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Current status and predictors of innovative-behavior profiles among clinical nurses: A latent profile analysis study

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Current status and predictors of innovative-behavior profiles among clinical nurses: A latent profile analysis study

Abstract Background: Innovation is critical for advancing nursing services under the Healthy China 2030 initiative. Existing studies mostly treat clinical nurses as a homogeneous group when exploring innovative behavior, ignoring inter-individual heterogeneity. Latent profile analysis (LPA) offers a person-centered approach to identify distinct subgroups of nurses based on their innovative-behavior patterns.

Aim: To investigate the current status of innovative behavior among Chinese clinical nurses, identify heterogeneous latent profiles of innovative behavior, and examine predictors of profile membership so as to inform targeted intervention strategies.

Methods: A convenience-sampling cross-sectional survey was conducted in September 2026. A total of 540 clinical nurses completed questionnaires including a general-information form, the Nurses' Innovative Behavior Scale, the Job Crafting Scale, and the Authentic Leadership Scale. Latent profile analysis was performed to classify nurses by their innovative-behavior patterns. One-way analysis and multinomial logistic regression were applied to test differences across latent profiles.

Results: Among 540 participating nurses, three distinct latent profiles of innovative behavior were identified: moderate-level innovative-behavior group (48.52%), high-level innovative-behavior group (25.56%), and low-level innovative-behavior group (25.92%). Job-crafting scores significantly predicted profile membership across comparisons (all $P<0.001$), whereas authentic leadership showed only marginal associations. Using the low-level profile as the reference group, higher job-crafting scores significantly raised the odds of membership in the high-level group (OR = 1.100, 95 % CI 1.074-1.126) and the moderate-level group (OR = 1.268, 95 % CI 1.223-1.315), with the largest estimate observed for the moderate-innovative-behavior subgroup. When the moderate-level profile served as the reference group, higher job-crafting scores significantly decreased the odds of belonging to the high-level profile (OR = 0.867, 95 % CI 0.843-0.892, $P < 0.001$). Although authentic leadership reached statistical significance in the high- versus low-level comparison, its odds ratio was close to 1 (OR = 1.014, 95 % CI 1.005-1.023) and the association was not

significant in the other two contrasts, indicating an effect of negligible practical value; authentic leadership is therefore not a promising target for distinguishing moderate- from high-level innovative-behavior nurses.

Conclusions and Implications for Nursing Management: This person-centered analysis identified three heterogeneous subgroups of nurses according to innovative-behavior levels. Job crafting acted as the core modifiable factor promoting innovative-behavior progression. Authentic leadership showed only marginal associations of negligible practical magnitude and cannot serve as a primary intervention target. Work years failed to predict profile membership. Nursing managers may implement differentiated talent-development measures targeting low-, moderate-, and high-innovative-behavior subgroups, with job-crafting-oriented training as a foundational intervention to foster nursing innovation.

Keywords: Nurses; innovative behavior; latent profile analysis; influencing factors

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1 Introduction

In the shared-economy era, innovation fuels national prosperity and continuous social progress. China delivers an enormous volume of health-care services; medical institutions recorded more than 8.4 billion patient visits in 2021 [1]. Demographic shifts have complicated public health demands: the aging population sharply increases nursing-service requirements, and the growing number of patients with chronic conditions calls for long-term continuous nursing care. The national Healthy China 2030 Plan Outline highlights medical innovation as a critical pillar for improving population health [2]. Information technology, mobile communication, and artificial intelligence create new opportunities for nursing innovation and reshape the scope, standards, and workflows of nursing services.

The National Nursing Development Plan (2021-2025) stresses the need to reform nursing services, innovate nursing management and service models, and satisfy public expectations for nursing care[3]. Therefore, innovative development has become an inevitable trend for the nursing discipline.

Nursing is a cornerstone of the health-care system and closely linked to patient safety and well-being[4]. Prior studies[5-8] demonstrate that nursing innovation optimizes clinical workflows and efficiency, promotes professional development, strengthens team communication and cohesion, and helps allocate limited human resources amid workforce shortages. Innovative nursing behaviors also satisfy nurses' self-actualization needs, improve care quality and treatment outcomes, and reduce complication rates[9,10]. It is therefore essential to understand nurses' innovative behavior and its antecedents to support managerial efforts to boost nursing innovation.

Existing domestic and international research indicates that nurses' innovative-behavior levels are generally suboptimal and require further improvement [11]. Individual-level predictors include demographic characteristics as well as dispositional traits: proactive personality[12] and core self-evaluation[13] correlate positively with innovative work behavior. Competency-related factors including information literacy, evidence-based-nursing capacity, and self-directed learning also

predict innovative behavior[14]. Intrinsic motivation serves as a key driver of innovative performance [15]. At the organizational level, organizational climate [16], practice environment[17], person-organization fit[18], and job autonomy[19] influence nurses' creativity, and leadership styles have attracted substantial research attention.

Nurses' innovative behavior is shaped by complex interactions between individual attributes and organizational contexts[20]. Most previous investigations adopt a variable-centered approach that treats nurses as a homogeneous population, overlooking potential inter-individual heterogeneity in innovative-behavior patterns [21,22]. Latent profile analysis (LPA) is a person-centered statistical technique that identifies unobserved subgroups according to individuals' response patterns on observed indicators[23,24]. This study applied LPA to clinical nurses' innovative-behavior data to move beyond traditional mean-based analytical frameworks and reveal heterogeneous innovation profiles, providing evidence for differentiated department-level innovation management.

2 Methods

2.1 Participants

A convenience-sampling cross-sectional survey was performed in September 2026 at one tertiary-A hospital in Shandong Province, China. Sample-size recommendations for latent profile analysis suggest that each latent subgroup should contain at least 50 participants. We expected to identify 3-4 subgroups; assuming four subgroups of 50 participants and allowing for a 20 % rate of invalid questionnaires, a minimum of 250 valid questionnaires was required. To ensure an adequate sample for model stability, 600 nurses were invited and 540 valid questionnaires were collected, meeting the sample-size requirements for latent profile analysis. Inclusion criteria: (1) Valid nursing practice license; (2) informed consent and voluntary participation. Exclusion criteria: Nurses unavailable to complete questionnaires due to leave, off-site training, or other reasons.

2.2 Instruments

2.2.1 General-information questionnaire

A self-designed questionnaire collecting demographic and work-related

information: sex, age, marital status, professional title, work years, education level, department, monthly night-shift frequency, employment type, and salary.

2.2.2 Nurses' Innovative Behavior Scale

Developed by Bao et al.[25] using literature review and semi-structured interviews, this scale assesses nurses' innovative-behavior performance. It contains 10 items across three dimensions: idea generation (items 1-3), idea promotion (items 4-7), and idea realization (items 8-10). Responses use a 5-point Likert scale ranging from 1 (never) to 5 (very frequently). Total scores range 10-50; higher scores indicate stronger innovative behavior. The scale has been widely used among Chinese nurses. In the original scale-development study, the total content-validity index (CVI) was 0.91, dimension-level CVI values ranged from 0.88 to 0.95, the overall Cronbach's α coefficient was 0.879, and dimension-level α values were 0.746-0.870. In the present sample, the Cronbach's α coefficient of the total scale was 0.905.

2.2.3 Job Crafting Scale

Originally developed by Dvorak[26] based on the theoretical framework proposed by Wrzesniewski and Dutton[27]. This 21-item instrument measures employee job-crafting behaviors across task crafting (items 1-7), cognitive crafting (items 8-14), and relational crafting (items 15-21). Responses use a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Total scores range from 21 to 105; higher scores reflect greater job-crafting engagement. In the original scale-development study, Cronbach's α was 0.91 for the full scale and 0.84-0.89 for the sub-dimensions; in the present sample, Cronbach's α for the full scale was 0.949. To place the three study scales on a common metric, job-crafting scores were expressed as item-level mean scores (total score divided by the number of items; possible range 1-5), and these item-mean scores were used as continuous variables in the latent-profile analysis, the one-way comparisons, and the multinomial logistic regression. For descriptive completeness, the original total scores are also reported in Table 2.

2.2.4 Authentic Leadership Scale

Originally created by Walumbwa et al. [28]; the Chinese revised version was translated and validated by Han et al. [29]. This 16-item scale measures subordinates'

perceptions of supervisors' authentic-leadership behaviors, covering four dimensions: relational transparency (5 items), internalized moral perspective (4 items), balanced processing (3 items), and self-awareness (4 items). Responses adopt a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Higher scores indicate higher perceived authentic-leadership levels. Previous nursing research using this scale reported Cronbach's α = 0.850 [30]. In the present sample, Cronbach's α for the total scale was 0.865.

2.3 Data collection

Electronic questionnaires were distributed via WeChat groups using Questionnaire Star. Before filling out the form, nurses read a written explanation of the study purpose, requirements, and participant rights, and indicated their consent by proceeding to complete the anonymous questionnaire (implied informed consent); no identifiable information was collected. Questionnaire-platform settings enforced mandatory responses and restricted duplicate submissions to avoid missing data and repeated entries. No questionnaire could be submitted until all items were completed. This study was approved by the Institutional Review Board of Jining Medical University (Ethics No.2026-08-C023). Implied informed consent was obtained when participants voluntarily filled out the anonymous electronic questionnaire. All participants were informed that participation was voluntary and all data would be processed anonymously for research purposes only.

2.4 Statistical analysis

Mplus 8.3 software was used for latent profile analysis. Latent profile models with 1-4 classes were fitted and compared, and Models with 1-4 latent profiles were fitted sequentially [31]. Model-fit evaluation indicators included log-likelihood value Log(L), Akaike information criterion (AIC), Bayesian information criterion (BIC), sample-adjusted Bayesian information criterion (aBIC); smaller values represent better model fit. Entropy evaluates classification precision, with values closer to 1 indicating higher accuracy (entropy ≥ 0.8 suggests > 90 % classification accuracy). The Lo-Mendell-Rubin adjusted likelihood-ratio test (LMR-LRT) and bootstrap likelihood-ratio test (BLRT) compare relative fit between k-class and (k-1)-class

models; significant P values indicate that the k-class model is superior. Latent profile analysis was conducted using the three sub-dimension composite scores of the Nurses' Innovative Behavior Scale as observed indicators (not individual raw items). Average posterior class-membership probabilities were calculated to evaluate classification accuracy.

SPSS 27.0 was used for remaining statistical analyses. Categorical variables were described using frequencies and percentages and compared with the χ^2 test; all categorical variables in Table 1 were compared with the χ^2 test. Continuous variables were summarized as mean ± standard deviation and compared by one-way analysis of variance (ANOVA). Multinomial logistic regression was applied to evaluate predictors of latent-profile membership. A two-tailed $P < 0.05$ was considered statistically significant.

3 Results

3.1 Participants' general characteristics

A total of 600 nurses were invited. After excluding questionnaires with patterned or illogical responses and applying the questionnaire platform's duplicate-submission restriction, 540 valid questionnaires were retained, giving an effective response rate of 90.0 % (540/600). Demographic and profile-distribution information is shown in Table 1.

Table 1 General characteristics of participants and one-way comparisons across three latent profiles of innovative behavior [n = 540, n (%)]

Item		**Total (N = 540)**	**Low-level innovative-behavior (n = 140)**	**Moderate-level innovative-behavior (n = 262)**	**High-level innovative-behavior (n = 138)**	**Test statistic**	***P*-value**
Sex	Male	112 (20.7)	34 (30.40)	51 (45.50)	27 (24.10)	$\chi^2 = 1.714$	0.424
	Female	428 (79.3)	104 (24.30)	211 (49.30)	113 (26.40)		
Age	< 25 y	44 (8.1)	12 (27.30)	21 (47.70)	11 (25.00)	*$\chi^2 = 12.632$*	0.125
	26-30 y	120 (22.2)	33 (27.50)	49 (40.80)	38 (31.70)		
	31-35 y	116 (21.5)	37 (31.90)	61 (52.60)	18 (15.50)		
	36-40 y	180 (33.3)	39 (21.70)	90 (50.00)	51 (28.30)		
	≥ 41 y	80 (14.8)	17 (21.30)	41 (51.20)	22 (27.50)		
Marital status	Married	421 (78.0)	107 (25.40)	207 (49.20)	107 (25.40)	$\chi^2 = 3.584$	0.465
	Unmarried	112 (20.70)	28 (25.00)	51 (45.50)	33 (29.50)		
	Divorced/widowed	7 (1.30)	3 (42.90)	4 (57.10)	0 (0.00)		

Item		Total (N = 540)	Low-level innovative-behavior (n = 140)	Moderate-level innovative-behavior (n = 262)	High-level innovative-behavior (n = 138)	Test statistic	*P*-value
Professional title	Staff nurse	56 (10.4)	13 (23.20)	32 (57.10)	11 (19.60)	$\chi^2 = 8.809$	0.185
	Nurse practitioner	136 (25.2)	42 (30.90)	52 (38.20)	42 (30.90)		
	Associate chief nurse	301 (55.7)	72 (23.90)	155 (51.50)	74 (24.60)		
	Deputy chief nurse or above	47 (8.7)	11 (23.40)	23 (48.90)	13 (27.70)		
Work years	< 5 y	134 (24.8)	35 (26.10)	57 (42.50)	42 (31.30)	*$\chi^2 = 12.389$*	0.135
	6-10 y	104 (19.3)	28 (26.90)	55 (52.90)	21 (20.20)		
	11-15 y	171 (31.7)	45 (26.30)	91 (53.20)	35 (20.50)		
	16-20 y	90 (16.7)	17 (18.90)	44 (48.90)	29 (32.20)		
	≥ 21 y	41 (7.6)	13 (31.70)	15 (36.60)	13 (31.70)		
Education	Junior college or	26 (4.8)	8 (30.80)	10 (38.50)	8 (30.80)	$\chi^2 = 3.302$	0.509

Item		Total (N = 540)	Low-level innovative-behavior (n = 140)	Moderate-level innovative-behavior (n = 262)	High-level innovative-behavior (n = 138)	Test statistic	*P*-value
	below						
	Bachelor's degree	506 (93.7)	129 (25.50)	246 (48.60)	131 (25.90)		
	Graduate or above	8 (1.5)	1 (12.50)	6 (75.00)	1 (12.50)		
Department	Internal medicine	211 (39.1)	57 (27.00)	99 (46.90)	55 (26.10)	$\chi^2 = 18.716$	0.176
	Surgery	65 (12.0)	14 (21.50)	31 (47.70)	20 (30.80)		
	Obstetrics-gynecology	12 (2.2)	2 (16.70)	7 (58.30)	3 (25.00)		
	Pediatrics	24 (4.4)	3 (12.50)	9 (37.50)	12 (50.00)		
	Emergency department	30 (5.6)	9 (30.00)	17 (56.70)	4 (13.30)		
	ICU	86 (15.9)	27 (31.40)	38 (44.20)	21 (24.40)		

Item		Total (N = 540)	Low-level innovative-behavior (n = 140)	Moderate-level innovative-behavior (n = 262)	High-level innovative-behavior (n = 138)	Test statistic	*P*-value
	Operating room	36 (6.7)	6 (16.70)	18 (50.00)	12 (33.30)		
	Other departments	76 (14.1)	20 (26.30)	43 (56.60)	13 (17.10)		
Monthly night shifts	< 6/month	255 (47.2)	60 (23.50)	126 (49.40)	69 (27.10)	$\chi^2 = 1.095$	0.578
	> 6/month	285 (52.8)	78 (27.40)	136 (47.70)	71 (24.90)		
Employment type	Permanent position	65 (12.0)	15 (23.10)	34 (52.30)	16 (24.60)	$\chi^2 = 0.571$	0.966
	Contract	136 (25.2)	36 (26.50)	66 (48.50)	34 (25.00)		
	Personnel agency	339 (62.8)	87 (25.70)	162 (47.80)	90 (26.50)		
Monthly salary	< 3000 CNY	14 (2.6)	4 (28.60)	5 (35.70)	5 (35.70)	$\chi^2 = 1.845$	0.985
	3000-5000 CNY	95 (17.6)	27 (28.40)	45 (47.40)	23 (24.20)		
	5000-10000 CNY	286 (53.0)	69 (24.10)	142 (49.70)	75 (26.20)		

Item		Total (N = 540)	Low-level innovative-behavior (n = 140)	Moderate-level innovative-behavior (n = 262)	High-level innovative-behavior (n = 138)	Test statistic	*P*-value
	10000-15000 CNY	133 (24.6)	35 (26.30)	64 (48.10)	34 (25.60)		
	> 15000 CNY	12 (2.2)	3 (25.00)	6 (50.00)	3 (25.00)		
Job crafting (item mean)		7.56 ± 1.757	6.1 ± 1.604	7.48 ± 1.292	9.15 ± 1.275	$F = 171.918$	$P < 0.001$
Task crafting (item mean)		7.21 ± 1.888	5.83 ± 1.647	7.11 ± 1.455	8.75 ± 1.693	$F = 121.54$	$P < 0.001$
Cognitive crafting (item mean)		7.58 ± 1.696	6.25 ± 1.44	7.48 ± 1.309	9.07 ± 1.371	$F = 150.633$	$P < 0.001$
Relational crafting (item mean)		7.88 ± 1.664	6.57 ± 1.598	7.84 ± 1.322	9.26 ± 1.136	$F = 138.284$	$P < 0.001$
Authentic		8.36 ± 1.835	7.25 ± 2.208	8.45 ± 1.525	9.31 ± 1.319	$F = 52.922$	$P < 0.001$

Item		Total (N = 540)	Low-level innovative-behavior (n = 140)	Moderate-level innovative-behavior (n = 262)	High-level innovative-behavior (n = 138)	Test statistic	*P*-value
leadership (item mean)							
Relational transparency (item mean)		8.26 ± 1.839	7.13 ± 2.12	8.29 ± 1.548	9.33 ± 1.327	$F = 60.729$	$P < 0.001$
Internalized moral perspective (item mean)		8.00 ± 1.806	6.95 ± 2.09	8.04 ± 1.541	8.96 ± 1.359	$F = 51.497$	$P < 0.001$
Balanced processing (item mean)		8.03 ± 1.886	6.89 ± 2.088	8.01 ± 1.632	9.19 ± 1.365	$F = 63.342$	$P < 0.001$
Self-awareness (item mean)		8.10 ± 1.873	7.05 ± 2.059	8.16 ± 1.694	9.02 ± 1.442	$F = 45.072$	$P < 0.001$

Notes: Values are n (%) for categorical variables (column percentages within each latent profile are given in the profile columns) and mean ± SD for

continuous variables. The three latent profiles are ordered as low-, moderate-, and high-level innovative behavior. Job-crafting and authentic-leadership values are item-level mean scores (possible range 1-5), with higher values indicating higher levels. F statistics are from one-way analysis of variance and χ^2 statistics from Pearson's χ^2 test; a few expected cell counts in the marital-status, education, salary, and department rows were below 5, so those χ^2 results should be interpreted with caution.

Among the 540 participants, the total score for nurses' innovative behavior was 36.96 ± 7.48 (item-level mean 3.70 ± 0.75), indicating an overall moderate-to-upper level of innovative performance. Detailed scale and sub-dimension scores are presented in Table 2.

Table 2 Descriptive statistics for nurses' innovative behavior, job crafting, and authentic-leadership scales

Item	Possible range	Observed range	Mean ± SD
Innovative behavior, total score (10 items)	10-50	11-50	36.96 ± 7.48
Idea generation (item mean)	1-5	1.00–5.00	2.49 ± 0.56
Idea promotion (item mean)	1-5	1.00–5.00	1.77 ± 0.47
Idea realization (item mean)	1-5	1.00–5.00	2.47 ± 0.59
Job crafting, total score (21 items)	21-105	24-105	78.12 ± 15.22
Job crafting (item mean)	1-5	1.14–5.00	3.72 ± 0.72
Task crafting (item mean)	1-5	1.00–5.00	1.03 ± 0.27
Cognitive crafting (item mean)	1-5	1.00–5.00	1.08 ± 0.24
Relational crafting (item mean)	1-5	1.00–5.00	1.13 ± 0.24
Authentic leadership, total score (16 items)	16-80	18-80	64.90 ± 13.09
Authentic leadership (item mean)	1-5	1.13–5.00	4.06 ± 0.82
Relational transparency (item mean)	1-5	1.00–5.00	1.65 ± 0.37
Internalized moral perspective (item mean)	1-5	1.00–5.00	2.00 ± 0.45
Balanced processing (item mean)	1-5	1.00–5.00	2.01 ± 0.47
Self-awareness (item mean)	1-5	1.00–5.00	2.03 ± 0.47

Notes: Item-mean scores were obtained by dividing the total or subscale score by the number of items and were used as continuous variables in the latent-profile analysis, the one-way comparisons, and the multinomial logistic regression. Observed ranges are given for the original summed scores and for the item-mean scores; the observed minima of the item-mean subscales correspond to the theoretical floor of each subscale. SD = standard deviation.

3.3 Latent-profile analysis and profile naming

Latent-profile models with 1-4 classes were fitted using the three sub-dimensions of innovative behavior as observed indicators. Fit statistics are shown in Table 3. AIC, BIC, and aBIC values continued to decrease as the number of classes increased, and entropy exceeded 0.80 for all solutions with two or more classes (0.891, 0.921, and 0.973 for the 2-, 3-, and 4-class solutions, respectively). For the 3-class solution, both the LMR-LRT (P = 0.0011) and the BLRT (P < 0.001) were statistically significant, and the smallest class comprised 25.6 % of the sample; in contrast, for the 4-class solution neither the LMR-LRT (P = 0.3652) nor the BLRT (P = 0.361) was significant and the smallest class contained only 6.9 % of participants. Balancing statistical criteria, model parsimony, and substantive interpretability, the 3-profile model was therefore selected as optimal. Average posterior probabilities for each latent class exceeded 90 %, indicating satisfactory classification accuracy.

Based on sub-dimension mean scores, the three profiles were labeled:

1. Moderate-level innovative-behavior profile (48.52 %): moderate scores across all innovative-behavior dimensions;

2. High-level innovative-behavior profile (25.56 %): consistently high scores across all dimensions;

3. Low-level innovative-behavior profile (25.92 %): consistently low scores across all dimensions.

Profile patterns are visualized in Figure 1. Consistent with the present findings, a recent latent-profile study of oncology nurses also identified three subgroups differing in innovative-behavior levels, although the proportions of the subgroups varied across settings.

Table 3 Model-fit indices for latent-profile analysis of nurses' innovative-behavior

Model	**Log-likelihood**	**AIC**	**BIC**	**aBIC**	**Entropy**	**LMR *P***	**BLRT *P***	**Class probabilities**
1-class	−7518.804	15077.608	15163.439	15099.952	—	—	—	—

Model	Log-likelihood	AIC	BIC	aBIC	Entropy	LMR *P*	BLRT *P*	Class probabilities
2-class	−6571.805	13205.611	13338.650	13240.244	0.891	< 0.001	< 0.001	0.402 / 0.598
3-class	−6157.317	12398.634	12578.880	12445.557	0.921	0.0011	< 0.001	0.256 / 0.485 / 0.259
4-class	−5925.633	11957.266	12184.719	12016.478	0.973	0.3652	0.361	0.069 / 0.278 / 0.407 / 0.246

Notes: AIC = Akaike information criterion; BIC = Bayesian information criterion; aBIC = adjusted Bayesian information criterion; LMR = Lo-Mendell-Rubin likelihood-ratio test; BLRT = bootstrap likelihood-ratio test.

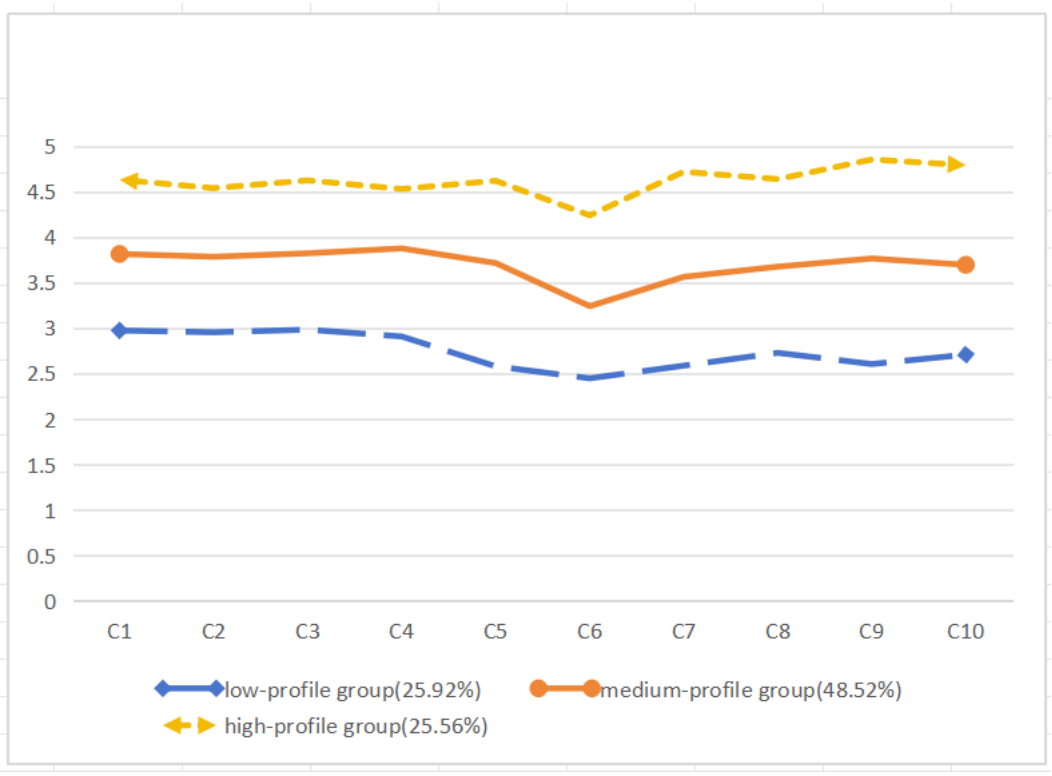


Figure 1 Latent-profile analysis of nurses' innovative behavior (n = 540). The three latent profiles are labelled according to their level of innovative behavior; the profile indicators are the three sub-dimension mean scores of the Nurses' Innovative Behavior Scale.

3.4 Predictors of latent-profile membership

One-way comparisons revealed significant inter-profile differences for job-crafting scores and authentic-leadership scores (both $P < 0.001$); none of the categorical characteristics, including work years ($\chi^2 = 12.389$, $P = 0.135$), differed significantly across profiles (Table 1). Job crafting, authentic leadership, and work years were entered into the multinomial logistic regression as predictors. The low-level innovative-behavior profile was set as the reference group. Item-mean scores were used for job crafting and authentic leadership, and work years was entered as a continuous variable coded from the midpoints of its five categories.

Multinomial-logistic-regression outputs are summarized in Table 4. Work years showed no significant predictive effect in any pairwise profile comparison (all $P > 0.05$). Job-crafting scores predicted profile membership in all comparisons (all $P < 0.001$). Using the low-level profile as the reference, each 1-point increase in the job-crafting item-mean score raised the odds of membership in the high-level group (OR = 1.100, 95 % CI 1.074-1.126) and in the moderate-level group (OR = 1.268, 95 % CI 1.223-1.316); the estimated effect was slightly larger for the moderate- than for the high-level contrast. When the moderate-level profile served as the reference, higher job-crafting scores were associated with lower odds of belonging to the high-level profile (OR = 0.867, 95 % CI 0.843-0.892, $P < 0.001$). Authentic leadership showed a statistically detectable but practically trivial association with profile membership in the high- versus low-level contrast (OR = 1.014, 95 % CI 1.005-1.023, $P = 0.002$); the association was not significant in the moderate- versus low-level contrast (OR = 1.016, 95 % CI 0.995-1.038, $P = 0.141$) or in the moderate- versus high-level contrast (OR = 0.996, 95 % CI 0.977-1.016, $P = 0.689$). The magnitude of these estimates indicates that authentic leadership has little practical value for differentiating moderate- from high-innovative-behavior nurses.

Table 4 Multinomial logistic regression predicting latent profiles of nurses' innovative-behavior (n = 540)

Variable	β	SE	Wald χ^2	*P*	OR	95 % CI lower
High-level vs Low-level						
Intercept	−6.623	1.045	40.168	< 0.001	—	—
Authentic leadership	0.014	0.0045	9.537	0.002	1.014	1.011–1.029
Job crafting	0.095	0.0118	65.671	< 0.001	1.099	1.074–1.125
Work years	−0.068	0.096	0.505	0.477	0.934	0.773–1.128
Moderate-level vs Low-level						
Intercept	−19.513	1.742	125.473	< 0.001	—	—
Authentic leadership	0.016	0.0108	2.150	0.143	1.016	0.992–1.035
Job crafting	0.238	0.0185	167.160	< 0.001	1.268	1.223–1.315
Work years	−0.188	0.138	1.866	0.172	0.828	0.632–1.085
High-level vs Moderate-level						
Intercept	12.890	1.432	81.025	< 0.001	—	—
Authentic leadership	−0.004	0.0100	0.161	0.688	0.996	0.976–1.015
Job crafting	−0.143	0.0141	100.310	< 0.001	0.867	0.843–0.891
Work years	0.120	0.109	1.207	0.272	1.127	0.910–1.396

Notes: The low-level innovative-behavior profile served as the reference category. Job

crafting and authentic leadership were entered as item-mean scores (range 1-5) and work years as a continuous variable. β = regression coefficient; SE = standard error; OR = odds ratio; CI = confidence interval. Every column is derived from the estimated coefficients: OR = exp(β), 95 % CI = exp(β ± 1.96 SE), Wald $\chi^2 = (\beta/SE)^2$ with 1 df, and P is the corresponding two-sided probability; P values below 0.05 are shown in bold.

4 Discussion

4.1 Overall status of nurses' innovative behavior

The mean total score for nurses' innovative behavior in this sample was 36.96 ± 7.48, corresponding to a moderate overall level and slightly higher than findings reported in several domestic studies[32-34]. Possible explanations include national-level advocacy for innovation and hospital-manager efforts to promote innovation-related training and education for clinical nurses[35], but nursing education in China started relatively late and formal curricula on innovation-thinking training for clinical nurses remain limited[36]. Heavy clinical workloads further hinder nurses' opportunities to translate creative ideas into practice.

Dimension scores were ranked from high to low as idea generation, idea realization, and idea promotion, consistent with prior research[37]. Nurses can easily spot opportunities for workflow improvement in daily clinical practice, yet transforming creative thoughts into real-world implementation faces multiple barriers such as resource shortages and practical complexity[38]. Idea promotion obtained the lowest score, indicating that nurses frequently lack adequate organizational support to advance their innovations. Prior literature confirms that leadership-level and organizational cultural support strongly shape employees' innovative performance [39]. Nursing administrators should therefore strengthen material-resource allocation and foster an open, inclusive organizational climate that encourages innovation so nurses feel supported to implement their creative proposals.

4.2 Characteristics of the three latent-profile subgroups

Three heterogeneous latent profiles of innovative behavior were identified: low-level, moderate-level, and high-level subgroups. Most participants belonged to the moderate-innovative-behavior group (48.52%), while the low-level and high-level

subgroups accounted for 25.92 % and 25.56 % respectively, a distribution that closely parallels that reported for oncology nurses in comparable samples.

The moderate-profile group represented the key intervention target. For nurses in this subgroup, sustained job-crafting enhancement combined with innovation incentives, research-training opportunities, and cross-departmental exchange resources may help some individuals advance toward high-level innovative performance. For the low-innovative-behavior subgroup (mostly nurses with less than five-year clinical experience), targeted job-crafting training can guide them to identify workflow pain points and adjust collaborative patterns, facilitating progression to moderate-level innovation. For nurses in the high-innovative-behavior profile, managers should reduce basic job-crafting training and instead prioritize special innovation funding, achievement-conversion platforms, and research-mentorship support to sustain high-quality innovative outputs.

4.3 Predictors of latent-profile membership

4.3.1 Job crafting serves as the core intervention lever for stratified innovation cultivation, with moderate-innovation nurses as priority targets

Job-crafting scores showed consistent predictive power across the regression comparisons (all $P < 0.001$). Relative to the low-level profile, each 1-point increase in the job-crafting item-mean score (possible range 1-5) was associated with a 26.8 % increase in the odds of belonging to the moderate-innovation subgroup and a 10.0 % increase in the odds of belonging to the high-innovation subgroup. When the moderate-level profile served as the reference, a 1-point higher job-crafting score was associated with a 13.3 % decrease in the odds of belonging to the high-innovation profile.

Job crafting describes bottom-up, self-initiated adjustments that employees make to their job boundaries and work arrangements to satisfy personal needs and achieve positive work outcomes[40-42]. Job-crafting behaviors supply critical resources for innovation and activate nurses' intrinsic motivation. Increasing structural job resources provides instruments, technical support, and educational opportunities that build the professional knowledge foundations for innovation[43]. Enhanced social job

resources promote information exchange and teamwork, build supportive workplace networks, and stimulate innovative thinking and collaborative capacity. Assigning challenging rather than hindrance job demands encourages continuous learning and strengthens nurses' creativity and proactivity, further fostering innovative work behavior [44].

Hospital managers should grant nurses appropriate job autonomy, help nurses understand job-crafting concepts and practical approaches, and guide nurses to apply job-crafting strategies tailored to their position and career stage. Administrators also need to help nurses identify opportunities, techniques, and methods for job-crafting practice and build comprehensive resource-support systems to boost nurses' innovative performance.

4.3.2 Authentic leadership cannot be adopted as a core innovation-cultivation strategy

Authentic leadership reached statistical significance only in the high- versus low-level contrast, where the odds ratio (1.014) lay extremely close to 1; the association was not statistically significant in the moderate- versus low-level contrast (OR = 1.016, 95 % CI 0.995-1.038) or in the moderate- versus high-level contrast (OR = 0.996, 95 % CI 0.977-1.016). Even where significance was reached, the confidence interval only just excluded 1 (1.005-1.023), so the effect size was trivial and offered little practical value for subgroup differentiation. This finding illustrates a well-known methodological point: large-sample cross-sectional surveys can yield statistically significant P-values for very small between-group differences, yet statistical significance does not guarantee practical managerial relevance. Improving supervisors' authentic-leadership styles alone is therefore unlikely to substantially elevate nurses' innovative-behavior levels, and authentic leadership should be regarded as an auxiliary rather than a primary intervention target in stratified innovation management; authentic leadership is expected to operate indirectly, for example through followers' trust and perceived job control, rather than to act directly on innovative output, and a weak direct association has likewise been reported in comparable samples.

5 Limitations and Future Perspectives

This study has several limitations. First, the cross-sectional design only reveals associations between variables and profile membership and cannot establish causal temporal relationships. Longitudinal follow-up studies are needed to clarify the dynamic causal links among authentic leadership, job crafting, and nurses' innovative behavior that cross-sectional designs cannot resolve. Second, only three predictors were included (job crafting, authentic leadership, and work years); innovation-relevant contextual factors such as department-level innovation climate were not entered into the model, limiting explanatory power. Third, data were collected from a single tertiary-A hospital, which restricts population representativeness. Multi-center large-sample investigations should replicate these results in the future. Fourth, all measurements relied on self-report questionnaires, which may introduce response bias. Fifth, because the latent profiles were derived from the same innovative-behavior instrument used to describe the outcome, they should be regarded as descriptive summaries of response patterns rather than externally validated subgroups; the predictors examined here (job crafting and authentic leadership) were nevertheless measured with independent instruments. Finally, only three sub-dimension scores served as indicators in the latent-profile analysis, and solutions based on a larger number of indicators or on factor scores should be examined in future work.

6 Conclusions

Job crafting was the only predictor that consistently differentiated low-, moderate-, and high-innovative-behavior latent profiles, and the estimated association was largest for the moderate-innovation subgroup. Authentic leadership showed only marginal, practically negligible associations and cannot serve as a core target for stratified innovation cultivation. Work years failed to predict innovative-behavior profile membership. Nursing managers can adopt job-crafting-oriented training as a foundational intervention and allocate differentiated supporting resources for each subgroup to implement stratified innovation-talent development, providing empirical evidence for clinical nursing-workforce innovation management.

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Author contributions:

Conceptualization:JJ,TPF; Methodology:LZX,LYC Formal analysis: LM;Investigation:ZYX; Writing-original draft: JJ; Writing-review & editing: LM;Supervision:LZX; Project administration:LYC.

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Abbreviations

LPA: Latent profile analysis; CVI: Content-validity index; Log(L): Log-likelihood value; AIC: Akaike information criterion; BIC: Bayesian information criterion; aBIC: Sample-adjusted Bayesian information criterion; LMR-LRT: Lo-Mendell-Rubin adjusted likelihood-ratio test; BLRT: Bootstrap likelihood-ratio test; ANOVA: One-way analysis of variance; χ^2: Chi-square; OR: Odds ratio; CI: Confidence interval

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