering critical supplementation and expansion to existing studies on patient satisfaction. Furthermore, this research extends the application boundaries of Social Cognitive Theory in healthcare contexts, providing novel theoretical support for patient satisfaction research. By deconstructing the "black box" of how physicians' overwork influences patient satisfaction, the findings not only furnish scientific evidence for improving healthcare service quality but also shift the focus of physician-patient relationship research from "outcome evaluation" to "process optimization", laying a theoretical foundation for constructing a patient-centered healthcare ecosystem. The comprehensive chain of "physicians' overwork→physician-nurse collaboration→patients' medical risk perception→patient satisfaction", constructed based on Social Cognitive Theory, provides a full-cycle intervention scheme for fostering harmonious physician-patient relationships. This framework informs evidence-based resource allocation in healthcare institutions and supports policy formulation for initiatives such as the Healthy China Strategy. The path "physicians' overwork→physician-nurse collaboration→patients' medical risk perception→patient satisfaction" accounts for 3.29% of the total effect size, reflecting the indirect impact intensity of physicians' overwork on patient satisfaction. This finding suggests that healthcare administrators should optimize physician scheduling to mitigate the "marginal decline" in service quality caused by excessive workload. It should be noted that the data used in this study exhibit a nested structure, whereby 512 hospitalized patients were matched to 81 physicians through hospital, department, and bed number information, resulting in patient data being nested within physician data. At the individual level, data processing was conducted using SPSS 23 and Mplus 8.3. To better capture variations at both physician and patient levels, future research may consider adopting a multilevel mixed-effects model that accounts for the hierarchical nature of the data structure.

Limitations and Suggestions

This study yielded valuable findings, yet several limitations should be acknowledged. First, the cross-sectional design limits the ability to infer causal relationships between variables. Future research could collect longitudinal data across multiple time points to address this issue. Second, Regarding the issue of skewed patient income distribution, this study did not stratify the analysis by low- and high-income levels. Income may act as a confounding variable, and future research could consider stratified analysis to account for this factor. Given the high proportion of low- and middle-income patients, policymakers should prioritize cost-reduction measures and tiered healthcare delivery models to enhance service accessibility. In future, governments should strengthen policy supervision and targeted rectification efforts, implementing action plans to enhance healthcare service quality, with particular focus on addressing physicians' overwork and patients' medical risk perception. Future research could explore physician-patient trust as a mediator or analyze how different dimensions of risk perception influence chain-mediated pathways.

Conclusion

This study demonstrates that the chain mediation effects of physician-nurse collaboration and patients' perceived medical risk play a significant role in the relationship between physicians' overwork and patient satisfaction. These findings provide a comprehensive intervention framework for the harmonious development of physician-patient relationships, broaden the scope of research on patient satisfaction, extend the application boundaries of social cognitive theory in the medical field, and offer new theoretical support for physician-patient interaction studies. Based on the research outcomes, healthcare management authorities should prioritize interventions targeting physicians' overwork, establish medical risk early-warning systems, and enhance healthcare service quality in the future.

Data Sharing Statement

Data can be available from the corresponding author upon reasonable request.

Ethical Approval and Informed Consent

All procedures performed in studies involving human participants were approved by the Ethics Committee Review Board of Guangdong Second Provincial General Hospital (2023-KY-KZ-236-01). Before the research began, participants were informed about the purpose and procedures of the study. This study complies with the Declaration of Helsinki.

Acknowledgments

We would like to thank the physicians, patients and administrative staff who took time and efforts in this study.

Funding

This study was funded by the Scientific Research Project of Traditional Chinese Medicine Bureau of Guangdong Province (20242003). Guangdong Provincial Medical Science and Technology Research Fund Project (B2025058). The "Tuoju Project" Special Fund of Guangdong Provincial People's Hospital (TJGC-2025007).

Disclosure

The authors declare no conflicts of interest in this work.

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