




# The Mediating Role of Nurses' Organizational Innovation Climate on the Relationship Between Head Nurses' Research-Innovation Leadership and Nurses' Innovation Behavior in China: A Cross-Sectional Observational Study

Kaihua Liu <sup>1,2,\*</sup>, Jing Ma<sup>3,\*</sup>, Ruohan Wang<sup>1,4</sup>, Dongxu Liu <sup>1,5</sup>, Miao Gao<sup>6</sup>, Yue Gao<sup>2</sup>, Ruihuan Zhang<sup>7</sup>, Xiaoping Yin<sup>1,8,9</sup>, Cong Fu <sup>10</sup>

<sup>1</sup>School of Nursing, Hebei University, Baoding, People's Republic of China; <sup>2</sup>Department of General Surgery, Affiliated Hospital of Hebei University, Baoding, People's Republic of China; <sup>3</sup>Nursing Department, First Hospital of Qinhuangdao, Qinhuangdao, People's Republic of China; <sup>4</sup>Department of Spine Surgery, Affiliated Hospital of Hebei University, Baoding, People's Republic of China; <sup>5</sup>Department of Emergency Medicine, Affiliated Hospital of Hebei University, Baoding, People's Republic of China; <sup>6</sup>Department of General Medicine, the Sixth People's Hospital of Hebei Province, Baoding, People's Republic of China; <sup>7</sup>Department of Gastroenterology, Affiliated Hospital of Hebei University, Baoding, People's Republic of China; <sup>8</sup>Department of Radiology, Affiliated Hospital of Hebei University, Baoding, People's Republic of China; <sup>9</sup>Hebei Key Laboratory of Precise Imaging of Inflammation Related Tumors, Baoding, People's Republic of China; <sup>10</sup>Department of Nursing, Affiliated Hospital of Hebei University, Baoding, People's Republic of China

\*These authors contributed equally to this work

Correspondence: Xiaoping Yin, Department of Radiology, Affiliated Hospital of Hebei University, 212 Yuhua East Road, Baoding City, Hebei Province, 071000, People's Republic of China, Email [hdfyrad@hbu.edu.cn](mailto:hdfyrad@hbu.edu.cn); Cong Fu, Department of Nursing, Affiliated Hospital of Hebei University, 212 Yuhua East Road, Baoding City, Hebei Province, 071000, People's Republic of China, Email [63194643@qq.com](mailto:63194643@qq.com)

**Objective:** To explore the mediating role of nurses' organizational innovation climate in the relationship between head nurses' research-innovation leadership and nurses' innovation behavior.

**Methods:** Using a convenience sampling method, 236 clinical nurses were selected from four tertiary grade-A hospitals in Hebei Province, China. Data were collected through four instruments: a general information questionnaire, the head nurses' research-innovation leadership scale, the nurses' innovation behavior scale, and the organizational innovation climate scale. An online data analysis tool SPSS was adopted to conduct descriptive analysis, correlation analysis, and structural equation model construction.

**Results:** The total score for head nurses' research-innovation leadership was  $55.32 \pm 12.18$ , which was at the upper middle level. The total score for organizational innovation climate among nurses was  $84.35 \pm 11.35$ , which was at the medium level. The total score for nurses' innovation behavior was  $34.65 \pm 6.21$ , which was at the medium level. Nurses' innovation behavior was positively correlated with head nurses' research-innovation leadership ( $r = 0.380$ ,  $P < 0.01$ ) and with the organizational innovation climate ( $r = 0.409$ ,  $P < 0.01$ ). Organizational innovation climate partially mediated the relationship between the head nurses' research-innovation leadership and nurses' innovation behavior, accounting for 29.6% of the total effect, 95% CI [0.0417~0.1412], the mediating effect is significant (0 excluded).

**Conclusion:** Head nurses' research-innovation leadership has a direct effect on nurses' innovation behavior and can also exert an indirect influence through the organizational innovation climate, but this indirect influence is not absolutely dominant. Nursing managers should enhance their leadership in research and innovation and actively foster a supportive organizational climate to promote innovation behavior among nurses.

**Keywords:** clinical nurses, innovation behavior, head nurses' research-innovation leadership, organizational innovation climate, mediating effect

## Introduction

Nurses' innovative behavior refers to the process in which nurses, aiming to promote health, prevent disease, and improve the quality of patient care, seek out and develop new methods, techniques, develop and implement them in practice with team support.<sup>1</sup> The *National Nursing Development Plan (2021–2025)* emphasizes that nursing is a critical component of the healthcare system, and that innovation and reform in the nursing field should be vigorously promoted to cultivate a high-quality and innovative nursing workforce.<sup>2</sup> As a vital part of the healthcare team, nurses are the main drivers of nursing innovation, and their innovation behavior has a profound impact on fostering the overall level and efficiency of medical services in hospitals.<sup>3</sup> Innovation serves as the driving force behind hospital development, and can promote the high-quality development of hospital.<sup>4</sup> Innovation serves as the driving force behind hospital development. Therefore, how to stimulate the innovative potential of hospital nurses has become an unavoidable challenge for hospital administrators.<sup>5</sup> In tertiary grade-A hospitals, nurses generally operate in more advanced professional environments, and hospital managers place greater emphasis on cultivating their innovative capabilities. Although efforts have been made to promote nurses' innovation behavior, its overall level still requires improvement.<sup>6</sup> Thus, attention to the status of nurses' innovation behavior in tertiary grade-A hospitals is of critical importance.

Head nurses' leadership plays a vital role in hospital management, particularly in ensuring and fostering the quality of nursing care. By fostering a supportive environment and providing adequate resources for nursing innovation and practice, head nurses help establish a positive organizational innovation climate that stimulates nurses' creativity and innovative spirit. This climate serves as an important external factor influencing nurses' innovation behavior and contributes to the improvement of care quality and the hospital's overall competitiveness.<sup>7</sup> Leadership behaviors and styles adopted by head nurses can directly influence nurses' innovation behaviors.<sup>8</sup> Research and innovation are driving forces in the development of the nursing discipline. They are essential in improving clinical nursing quality, reducing patient complications, and shortening hospital stays.<sup>9</sup> However, the mechanisms by which head nurses' research-innovation leadership affects nurses' attitudes and behaviors toward innovation remain poorly understood. Research-innovation leadership in head nurses refers to the ability of those with a research role or orientation to lead and manage research inquiry, thereby attracting and motivating nurses or other stakeholders to voluntarily engage in and sustain research and innovation activities to achieve collective goals.<sup>10</sup> This form of leadership extends beyond individual innovation behaviors; it involves mobilizing human, material, and temporal resources to inspire and guide nurses within the unit to realize their potential for innovation. Ultimately, it can serve as a powerful driver for innovation throughout the healthcare system.<sup>11</sup>

The organizational innovation climate plays a crucial role in shaping nurses' innovation behavior. It provides the cognitive foundation necessary to support the development of innovation-related actions. Organizational innovation climate refers to the shared perception among nurses regarding the extent to which their department, nursing division, and hospital as a whole support innovation.<sup>12</sup> As a subjective perception of the organizational environment, the innovation climate strongly influences how supported individuals feel in their efforts to innovate. Studies have shown that when an organization maintains a favorable innovation climate, nurses experience a greater sense of support for innovation,<sup>13</sup> thereby stimulating their innovation behavior. Evidence also suggests that a positive organizational innovation climate significantly promotes innovation behavior in nurses.<sup>14</sup> Therefore, nursing administrators should actively cultivate a supportive innovation climate, nurture nurses' awareness of innovation, stimulate their enthusiasm for creativity, and foster their capacity for innovation.<sup>15</sup>

A proactive leadership style can enhance the organizational innovation climate and increase nurses' perceived innovativeness in their work.<sup>12</sup> Research has shown a positive correlation between head nurses' leadership and the organizational innovation climate: the stronger the leadership exhibited by head nurses, the more robust the innovation climate perceived by nurses, which in turn promotes more active innovation behavior.<sup>16</sup> Leadership style influences the formation of an organizational innovation climate, which subsequently affects both individual members and the organization. Head nurses' research-innovation leadership can convey the value of nursing research and innovation, provide resources for realizing innovative ideas, foster an organizational innovation climate, and ultimately promote innovation behavior among nurses.

Previous studies have found that nurses' innovation behavior is not only associated with the organizational innovation climate but also with the leadership style of head nurses.<sup>17</sup> In light of this, the present study aims to investigate clinical nurses' perceptions of the organizational innovation climate, head nurses' research-innovation leadership, and nurses' innovation behavior, and to explore the mediating role of organizational innovation climate in this relationship. The findings are expected to provide practical implications for nursing administrators seeking to enhance innovation in clinical settings. Based on the importance of nurses' innovative behavior, further in-depth research is warranted. However, there is currently a lack of studies on the mechanism through which head nurses' research-innovation leadership influences this behavior via the organizational innovation climate. This study provides hospital nursing managers with a new perspective, starting from head nurses' research-innovation leadership, to promote innovative behaviors among nurses. It calls for and promotes greater emphasis on nursing innovation among nursing leaders, thereby improving the quality of nursing care.

## Theoretical Framework

This study is grounded in Spatial Theory,<sup>18,19</sup> which is based on Field Dynamics Theory.<sup>20</sup> According to this framework, innovation behavior is conceptualized through the equation  $Bi = f(Pi \times Ei)$ , where  $Bi$  represents behavior (including innovation behavior),  $Pi$  refers to the person (including internal needs, perceptions, and psychological factors), and  $Ei$  denotes the environment (comprising external factors). The function  $f$  is a coefficient representing the interaction between these components. Within this model, the innovation subject ( $Pi$ ) and the innovation environment ( $Ei$ ) are interdependent variables that together constitute the "innovation space." In this study,  $Bi$  represents nurses' innovative behavior,  $Pi$  represents the organizational innovation climate,  $Ei$  represents head nurses' leadership.

Drawing on spatial and field dynamics, nurses' innovation behavior can be interpreted as a response to external factors that disrupt their routine clinical work. Nurses engage in innovation behavior to adapt to a constantly changing environment, restore equilibrium, and sustain nursing practice. According to Spatial Theory, internal personal factors (in this study, the organizational innovation climate) and external environmental factors (in this study, head nurses' research-innovation leadership) work in tandem to promote clinical nurses' innovation behavior. This theoretical framework further implies that external factors may influence internal perceptions, thereby facilitating innovation. The combination of internal and external factors may jointly affect nurses' innovation behavior and suggests that internal factors may mediate the influence of external ones. This study draws on Space Theory to conceptualize the context for nursing innovation—the nursing unit or department as a multidimensional innovation space. The space is a dynamic and complex system jointly constituted by the physical environment, social relationships, and psychological perceptions. It is within this space that nurses' innovation behavior is either facilitated or inhibited.

Based on this theoretical framework and previous literature, the conceptual model of the study is presented in Figure 1. Despite growing interest, the interrelationships among nurses' innovation behavior, head nurses' research-innovation leadership, and the organizational innovation climate remain underexplored. Therefore, the significance of this study lies in examining these constructs and particularly in exploring the mediating role of the organizational innovation climate. The ultimate aim is to improve nurses' innovation behavior and, consequently, enhance the quality and satisfaction of nursing services.

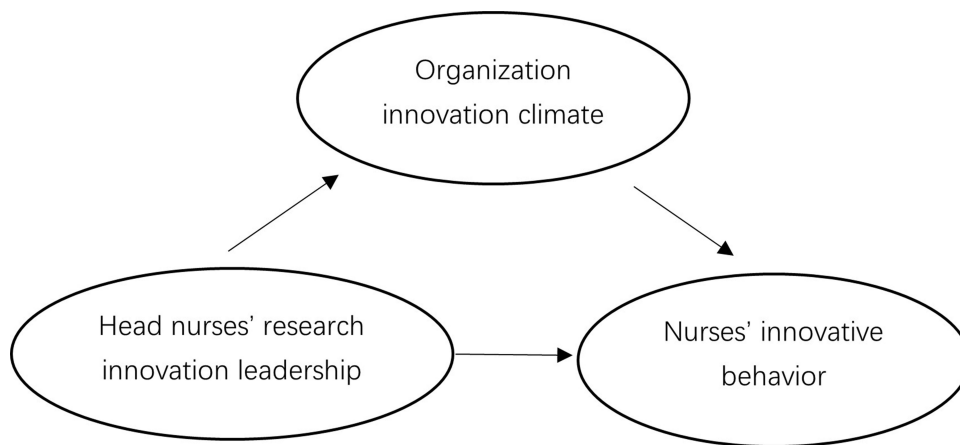
The study hypotheses:

- **Hypothesis 1:** Head nurses' research-innovation leadership, organizational innovation climate, and nurses' innovation behavior are positively correlated with one another.
- **Hypothesis 2:** Organizational innovation climate mediates the relationship between head nurses' research-innovation leadership and nurses' innovation behavior.

## Methods

### Participants

In March 2025, clinical nurses from four tertiary grade-A hospitals in Hebei Province were selected using a convenience sampling method. Participants were included if they met the following criteria: (1) currently employed as registered



**Figure 1** Mediating role model of organizational innovation climate.

nurses in the selected hospitals; (2) working in direct clinical care; (3) had worked with their current head nurse for at least one year; and (4) were informed about the study and voluntarily agreed to participate. Exclusion criteria were: (1) nurses who were on leave during the survey period (including maternity leave, sick leave, or attending external training); and (2) nurses who had experienced major physical trauma or psychological illness in the past two years, such as documentation of consecutive sick leave exceeding 30 days (in aggregate) due to physical or traumatic conditions; records of hospitalization for diagnosed psychiatric or psychological disorders.

The required sample size was estimated using Kendall's sample size estimation method,<sup>21</sup> which recommends a sample size of 5–10 times the number of variables. Given the 31 variables in this study and accounting for a 20% invalid response rate, the required sample size was estimated to be between 186 and 372 participants. A total of 236 valid responses were ultimately collected, meeting the sample size requirement.

This study has certain limitations and potential selection bias due to the use of convenience sampling. The sample was collected from four tertiary grade-A hospitals in Hebei Province, which possess specific characteristics and may not fully represent the broader nursing population. Furthermore, the sample may consist only of nurses who were willing to participate in the survey, which could introduce bias into the results.

## Instruments

### General Information Questionnaire

A self-designed general information questionnaire was used to collect demographic and work-related data, including gender, age, educational background, marital status, hospital level, employment type, department, years of work experience, professional title, monthly income, and whether the nurse served as a clinical instructor.

### Nurse Innovation Behavior Scale (NIBS)

This study utilized the Nurse Innovation Behavior Scale (NIBS) developed by Bao Ling et al<sup>1</sup> specifically designed for the nursing population. The scale consists of three dimensions and ten items: idea generation (3 items), obtaining support (4 items), and idea implementation (3 items). A five-point Likert scale is used, ranging from 1 (never) to 5 (very frequently), with total scores ranging from 10 to 50. Higher scores indicate more pronounced innovation behavior. The scale demonstrates good psychometric properties, a content validity index (CVI) of 0.91, and a Cronbach's  $\alpha$  coefficient of 0.879.

### Head Nurses' Research-Innovation Leadership Scale

This scale was developed by Ma Keke et al<sup>22</sup> to assess head nurses' research-innovation leadership. It comprises five dimensions—foresight, charisma, influence, decisiveness, and control—containing a total of 15 items. Each item is rated on a five-point Likert scale from 0 (almost never) to 4 (always), with a total score range of 0–60. Higher scores reflect stronger research-innovation leadership. The scale has demonstrated excellent validity and reliability. The overall content validity index is 0.923, and a total Cronbach's  $\alpha$  coefficient of 0.976.

## Nurses' Organizational Innovation Climate Scale (NOICS)

The Nurses' Organizational Innovation Climate Scale developed by Qian Yan et al<sup>12</sup> was employed to assess nurses' perception of the innovation climate. The scale includes 21 items across three dimensions: innovation encouragement (7 items), resource availability (6 items), and managerial practices (8 items). A five-point Likert scale is used, ranging from 1 (strongly disagree) to 5 (strongly agree). Higher total scores indicate a more favorable perception of the organizational innovation climate. The scale shows strong reliability and validity, with an overall Cronbach's  $\alpha$  of 0.938.

## Data Collection

Data were collected from clinical nurses via an electronic questionnaire. The research team contacted the nursing departments of the participating hospitals to explain the purpose, significance, and content of the study, and obtained their consent and support. Detailed instructions regarding the questionnaire and guidance on completing it were also provided. The nursing departments distributed the QR code and web link to the electronic questionnaire through head nurses' online group. The head nurses then forwarded the information to nurses in their departments via departmental online group. Nurses completed and submitted the questionnaire directly to the researchers. The first page of the questionnaire included an introduction, instructions for completion, and an informed consent statement. Participants were informed that the survey was anonymous, that only one submission was allowed per IP address, and that all questions were mandatory and single choice. A total of 580 questionnaires were collected, of which 236 were valid, resulting in a valid response rate of 40.7%. The primary reasons for the low response rate are as follows: nurses face heavy workloads and have highly valued time while also being frequently exposed to various surveys, leading to survey fatigue and consequently directly abandoning the survey; additionally, the researchers distributed the questionnaires only once without sending reminders at appropriate times, causing nurses to forget to complete them. The significance of this result lies in the fact that it may cause a certain deviation in the research validity and potentially affect the research conclusion.

## Ethical Considerations

Ethical approval for this study was obtained from the Ethics Committee of the Affiliated Hospital of Hebei University (Approval No. HDFYLL-KY-2024-172).

## Statistical Analysis

All data were securely stored online using encryption technology to ensure data integrity and confidentiality. Statistical analyses were conducted using SPSS version 25.0. Descriptive statistics were used to provide an overview of participant characteristics. Continuous variables were summarized using means and standard deviations, while categorical variables were described using frequencies and percentages. Following descriptive analysis, Pearson correlation analysis was performed to examine the relationships among the three key variables: nurses' innovation behavior, head nurses' research-innovation leadership, and organizational innovation climate. Structural equation modeling (SEM) was conducted using AMOS version 24.0. The model included dimensions of nurses' innovation behavior, head nurses' research-innovation leadership, and organizational innovation climate as observed variables. Path analysis was used to examine the relationships among these variables. The maximum likelihood estimation method was applied to fit and modify the model. The analysis followed four steps: Examining the relationship between the predictor variable (head nurses' research-innovation leadership) and the outcome variable (nurses' innovation behavior). Assessing the relationship between the predictor variable and the mediator (organizational innovation climate). Testing the relationships among the predictor, mediator, and outcome variable. Evaluating the mediating effect of organizational innovation climate based on the results of step three. The Bootstrap method was used to test the significance of the mediating effect, with a significance level set at  $\alpha = 0.05$ . A total of 5,000 bootstrap samples were drawn to estimate the direct and indirect effects of organizational innovation climate on nurses' innovation behavior, along with the 95% confidence interval (CI).

## Results

### Demographic Characteristics of Nurses

A total of 236 clinical nurses were included in the final analysis. Among them, 14 were male (5.9%) and 222 were female (94.1%). The majority of participants were aged 31–40 years ( $n = 123$ , 52.1%). Most nurses held a bachelor's degree ( $n = 227$ , 96.2%) and were married ( $n = 190$ , 80.5%). All participants were employed at tertiary grade-A hospitals. Most were contract-based employees ( $n = 180$ , 76.3%). Additional demographic characteristics are presented in Table 1.

**Table 1** Frequency Distribution of Demographic Variables Among Clinical Nurses ( $n = 236$ )

Variable	Group	Frequency	Percentage
Gender	Male	14	5.90%
	Female	222	94.10%
Age	20–30	43	18.20%
	31–40	123	52.10%
	41+ years	70	29.70%
Education	Associate or below	6	2.50%
	Bachelor	227	96.20%
	Master+	3	1.30%
Marital status	Unmarried	43	18.20%
	Married	190	80.50%
	Divorced	3	1.30%
Employment type	Contract	180	76.30%
	Permanent	55	23.30%
	Dispatched	1	0.40%
Department	Internal Medicine	85	36.00%
	Surgery	74	31.40%
	OB/Peds	12	5.10%
	Emergency	16	6.80%
	Critical Care	20	8.50%
	Other	29	12.30%
Years of work	1–5 years	28	11.90%
	6–10 years	69	29.20%
	11–15 years	58	24.60%
	16–20 years	40	16.90%
	21 years and above	41	17.40%
Title	Nurse	13	5.50%
	Senior Nurse	43	18.20%
	Supervisor	144	61.00%
	Deputy Chief or above	36	15.30%
Monthly income	5000	17	7.20%
	5001–10,000	180	76.30%
	10,001	39	16.50%
Teaching role	Yes	154	65.30%
	No	82	34.70%
Work attitude	Dislike	3	1.30%
	Neutral	104	44.10%
	Like	129	54.70%
Research training	No	132	55.90%
	Yes	104	44.10%
Core journal published	No	203	86.00%
	Yes	33	14.00%

(Continued)

**Table 1** (Continued).

Variable	Group	Frequency	Percentage
Patent application	No	216	91.50%
	Yes	20	8.50%
Research project application	No	217	91.90%
	Yes	19	8.10%
Head Nurse age	30-40 years	59	25.00%
	41+ years	177	75.00%
Head Nurse gender	Male	8	3.40%
	Female	228	96.60%
Head Nurse education	Associate or below	7	3.00%
	Bachelor	202	85.60%
	Master and above	27	11.40%
Head Nurse title	Supervisor	78	33.10%
	Deputy Chief or above	158	66.90%
Head Nurse work experience	5-10 years	6	2.50%
	11-15 years	50	21.20%
	16 years and above	180	76.30%
Head Nurse management experience	<5 years	30	12.70%
	5-10 years	120	50.80%
	11+ years	86	36.40%

## Normality Test and Common Method Bias Test

### Normality Test

A normal distribution of data is a prerequisite for conducting statistical analysis. Skewness and kurtosis were used to examine the normality of the data. According to the criteria proposed, when the absolute value of skewness is less than 2 and the absolute value of kurtosis is less than 10, the data can be considered approximately normally distributed. The analysis results of this study showed that the skewness and kurtosis values of all scales fell within these criteria, indicating that the data approximated a normal distribution. See [Table 2](#).

### Common Method Bias Test

Common method bias refers to systematic errors arising from the same data source, measurement method, or from the wording and contextual characteristics of the questionnaire items themselves.<sup>23</sup> Since the data in this study were mainly collected through self-report questionnaires, the potential issue of common method bias was examined. Harman's single-factor test was conducted, and the results showed that 14 factors had eigenvalues greater than 1. The first factor explained 23.52% of the total variance, which was below the critical threshold of 40%. Therefore, it can be concluded that there was no serious common method bias in this study.

## Scores of Head Nurses' Research-Innovation Leadership, Organizational Innovation Climate, and Nurses' Innovation Behavior

The total score for head nurses' research-innovation leadership was  $55.32 \pm 12.18$ , with an average item score of  $3.69 \pm 0.81$ . Among the dimensions, charisma and influence scored the highest, while foresight scored the lowest

**Table 2** Skewness and Kurtosis Tests of the Scales

Variable Name	Skewness	Kurtosis
Head Nurses' Research-Innovation	-0.396	-0.187
Organizational Innovation Climate	-1.215	2.746
Nurses' Innovation Behavior	-0.593	0.129

(Table 3). The total score for organizational innovation climate among nurses was  $84.35 \pm 11.35$ , with an average item score of  $4.02 \pm 0.54$ . The managerial practices dimension had the highest score, followed by innovation encouragement, and resource availability scored the lowest (Table 4). The total score for nurses' innovation behavior was  $34.65 \pm 6.21$ , with an average item score of  $3.46 \pm 0.62$ . The obtaining support dimension scored the highest, followed by idea generation, with idea implementation scoring the lowest (see Table 5).

### Correlation Analysis Among Nurses' Innovation Behavior, Organizational Innovation Climate, and Head Nurses' Research-Innovation Leadership

Nurses' innovation behavior was positively correlated with both head nurses' research-innovation leadership ( $r = 0.380$ ,  $P < 0.01$ ) and organizational innovation climate ( $r = 0.409$ ,  $P < 0.01$ ). Additionally, head nurses' research-innovation leadership was positively correlated with organizational innovation climate ( $r = 0.358$ ,  $P < 0.01$ ). These findings indicate that all three variables are significantly and positively interrelated, thus confirming Hypothesis 1 (Table 6).

### Mediating Role of Organizational Innovation Climate between Head Nurses' Research-Innovation Leadership and Nurses' Innovation Behavior (SEM)

Based on the results of the correlation analysis, head nurses' research-innovation leadership, organizational innovation climate, and nurses' innovation behavior were all positively correlated. To further explore the relationships among these three variables, a structural equation model (SEM) was constructed to test the mediating effect. Guided by previous literature, AMOS 24.0 was used to build the SEM using the dimensions of the three variables as observed indicators (see Figure 2). Maximum likelihood estimation was applied to estimate and test the parameters of the model. The model fit indices indicated a good model fit, Chi-square/df (CMIN/DF) = 1.423 (<3), Goodness-of-Fit Index (GFI) = 0.956 (>0.9), Normed Fit Index (NFI) = 0.939 (>0.9), Comparative Fit Index (CFI) = 0.981 (>0.9), Incremental Fit Index (IFI) = 0.981 (>0.9). These results demonstrate that the model had a good overall fit.

### Mediating Effect of Organizational Innovation Climate

The Bootstrap method with 5,000 resamples was used to test the mediating role of organizational innovation climate in the relationship between head nurses' research-innovation leadership and nurses' innovation behavior. The results showed that the total effect, direct effect, and indirect effect of head nurses' research-innovation leadership on nurses' innovation behavior were 0.291, 0.205, and 0.086, respectively. The 95% confidence intervals for all effects did not

**Table 3** Scores of Head Nurses' Research-Innovation Leadership (n = 236)

Dimension	Number of Items	Score Range	Total Score (Mean $\pm$ SD)
Total scale	15	0–60	55.32 $\pm$ 12.18
Foresight	3	0–12	11.08 $\pm$ 2.89
Charisma	3	0–12	11.22 $\pm$ 3.12
Influence	3	0–12	11.23 $\pm$ 2.92
Decisiveness	3	0–12	10.69 $\pm$ 3.29
Control	3	0–12	11.10 $\pm$ 2.95

**Table 4** Scores of Organizational Innovation Climate (n = 236)

Dimension	Number of Items	Score Range	Total Score (Mean $\pm$ SD)
Total scale	21	21–105	84.35 $\pm$ 11.35
Innovation encouragement	7	7–35	29.92 $\pm$ 4.15
Resource availability	6	6–30	22.54 $\pm$ 4.69
Managerial practices	8	8–40	31.89 $\pm$ 5.14

**Table 5** Scores of Nurses' Innovation Behavior (n = 236)

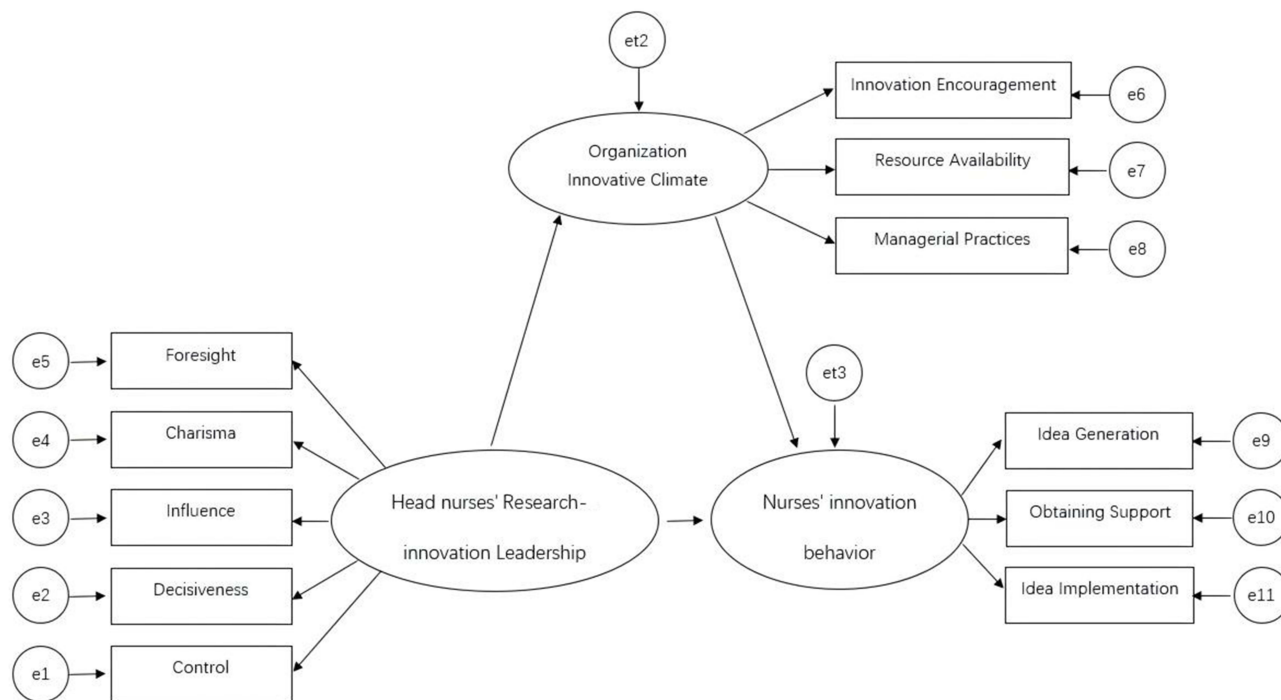
Dimension	Number of Items	Score Range	Total Score (Mean±SD)
Total scale	10	10–50	34.65±6.21
Idea generation	3	3–15	10.98±2.03
Obtaining support	4	4–20	13.51±3.11
Idea implementation	3	3–15	10.16±2.45

**Table 6** Correlation Matrix Among the Three Variables (r Values, n = 236)

Variables	Head Nurses' Research-Innovation Leadership	Nurses' Innovation Behavior	Organizational Innovation Climate
Head Nurses' Research-Innovation Leadership	1		
Nurses' Innovation Behavior	0.380**	1	
Organizational Innovation Climate	0.358**	0.409**	1

Note: \*\*p<0.001.

include zero, indicating that the total, direct, and indirect effects were statistically significant ( $P < 0.001$ ). These findings confirm that organizational innovation climate plays a partial mediating role in this relationship, accounting for 29.6% of the total effect. This supports Hypothesis 2. Detailed results are presented in Table 7.



**Figure 2** Structural Equation Model and Standardized Path Coefficients.

**Table 7** Bootstrap Test of the Mediating Effect of Organizational Innovation Climate

Effect Type	Effect Value	SE	95% CI Lower	95% CI Upper	P	Proportion of Total Effect (%)
Head Nurses' Research-Innovation Leadership→Organizational Innovation Climate→Nurses' Innovation Behavior	0.086	0.025	0.044	0.141	<0.001	29.6%
Head Nurses' Research-Innovation Leadership→Nurses' Innovation Behavior	0.205	0.047	0.112	0.298	<0.001	70.4%
Total effect	0.291	0.046	0.200	0.382	<0.001	100.0%

## Discussion

Although previous studies have shown that head nurses' research-innovation leadership influences nurses' innovative behavior, the mediating role of organizational innovation climate between the two has not been empirically verified. This study is an important contribution as it links head nurses' research-innovation leadership, organizational innovation climate, and nurses' innovative behavior, thereby broadening the understanding of factors influencing nurses' innovation behavior. The findings provide theoretical insights for improving the management of the nursing workforce.

This study using Kendall's sample size estimation method, which recommends a sample size of 5–10 times the number of variables, this may lead to an insufficient and may be a limitation to the study's internal validity.

## Status Quo of Nurses' Innovation Behavior

In this study, the average score for nurses' innovative behavior was  $34.65 \pm 6.21$ , which is lower than the results reported by Zhang Jia et al<sup>24</sup> and Chen Xi et al,<sup>25</sup> but higher than those of Zhangyi Wang,<sup>26</sup> indicating a moderate level. This may be attributed to the fact that the participants were from well-established tertiary grade-A hospitals, where innovative behavior is valued, innovation training seminars are regularly conducted, and incentive mechanisms are implemented to support nurses' innovation. Among the dimensions, idea generation scored the highest, while idea implementation scored the lowest. This suggests that nurses are capable of independent thinking and can identify innovative ideas when facing clinical challenges, yet may struggle to convert these ideas into actual practice. Several factors may explain this gap. First, some clinical nurses may have relatively low levels of formal education, limited theoretical and research knowledge, and lack systematic training in research inquiry, resulting in weak awareness and capacity for innovation. Second, the heavy workload and limited time and energy available in clinical practice,<sup>27</sup> coupled with insufficient communication with senior staff, may reduce their ability to take initiative and effectively implement innovative activities.<sup>14</sup> Third, nurses may be cautious about whether implementing innovative ideas could negatively impact patients, which can ultimately hinder the execution of those innovations. To address these issues, it is recommended that head nurses and nursing administrators actively respond to the national call to promote innovation in nursing. Cultivating innovative behavior should be considered a vital component of nurses' professional development. Administrators should provide support in terms of information, time, and funding, create a favorable organizational innovation climate, and fully mobilize nurses' enthusiasm and initiative for innovation.

## Status Quo of Head Nurses' Research-Innovation Leadership

In this study, the score for head nurses' research-innovation leadership was  $55.32 \pm 12.18$ , which was higher than the findings reported by Xiang Dan<sup>28</sup> and Huang Hualing,<sup>29</sup> and indicates a slightly above-average level. This may be related to the fact that hospital administrators place a strong emphasis on cultivating research-innovation leadership among head nurses and recognize the influence of head nurses' individual scientific and innovative capacities on the innovative behavior of their subordinate nurses. Among the five dimensions, charisma had the highest score, while decisiveness had the lowest. This pattern may reflect several factors. Head nurses may have adequate time and energy to engage in research and innovation, especially when under pressure to meet professional promotion requirements, which could lead to higher research productivity. In addition, head nurses may inspire and guide nurses by creating a research-oriented atmosphere through their own innovative actions and enthusiasm.<sup>8</sup> However, hospital leadership and head nurses may not

always provide sufficient time, personnel, or funding in routine work to support the realization of nurses' innovative behavior. To address this, hospital administrators should strengthen training programs aimed at improving head nurses' research-innovation leadership and continue refining current incentive mechanisms for research innovation. At the same time, head nurses should be encouraged to enhance communication and mentorship in daily practice, with greater attention paid to developing nurses' research and innovation competencies. This may help expand access to funding resources and further enhance nurses' perception of their head nurses' leadership in research innovation, ultimately promoting the advancement of nursing research.<sup>30</sup>

## Status Quo of Organizational Innovation Climate Among Nurses

In this study, the total score for nurses' perceived organizational innovation climate was  $84.35 \pm 11.35$ . This score is lower than that reported by Lv M et al<sup>31</sup> but higher than that found by Zhangyi Wang et al,<sup>26</sup> indicating a relatively favorable innovation climate in the study sample. Among the dimensions, managerial practices scored the highest, while resource availability scored the lowest. This suggests that nursing managers have valued nurses' willingness to participate in management, and provide active and effective guidance. As a result, nurses are more willing to engage in innovation behavior. However, greater policy and institutional support for nursing innovation is still needed from hospitals and their leadership. Prior studies have shown that a positive organizational innovation climate enhances nurses' access to support and recognition from leadership, which in turn facilitates innovation behavior. Therefore, nursing administrators should strive to foster a strong organizational innovation climate, cultivate nurses' innovation awareness, and intensify innovation-related training to improve their capabilities. They should also encourage participation in both intra- and extra-institutional innovation initiatives, thereby stimulating enthusiasm and providing robust support for nurses to implement innovation.<sup>14</sup>

## Correlation Between Nurses' Innovation Behavior, Head Nurses' Research-Innovation Leadership, and Organizational Innovation Climate

The results of this study indicated that the total score and subdimension scores of nurses' innovation behavior were positively correlated with head nurses' research-innovation leadership ( $P < 0.01$ ), consistent with the findings of Xiang Dan et al.<sup>28</sup> As direct supervisors of clinical nurses, head nurses play a critical role in guiding innovation. Their leadership in research and innovation exerts a direct and promotive effect on nurses' innovation behavior. The stronger the head nurses' research-innovation leadership, the more frequent the nurses' innovation behaviors. In addition, the total and subdimension scores of nurses' innovation behavior were positively correlated with organizational innovation climate ( $P < 0.01$ ), which aligns with previous studies by Lv M et al<sup>31</sup> and Zhangyi Wang et al.<sup>26</sup> This suggests that the stronger the perceived innovation climate within the organization, the higher the level of innovation behavior among nurses. This may be because a supportive innovation climate provides favorable external conditions for innovation. A positive innovation climate stimulates nurses' enthusiasm and initiative while also offering more opportunities to explore and implement innovative practices.<sup>32</sup> Support from nursing administrators helps nurses transform innovative ideas into actions.

## Organizational Innovation Climate as a Partial Mediator Between Head Nurses' Research-Innovation Leadership and Nurses' Innovative Behavior

The results of this study revealed that organizational innovation climate plays a partial mediating role in the relationship between head nurses' research-innovation leadership and nurses' innovation behavior, accounting for 29.6% of the total effect. Head nurses' research-innovation leadership significantly predicted both nurses' innovation behavior and the organizational innovation climate. This indicates that such leadership influences nurses' innovation behavior both directly and indirectly through its impact on the innovation climate. As noted in prior research,<sup>31</sup> organizational innovation climate is an essential factor that supports nurses in carrying out innovative activities. Since innovation is a complex, multi-stage process, it is necessary not only to enhance nurses' perception of leadership in research and innovation but also to ensure adequate organizational support to secure the implementation of innovation behavior. Therefore, nursing

administrators should strengthen their influence within the nursing workforce in terms of research and innovation, develop effective incentive policies, and allocate sufficient human, material, and financial resources. In addition, efforts should be made to acquire external organizational support, creating favorable conditions that fully mobilize nurses' innovative potential and enhance their innovation behavior.

Based on spatial theory, this study introduces head nurses' research-innovation leadership and organizational innovation climate into the investigation of nurses' innovative behavior for the first time, exploring the underlying mechanisms among these three factors and verifying the mediating role of organizational innovation climate. According to the theoretical findings of this study, hospital administrators should emphasize the promotion of the nursing innovation philosophy and incorporate the cultivation of innovative behavior into nurses' career development plans, hospitals could develop a series of training courses aimed at improving leadership in nursing research in the future and consider incorporating research and innovation as key criteria in the selection criteria for head nurses.

## Limitations

This study has several limitations. First, as an online-based survey, the sampling process and reliance on self-reported data may have introduced certain biases and the risk of social desirability bias, nurses may overrate their innovation behavior. Second, the survey was conducted exclusively among clinical nurses from four tertiary grade-A hospitals in Hebei Province, which may limit the generalizability of the findings to broader populations. Third, the low response rate of the questionnaire survey in this study may, to some extent, affect the validity of the research, as well as the representativeness and generalizability of the findings. Fourth, the correlation between the head nurses cohort and the survey completion rate is not yet established. Last, the cross-sectional design of the study restricts the ability to draw causal inferences from the results. To enhance generalizability, future research should expand to adopt a mixed-methods approach, integrating quantitative data with qualitative insights to gain a more comprehensive understanding. Expanding the study to include diverse geographical regions and healthcare settings – particularly through multi-center research and larger sample sizes—may help validate and enhance the generalizability and robustness of the findings.

## Conclusion

The findings of this study indicate that the head nurses' research-innovation leadership, organizational innovation climate, and the nurses' innovation behavior were all at a moderate level and require further enhancement. Both head nurses' research-innovation leadership and organizational innovation climate were found to be significant predictors of nurses' innovation behavior, with all three variables positively correlated with one another. The structural equation modeling analysis confirmed that organizational innovation climate plays a mediating role in the relationship between the head nurses' research-innovation leadership and nurses' innovation behavior, but this effect is not absolutely dominant; the head nurses' research-innovation leadership may also function through other unmeasured pathways, either directly or indirectly. This precisely indicates that nurses' innovative behavior is a complex phenomenon driven by multiple factors. The presence of other influences is not only logical but also guides us toward a more holistic understanding. Based on these findings, it is recommended that nursing administrators develop targeted interventions to leverage head nurses' research-innovation leadership, foster a positive organizational innovation climate, and provide strong support for nurses to carry out innovative practices in clinical settings. As the sample in this study was limited to tertiary grade-A hospitals in a single province, future studies should involve hospitals of different levels and from various regions to conduct multi-center research. Expanding the sample size may help further validate the reliability and generalizability of the results.

## Data Sharing Statement

Data can be obtained from corresponding author for acceptable reasons. Data availability: The data that support the findings of this study are available from the corresponding authors upon reasonable request. Data can be obtained from Cong Fu (63194643@qq.com), who was responsible for the clinical coordination and data collection. Requests for data concerning the statistical analysis and validation should be directed to Xiaoping Yin (hdfyrad@hbu.edu.cn), who oversaw the data analytical processes.

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## Author Contributions

Kaihua Liu and Jing Ma contributed equally to this work and should be considered as co-first authors. Xiaoping Yin and Cong Fu contributed equally to this work and should be considered as co-corresponding authors. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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## Disclosure

The authors report no conflicts of interest in this work.

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