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The impact of nurses' perceptions of systems thinking on patient safety competencies: a cross-sectional study

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Abstract

Background Systems thinking—conceptualized as an approach for understanding the dynamic interactions and interdependencies among components within complex systems such as healthcare—has been widely recognized in the literature as a critical framework for strengthening patient safety competencies (PSCs). Despite this recognition, empirical studies specifically examining the impact of systems thinking on nurses' PSCs remain limited. Accordingly, the present study aims to examine the relationship between systems thinking and PSCs among Iranian nurses.

Methods This study employed a cross-sectional descriptive design with a simple random sample of 400 nurses working in teaching hospitals in Qazvin, Iran between August and November 2024. Data were collected using the valid scales including, Systems Thinking Scale and the Patient Safety Competency Self-Evaluation tool for assessing perceptions of nurses towards systems thinking and PSCs, respectively. Data were analyzed using the independent sample t-test, ANOVA, and multiple linear regression.

Results The mean score for systems thinking and PSCs was 56.77 ± 12.24 out of 80 and 3.65 ± 0.54 out of 5, respectively. A positive correlation was found between systems thinking and PSCs scores ($r = .583$, $p < .001$). The findings of multiple linear regression analysis indicated that the level of systems thinking significantly predicted PSCs after control demographic and professional characteristics as potential confounders ($R^2 = 0.355$; B = 0.026, 95% CI = 0.022 to 0.029; $p < .001$).

Conclusion Nurses in the study population demonstrated moderate levels of both systems thinking and PSCs. These findings underscore the critical role of systems thinking in enhancing nurses' PSCs. The results can serve as a foundational basis for the formulation of hospital policies aimed at bolstering nurses' PSCs, thereby contributing to improved patient safety within healthcare settings. Policies and interventions on promoting systems thinking among nursing staff must be created and implemented. However, further studies using robust designs, including longitudinal and intervention research designs, are needed to examine the effect of systems thinking to enhance PSCs in nurses working in hospitals.

Keywords Patient safety, Patient safety competency, Systems thinking, Adverse events, Nurses

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Introduction

Patient safety, defined as the prevention of harm to patients during healthcare delivery, remains a cornerstone of high-quality health systems worldwide [1]. Globally, unsafe healthcare leads to significant harm, with more than one in ten patients affected and over three million deaths each year. This burden, equivalent to that of major global diseases like HIV/AIDS, disproportionately impacts low- and middle-income countries, where up to four out of every hundred patients may die due to unsafe care [2]. The WHO's Global Patient Safety Action Plan 2021–2030 underscores the urgency of addressing systemic vulnerabilities, shifting the focus from individual blame to organizational and structural improvements [3]. In low- and middle-income countries (LMICs), challenges such as workforce shortages, fragmented care, and inadequate infrastructure amplify risks, making patient safety a critical public health concern [4, 5]. Patient safety incidents typically stem from multiple factors, often arising from complex system failures rather than individual mistakes [6]. This paradigm emphasizes the need for holistic strategies that address both human and system-level factors.

Nurses, as frontline caregivers, play an essential role in ensuring patient safety through surveillance, advocacy, and direct clinical interventions [7]. Their responsibilities span medication administration, infection control, and error reporting, requiring a blend of technical proficiency and situational awareness [8]. Competencies such as effective communication, critical thinking, and adherence to evidence-based protocols are integral to mitigating risks [9]. Studies demonstrate that nurses with strong safety competencies reduce preventable adverse events [10], such as falls and pressure ulcers [11]. A study found that higher levels of patient safety competencies (PSCs) among nurses were associated with fewer adverse events and greater likelihood of reporting them. Notably, nurses with stronger skills, knowledge, and attitudes toward patient safety demonstrated better outcomes in both the occurrence and reporting of adverse events [12]. In Iran, where nurse-to-patient ratios often exceed international standards and workloads are high [13–15], these competencies become even more critical. However, systemic barriers, including hierarchical communication structures and limited autonomy, may hinder nurses' ability to apply these skills effectively [16].

Systems thinking, an analytical approach that examines interrelationships between components within a system, offers a framework for addressing healthcare's inherent complexities [17]. In health systems, this perspective acknowledges that patient outcomes are shaped by dynamic interactions among policies, workflows, technologies, and human behaviors [18]. For example, medication errors may stem not only from individual oversight but also from poorly designed dispensing protocols or inadequate staffing models [19]. In Iran's healthcare context, characterized by rapid urbanization and disparities in resource distribution [20], systems thinking could help identify leverage points for improvement, such as optimizing supply chains or fostering interdisciplinary collaboration [21]. Despite its potential, the integration of systems thinking into clinical practice remains inconsistent, particularly in LMICs where traditional, siloed approaches dominate [22].

Emerging evidence suggests that systems thinking enhances healthcare professionals' ability to anticipate risks, adapt to uncertainties, and collaborate across disciplines—core elements of PSCs [23, 24]. Nurses who adopt a systems perspective are better equipped to identify workflow inefficiencies or communication gaps that contribute to errors, enabling proactive interventions such as advocating for standardized handoff procedures during shift changes [25–27]. Recent studies confirm that higher systems thinking is associated with improved safety practices—including error reporting, communication, and infection prevention—and lower incidence of adverse events [28, 29]. Moreover, systems thinking has been shown to partially mediate the relationship between safety knowledge, attitudes, and missed nursing care [30], and to enhance safe care delivery across multiple dimensions such as teamwork, skills, and addressing patients' physical and psychological needs [31].

In Iran, where challenges such as understaffing and fragmented care coordination compromise care quality, systems thinking may help nurses address specific patient safety concerns—such as missed care at the individual level, communication breakdowns during handovers at the unit level, and lack of standardized protocols at the organizational level. While some studies have addressed aspects of systems thinking and patient safety, the link between nurses' systems thinking and their safety competencies remains underexplored. Therefore, this study aimed to determine the relationships between systems thinking and PSCs among Iranain nurses. Insights from this research may help inform future educational initiatives and organizational efforts aimed at enhancing patient safety in complex healthcare environments.

Objectives

The present study aims to examine the relationship between systems thinking and PSCs among Iranian nurses. The specific objectives of this study were as follows:

- To describe the levels of systems thinking and perceptions of PSCs among Iranian nurses.
- To examine differences in systems thinking and PSCs according to nurses' general characteristics.

- To identify the correlation between systems thinking and PSCs.
- To identify the factors influencing PSCs.

Methods

Study design

This cross-sectional descriptive study was conducted from August to November 2024. This approach was chosen as it enables the identification of correlations between variables and provides insights into current practices without requiring longitudinal data collection. The reporting of this study adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) cross-sectional checklist (Supplementary 1).

Study setting

This research was conducted in five teaching hospitals affiliated with Qazvin University of Medical Sciences in Iran. These hospitals are equipped with 150 to 255 active beds. In addition to providing medical services, these hospitals are responsible for training medical students and health research.

Population and sample

Eligible participants were full-time nurses with at least one year of clinical experience at the participating hospitals, a minimum of a bachelor's degree, and direct patient care responsibilities; nurses who declined to participate, held administrative positions, or were unavailable during data collection were excluded.

The appropriate sample size for this study was calculated using the Cochran formula [32], which indicated that at least 384 participants were needed to achieve a 5% margin of error and 95% confidence level. To account for a potential 15% non-response rate, the sample size was increased to 442. A total of 412 nurses completed the survey (response rate = 93.2%). After screening, 12 questionnaires with substantial missing data (more than 20% unanswered items) were excluded to ensure data quality and reliability. The final analysis was conducted on 400 complete responses, which still exceeded the minimum required sample size and thus preserved the study's statistical power.

A simple random sampling method was utilized to recruit nurses in each hospital. The determined sample size was divided proportionally among nurses working in five hospitals. Next, in each hospital, the allocated sample was divided according to the number of different units. Finally, nurses were recruited from each unit using a simple random sampling technique. For this purpose, a list of all nurses working in the departments was obtained from the Human Resources Department of hospital. Then, samples were selected based on the tables of random numbers in Microsoft Excel 2016.

Measures

Data were gathered using a self-reported questionnaire composited three parts including Demographic and professional characteristics, Patient safety competency self-evaluation questionnaire (PSCSE), and systems thinking scale.

Demographic and professional characteristics

This part consisted of nine variables gender, age, education, experience in nursing, workplace unit, workload (work hour per week), training in patient safety, experience in patient safety activities, and adverse events reported.

Patient safety competency self-evaluation questionnaire

To evaluate the level of PSCs among nurses, the 41-item Iranian version of the PSCSE developed by Lee et al. [12, 33] was utilized. The results of the construct validity analysis identified the following three factors: knowledge and awareness (6 items), skills (21 items), and attitudes (14 items) [33].

The knowledge and awareness dimension were further subdivided into two subcategories: patient safety culture (4 items) and error and cause analysis (2 items). Responses for this dimension were rated on a 5-point Likert scale, ranging from 1 (not knowledgeable) to 5 (very knowledgeable).

The skills dimension encompassed six subcategories: error reporting and response to an error (4 items), communication related to error (3 items), resource utilization/evidence-based practice (3 items), safe nursing practice (5 items), infection prevention (4 items), and precise communications during handoffs (2 items). Items in this dimension were scored using a 5-point Likert scale, with ratings from 1 (very uncomfortable) to 5 (very comfortable). Finally, the attitude dimension was divided into four subcategories: patient safety promotion/prevention strategy (4 items), responsibility of healthcare professionals for patient safety culture (4 items), error reporting and disclosing (4 items), and the components of patient safety culture (2 items). These items were assessed using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

The total score for the PSCSE tool was calculated by summing the scores from all three dimensions. A higher score indicates more level of PSCs between nurses. The total PSCs scores ranged from 1 to 5. Nurses' self-assessed PSCs were categorized into three levels based on their scores: low (1.0–2.3), moderate (2.4–3.65), and high (3.66–5.0) [28]. This instrument has demonstrated high reliability, evidenced by a Cronbach's Alpha Coefficient of 0.92 in its original validation study [33]. The overall value of Cronbach's alpha reported 0.95, and that

of each subdimension was 0.76–0.95 [12]. Cronbach's alpha of subscales in our study was between 0.83 0.94.

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Systems thinking scale (STS)

The 20-Item Iranian version of the Systems Thinking Scale, developed by Dolansky et al. [29, 34], was used to, assess systems thinking by evaluating nurses' capacity to recognize, comprehend, and synthesize event sequences, causal pathways, multiple potential causes, diverse event types, feedback loops, and interrelated factors. Construct validity was verified, indicating a three-factor solution: (1) interdependencies of system, (2) personal effort and (3) reliance on authority [34]. Participants rated items on a 5-point Likert scale ranging from 0 (never) to 4 (always). The total score for the scale ranges from 0 to 80. High competency in systems thinking was defined as a score of 60 or higher, while low competency was indicated by a score less than 40. Scores between 40 and 59 were classified as moderate competency [35]. The scale has demonstrated strong reliability, with a Cronbach's alpha coefficient of 0.89 in Dolansky et al.'s original study [34] and 0.88 in a subsequent Iranian study [34]. The current sample yielded a Cronbach's α coefficient of 0.92.

Data collection

Upon securing institutional consent from the management of each hospital and the nursing office of each ward, data collection commenced. Two final-year undergraduate students and two of the researchers facilitated the in-person, paper-based collection of questionnaires. These students had sufficient academic preparation to support the data collection process and, prior to the study, received structured training on the research protocol, including how to introduce the study purpose, distribute questionnaires, and address participants' questions without influencing their responses. Data collection was conducted under the close supervision of the principal investigator (E.K), and all stages of the process were carefully monitored to ensure consistency and minimize any potential misinterpretation. Initially, all prospective participants were provided with a letter detailing the study's purpose, ensuring their anonymity and confidentiality, and affirming their right to withdraw prior to signing an informed consent form. Data collectors then distributed the questionnaires to nurses in the approved departments and later revisited these areas to collect the completed forms. They visited the hospitals in different shifts to collect data. Nurses were given up to two weeks to complete the questionnaires at their convenience during work or off-duty hours. To ensure a high response rate, the researchers made multiple visits to the units throughout the week to collect questionnaires, and weekly visits to the hospitals to retrieve completed questionnaires from the research assistants. The entire data collection phase spanned four months, from August to November 2024.

Bias

We used several strategies to minimize potential sources of bias. First, nurses were selected through simple random sampling across all hospital units and shifts—including morning, evening, and night—to reduce selection bias. The sample allocation was stratified proportionally by hospital and unit. Second, participation was voluntary, and data collection was conducted confidentially to reduce response bias. In addition, all participants received clear explanations of the study's purpose and were given sufficient time to complete the survey. Finally, to minimize potential subjective or social desirability bias, no identifying information was collected. Participants were assured of complete anonymity and confidentiality, and they were informed that their responses would be used solely for research purposes.

Data analysis

All data was analyzed using SPSS-26. First, measures of central tendency and dispersion such as mean, standard deviation, frequency and percentage was used to describe and summarize all variables. Next, we assessed normality of the data using the Kolmogorov–Smirnov test. One-way analysis of variance (ANOVA) and independent sample t-test was used to compare demographic variables and the reported PSCs. Also, effect size was reported for the ANOVA (Eta^2) and the independent sample t-test (Cohen's d). Then, the inter-correlation of sub-scales of PSCs and systems thinking was analyzed using Pearson's correlation coefficient (r). Finally, multiple linear regression was conducted to examine the predictive value of PSCs among nurses by systems thinking while controlling for demographic factors. Multicollinearity in regression analysis was examined using the Variance Inflation Factor and Tolerance indices [36]. The significance level was considered to be $p < .05$.

Results

Demographic and professional characteristics of participants

Demographic and professional characteristics of participants in the study are provided in Table 1. The largest proportion of nurses (35.7%) were aged less than 30 years, with a mean age of 35.7 ± 8.4 years. The majority nurses (90.8%) held a bachelor's degree. Regarding experience in nursing, 46.0% had less than 10 years of work experience in nursing profession, with an average of 11.7 ± 7.7 years. More than half (51.5%) worked in general wards. A substantial proportion of the nursing staff frequently engaged in overtime work. (67.8%). Notably, 90.0% of nurses taken part in training related to patient safety and most of them (68.8%) experienced patient safety activities. Additionally, 82.0% did not reported any AEs in in the past six months.

Table 1 Demographic and professional characteristics of participants and differences in PSC by general characteristics ($n = 400$)

Variables	Number	Percentage	PSC	Effect sizes* (Eta^2 or Cohen's d)	*p*-value
			Mean ± SD		
Gender					
Female	319	79.7	3.66 ± 0.56	0.039	0.751†
Male	81	20.3	3.64 ± 0.54		
Age (years)					
≤ 30	143	35.7	3.66 ± 0.57	0.031	0.571‡
31–40	137	34.3	3.64 ± 0.54		
> 41 y	120	30.0	3.65 ± 0.55		
Education					
Bachelors' degree	363	90.8	3.65 ± 0.55	0.008	0.965†
Maser or PhD degree	36	9.3	3.64 ± 0.57		
Experience in nursing (years)					
< 10	184	46.0	3.57 ± 0.58	0.016	0.041‡
10–20	160	40.0	3.71 ± 0.55		
> 20	56	14.0	3.71 ± 0.39		
Workplace					
Emergency department	60	15.0	3.78 ± 0.56	0.011	0.118‡
Intensive care units	134	33.5	3.61 ± 0.57		
General wards	206	51.5	3.63 ± 0.53		
Workload (weekly)					
Normal (44 h or less)	129	32.3	3.71 ± 0.43	0.178	0.097†
Overtime (> 44 h)	271	67.8	3.61 ± 0.59		
Training in patient safety					
Yes	360	90.0	3.68 ± 0.52	0.611	< 0.001†
No	40	10.0	3.35 ± 0.72		
Experience in patient safety activities					
Yes	275	68.8	3.66 ± 0.52	0.084	0.438†
No	125	31.3	3.61 ± 0.60		
Adverse events reported					
Yes	70	17.5	3.55 ± 0.54	− 0.205	0.119†
No	328	82.0	3.67 ± 0.51		

*: Eta-squared for ANOVA and Cohen's d for t-tests; †: Independent sample t-test, ‡: ANOVA, PSC: Patient safety competency

Comparison of patient safety competencies according to general characteristics of nurses

The results of the t-test and one-way ANOVA indicated that years of nursing experience and training in patient safety were significantly associated with differences in PSCs. Specifically, nurses with 10 years or more of experience reported significantly higher PSC scores compared to those with less than 10 years ($p = .041$). Moreover, nurses who had received training in patient safety demonstrated significantly higher PSC scores than those without such training ($p < .001$), suggesting the importance of continuous education in enhancing safety-related competencies (Table 1).

No statistically significant differences in PSCs were observed according to gender ($p = .751$), age group ($p = .571$), educational level ($p = .965$), workplace ($p = .118$), weekly work hours ($p = .097$), participation in patient safety activities ($p = .438$), or adverse event reporting experience ($p = .119$). These findings suggest that these demographic and professional characteristics may not have a substantial impact on perceived PSCs among nurses in this sample (Table 1).

Descriptive statistics and correlations of study variables

The mean scores of nurses' perceptions of systems thinking and the PSCs showed in Table 2. The mean score for systems thinking was 56.77 ± 12.24, which indicates a moderate level of proficiency within the study's scoring framework. Similarly, the overall mean score for PSCs was 3.65 ± 0.54, also reflecting a moderate level of competency based on the established criteria. However, analysis across the individual domains revealed variability. The **knowledge/awareness** domain showed a moderate level of awareness, with a mean score of 3.46 ± 0.87. Within this domain, the Patient Safety Culture subcategory exhibited a comparatively lower score of 3.41 ± 0.87, suggesting a specific area warranting improvement. **Skills** related to safe practice fall within the moderate range (3.56 ± 0.66). Skills related to infection prevention, precise communications during hand-off, and safe nursing practice were within the high range (3.88 ± 0.79, 3.84 ± 0.87, and 3.83 ± 0.80, respectively). However, error reporting & response to an error, resource utilization/evidence-based practice, and communication related to error scores lower (3.24 ± 0.89, 3.25 ± 0.88, and 3.32 ± 0.85, respectively), signaling gaps. **Attitudes** toward patient safety were observed to be high, with a mean score of 3.92 ± 0.52. Specifically, the error reporting and disclosing sub-dimension scored 14.69 ± 2.81. However, lower scores in patient safety culture (8.77 ± 1.56) and safety promotion strategies (16.18 ± 2.81) suggest areas where proactive safety environments could be strengthened. Table 2 demonstrates a strong positive correlation between systems thinking and overall PSCs among nurses ($r = .583$, $p < .001$), which represents a large effect size. This indicates that higher systems thinking is significantly associated with improved PSCs. Furthermore, all subdomains of PSCs—knowledge ($r = .397$), skills ($r = .513$), and attitudes ($r = .535$)—also exhibited positive correlations with systems thinking, corresponding to moderate to large effect sizes. These findings suggest that nurses possessing strong systems thinking abilities are better equipped with essential PSCs.

Table 2 Descriptive statistics of study variables among nurses ($n = 400$)

Variables (No. of items)	Possible score range	Mean ± SD	Systems Thinking *r*
Systems Thinking (20)	**10–80**	**56.77 ± 12.24**	-
Total Patient Safety Competencies (41)	**2.08-5**	**3.65 ± 0.54**	0.583**
Knowledge/Awareness (6)	**1–5**	**3.46 ± 0.87**	0.397**
Patient safety culture (4)	1–5	3.41 ± 0.87	0.383**
Error & cause analysis (2)	1–5	3.50 ± 0.92	0.376**
Skills (21)	**1.28-5**	**3.56 ± 0.66**	**0.513****
Error reporting & response to an error (4)	1–5	3.24 ± 0.89	0.407**
Communication related to error (3)	1–5	3.32 ± 0.85	0.370**
Resource utilization/evidence-based practice (3)	1–5	3.25 ± 0.88	0.191**
Safe nursing practice (5)	1.20-5	3.83 ± 0.80	0.485**
Infection prevention (4)	2–5	3.88 ± 0.79	0.482**
Precise communications during hand-offs (2)	1–5	3.84 ± 0.87	0.479**
Attitude (14)	**2.06-5**	**3.92 ± 0.52**	**0.535****
Patient safety promotion/prevention strategy (4)	2–5	4.04 ± 0.66	0.467**
Responsibility of health care professionals for patient safety culture (4)	1.75-5	4.16 ± 0.67	0.510**
Error reporting & disclosing (4)	1.50-5	3.40 ± 0.72	0.226**
Components of patient safety culture (2)	1.50-5	4.09 ± 0.75	0.405**

r: Pearson correlation coefficient, **: Statistically significant at $p < .001$

Table 3 Multiple linear regression analysis to assess factors affecting patient safety competencies ($n = 400$)

Variables	B	SE	95% CI		*p*-value
			Lower	Upper	
Gender *[reference = Female]*	−0.007	0.056	−0.117	0.102	0.894
Education *[reference = Maser or PhD degree]*	0.033	0.078	−0.120	0.185	0.676
Workplace unit *[reference = General wards]*					
Emergency	0.080	0.068	−0.053	0.212	0.238
ICUs	−0.056	0.049	−0.153	0.041	0.258
Workloads *[reference = Overtime]*	−0.073	0.049	−0.170	0.024	0.140
Training in patient safety *[reference = No]*	0.183	0.082	0.022	0.345	0.026
Experience in patient safety activities *[reference = No]*	−0.017	0.054	−0.123	0.090	0.757
Adverse events reporting *[reference = No]*	−0.064	0.059	−0.179	0.051	0.278
Age	−0.001	0.008	−0.016	0.014	0.884
Experience in nursing	0.003	0.009	−0.013	0.020	0.686
Systems Thinking	**0.026**	**0.002**	**0.022**	**0.029**	**< 0.001**

$R = .355$, $R^2 = 0.355$, $F = 21.399$*, $p < .001$*

Table 3 presents the results of a multiple linear regression analysis examining the factors influencing PSCs among the participating nurses. No multicollinearity was reported between independent variables (Variance inflation factor < 5; Tolerance > 0.2). Also, the Durbin-Watson was 1.80, which confirms the absence of positive or negative self-correlation. Multiple linear regression analysis, adjusted for potential covariates, identified systems thinking as significantly associated with increased PSC levels among nurses.

The overall model was statistically significant ($F = 21.399$, $p < .001$), with an R^2 of 0.355, indicating that approximately 35.5% of the variance in PSCs was explained by the included variables. This reflects a moderate to large effect size, suggesting that the model has substantial practical significance in predicting patient safety competencies based on systems thinking and demographic factors.

Among the predictors, systems thinking emerged as a significant positive predictor of PSCs (B = 0.026; 95% CI [0.022 to 0.029]; $p < .001$), suggesting that higher levels of systems thinking were associated with greater PSCs. Among the demographic variables, having received patient safety training was positively associated with PSCs (B = 0.183; 95% CI [0.022, 0.345]; $p = .026$).

Other variables, including gender, age, educational level, years of nursing experience, working ward, workload, participation in patient safety activities, and reporting of adverse events, were not statistically significant predictors of PSCs ($p > .05$ for all).

Discussion

The current study explored the relationship between nurses' perceptions towards systems thinking and the level of PSCs in Iranian teaching hospitals.

Patient safety competencies among nurses

The findings of the current research disclosed that nurses rated their overall PSCs level as moderate. However, when analyzing each of the three PSC domains independently, the mean scores for self-reported knowledge and skills were lower than those for attitudes, with knowledge demonstrating the lowest score. These findings suggest that while nurses in this setting hold positive attitudes toward patient safety—likely shaped by general awareness and moral responsibility—they lack the essential knowledge and practical skills necessary to implement safety practices effectively. Attitude plays a vital role in establishing a robust patient safety culture, encompassing an understanding of activities that promote patient safety, prevent errors, and define the duties of a healthcare professional [33].

This discrepancy may be explained by several specific factors in the Iranian nursing education system and clinical environment. Patient safety has not yet been formally integrated as a standalone subject within nursing curricula at undergraduate or postgraduate levels. Relevant content is often embedded within broader theoretical courses without systematic instruction or assessment of practical safety competencies such as root cause analysis, systems thinking, or safe medication administration [37]. In clinical settings, nursing students are often supervised in hierarchical structures with limited opportunities for reflective learning, error reporting, or interprofessional collaboration [38]. Furthermore, continuing education programs on patient safety are mostly non-mandatory, infrequent, and theoretical in nature. High clinical workloads, understaffing, and organizational constraints further limit access to skill-based safety training [16]. These systemic gaps may contribute to the imbalance observed in this study between nurses' favorable attitudes and their insufficient knowledge and skills in patient safety.

Although the total PSCs score in the current study was lower than those reported in previous studies in Iran [39] and countries like South Korea [30, 40, 41] and Egypt [28], it aligns with findings from other Iranian studies in Tabriz and Tehran, which showed that nurses were particularly weak in knowledge and skills but scored highest in attitudes toward patient [12, 39]. These cross-country variations may be partly explained by differences in educational systems, organizational culture, and healthcare structures. For example, South Korea has formally incorporated patient safety into nursing curricula and mandates structured training programs, which may account for higher PSC scores [42]. In contrast, in

Egypt, greater emphasis has been placed on patient safety workshops and national initiatives [43], whereas in Iran, patient safety education remains fragmented and mostly non-mandatory.

In particular, the lowest scores in our study were observed in the domains of "error reporting and response to an error" and "communication related to error", reflecting weaknesses in the culture of error disclosure and open communication. These results are consistent with previous evidence suggesting that fear of blame, lack of institutional support, and hierarchical structures hinder error reporting among Iranian nurses [12, 16]. While nurses may express positive attitudes, likely influenced by general moral responsibility and social expectations, this does not necessarily translate into practical competence—a gap further exacerbated by the absence of structured patient safety training in Iranian nursing curricula [37]. Addressing this gap requires systemic reforms, including integration of patient safety into nursing education, establishment of anonymous reporting mechanisms, training on non-punitive error response, and development of structured, case-based continuing education programs. Additionally, periodic educational needs assessments using validated tools can help nurse managers tailor interventions to improve real-world patient safety competencies.

Systems thinking among nurses

Our findings indicate that nurses' perceived level of systems thinking was moderate, consistent with results from previous studies conducted in Iran [29, 39] and South Korea [30, 35], all of which reported moderate levels of nurses' systems thinking. While, contrary to the results of this study, several studies carried out in Egypt [28] and Iran [31] reported high levels of systems thinking among nurses. This result shows the necessity to boost the level of systems thinking among Iranian nurses. The moderate systems thinking scores observed among nurses in this study may be attributable to several factors, including a limited understanding of systems thinking among nursing managers and educators, insufficient training opportunities, and inadequate efforts to institutionalize systems thinking within the healthcare organization [31]. In addition, studies have mentioned several obstacles such as high workload, insufficient training, and organizational constraints for effective implementing systems thinking [28, 44]. The demanding workload in nursing often limits opportunities for reflective practice, making it difficult to consistently apply systems thinking principles [45]. As Cho and Baek observed, such practical constraints can hinder the regular use of these skills [46]. These insights underscore the importance of conducting targeted, context-sensitive research to better understand how systems thinking can be effectively integrated into nursing practice.

Therefore, it is imperative to implement strategies aimed at enhancing nurses' systems thinking. The literature suggests several approaches, such as engaging in multidisciplinary quality improvement projects and utilizing systems thinking tools [47–49]. To effectively embed systems thinking, nurse managers can foster professional configurations including interprofessional collaborations, academic-clinical practice partnerships, and shared governance [25, 50]. Furthermore, nurse educators can adopt a systems thinking perspective in continuing education by acknowledging the healthcare team as an integral part of a complex system. This includes integrating individual, group, and governance leadership competencies into both onboarding and ongoing educational programs [25].

Role of systems thinking in fostering patient safety competencies among nurses

Our findings underscore the pivotal role of systems thinking in shaping PSCs among nurses. The analysis demonstrates that systems thinking exerts a significant positive influence on overall PSCs, with robust correlations observed across all subdimensions. Notably, integrating systems thinking into predictive models markedly enhances their explanatory power, suggesting that this cognitive approach is not merely additive but foundational to cultivating a nurse's ability to navigate complex healthcare environments safely. These results are consistent with previous studies that have identified systems thinking as a critical driver of safety competency development, particularly in dynamic clinical settings [28, 39, 51]. The observed relationship between systems thinking and proactive risk management further substantiates its value. Previous studies have shown that systems thinking enables nurses to anticipate and mitigate risks by situating individual actions within the context of broader systemic workflows [23, 52]—a pattern also reflected in our findings. This forward-looking orientation is essential for reducing preventable harm, as it emphasizes upstream prevention rather than reactive error correction.

Moreover, our results support the view that systems thinking is inherently linked to the knowledge domain of patient safety competence, facilitating the integration of interdisciplinary insights into clinical decision-making [53]. Importantly, this study bridges theoretical frameworks with educational imperatives. Previous research has shown that embedding systems thinking into nursing curricula enhances learners' understanding of how micro-level decisions affect macro-level safety outcomes [54]. Our findings corroborate this, suggesting that sustained emphasis on systems-oriented pedagogy could amplify competency gains. For instance, nurses trained

in systems approaches may better recognize latent institutional vulnerabilities, such as workflow fragmentation or resource constraints, and advocate for structural improvements.

Collectively, these insights advocate for systems thinking as a linchpin in safety competency frameworks. Future interventions should prioritize its integration into continuing education programs, simulation-based training, and institutional policy design. By fostering a systems mindset, healthcare organizations can empower nurses to transcend individualistic problem-solving and contribute to resilient, patient-safe ecosystems.

Limitation of study

Several limitations of this study should be considered when interpreting the findings. First, the study used a cross-sectional descriptive design. This design limits the causal relationships between variables. Therefore, future studies need to use robust designs such as longitudinal and interventional to provide strong evidence. Second, the specific geographical and organizational context of this study limits generalizability, so conducting further studies in different settings and countries is essential. Third, the sample of this study only included nurses, since systems thinking and patient safety are a team effort, it is essential that other healthcare professionals, such as physicians, allied health workers, and other hospital staff, be included in future studies. Fourth, workload was measured solely by work hours per week, using a non-validated and potentially unreliable indicator. Additionally, other potentially influential variables, such as organizational culture, were not examined. Fifth, although 12 questionnaires with more than 20% missing data were excluded to ensure data quality and sufficient statistical power, no sensitivity analysis was performed; this may be considered a minor limitation. Sixth, while the instruments used in this study had been previously translated and validated in Iranian populations and showed strong internal consistency in our sample, construct validity was not reassessed specifically for this sample. Finally, data were collected through a self-report questionnaire without the use of blinding procedures for participants or data collectors, a common limitation in survey-based research. This may have introduced recall bias and subjective or social desirability bias, potentially affecting the accuracy of responses [55].

Conclusion

This study confirmed that systems thinking plays a key role in predicting PSCs among Iranian nurses. Improving nurses' perceptions of systems thinking skills can lead to improved PSCs and, in turn, may contribute to enhancing the quality of care and patient safety. Therefore, prioritizing systems thinking in both education and practice by healthcare organizations, especially hospitals, should be considered a strategic priority. To foster systems thinking among nurses, several recommendations can be considered. Firstly, nurses should engage in continuous education and simulation-based training. This approach can enhance their ability to comprehend the complexities of healthcare settings. Secondly, hospital managers are instrumental in strengthening systems thinking among their staff. They can achieve this by providing training programs that emphasize interdisciplinary collaboration, error analysis, and systems-based problem-solving. Additionally, managers should develop policies that integrate systems thinking into the organizational culture and clinical practice, fostering an environment that encourages reflective practice and team-based learning. Most importantly, it is recommended that systems thinking be integrated into curricula and national patient safety standards. Developing standard modules on systems thinking may help prepare nursing students to more easily understand the complexities of healthcare in the future. Given the limitations of the current study, future research should include interventional, mixed-methods, and interprofessional studies—such as implementing targeted training programs, conducting qualitative interviews, and involving diverse healthcare professionals—to validate and expand on the current findings, enhance generalizability, and provide a more comprehensive understanding of the relationship between systems thinking and PSCs.

Abbreviations

PSC	Patient safety competency
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
PSCSE	Patient safety competency self-evaluation
ANOVA	Analysis of variance

Supplementary Information

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Supplementary Material 1

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Author contributions

EK and RK were involved in the study design, analysed and interpreted the data, and was a major contributor in writing the manuscript. AM and YSR participated in conceptualization, data analysis and revising the final version of the manuscript. SM, EP and RT was responsible for data collection and drafting and revising of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets and materials of the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

An official approval for conducting the study was obtained from the Research Ethics Committee of Qazvin University of Medical Sciences (IR.QUMS.REC.1402.281). Data collection was carried out by official permission from the hospital managers. The research was performed in accordance with the requirements of the Helsinki Declaration. A written informed consent from nurses was obtained after providing an appropriate explanation about the aim of the study. The confidentiality of the data was maintained. The anonymity of the study subjects was maintained. Subjects participated in the study voluntarily and had the right to withdraw at any time from the study without any consequences.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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