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ORIGINAL RESEARCH

# Reducing Nurses' Barriers to Reporting Adverse Events Using a WeChat-Based Cognitive Load Training Platform: An Open-Label, Randomized Controlled Trial

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**Objective:** To investigate the effects of a cognitive load theory (CLT)-based WeChat training platform on reducing the barriers to reporting adverse events among clinical nurses.

**Methods:** In total, 400 clinical nurses from a tertiary general hospital were randomized into experimental and control groups (200 each). The experimental group used the CLT-based WeChat training platform, whereas the control group received conventional training for nursing adverse events. Both interventions lasted 12 weeks. Barriers to reporting, reporting awareness, intention, and habit scores were compared between the groups.

**Results:** After the dropouts, 197 experimental and 196 control participants completed the study. In the experimental group, the total scores for barriers to reporting adverse events and in the dimensions of punitive culture, reporting process, and reporting significance scores were 93.87 ± 6.85, 48.88 ± 4.68, 21.53 ± 4.15, and 23.40 ± 2.11, respectively, whereas the control group corresponding scores were 72.07 ± 6.67, 34.20 ± 6.02, 20.06 ± 3.25, and 17.36 ± 2.92, respectively. The experimental group demonstrated significantly higher scores and reporting significance (P all < 0.01). Additionally, the experimental group had significantly higher scores for safety event reporting awareness, intention, and habits than those in the control group (P < 0.01). When responding to nursing adverse events of various severity, the only exception to statistically significant differences between the groups was in "reporting to the head nurse" for medium-severity incidents (P = 0.302). However, the experimental group demonstrated significantly higher rates of "submitting an adverse event report", "reporting to the head nurse", and "discussing with colleagues" than those in the control group regardless of the severity of the adverse event (P < 0.01).

**Conclusion:** This study confirmed that the CLT-based WeChat training platform model can effectively reduce the level of barriers to adverse event reporting by nurses, enhance nurses' adverse event reporting awareness, intention, and promote improvement in nurses' adverse event reporting behaviors, thereby improving the quality of nursing care and patient safety.

**Keywords:** cognitive load theory, WeChat training platform, nurse, adverse event reporting barriers, patient safety

## Introduction

Patient safety is the cornerstone of the modern healthcare system, and effective reporting of adverse events is critical for ensuring patient safety and improving health outcomes.[1–3]

According to the World Health Organization, approximately 134 million adverse events and 2.6 million related deaths occur annually in low- and middle-income countries as a result of unsafe care.[4] The healthcare costs associated with preventable medical errors are as high as $17.1 billion.[5] In China, 72.5% of medical malpractice claims in tertiary hospitals involve medical errors, with an average payment of $31,430.[6] Clinical evidence indicates that >50% of nurses have encountered an adverse event,[7,8] which increases patient mortality and costs and has a negative impact on nurses' physical and mental well-being.[9,10] Murphy et al estimated that nurse-sensitive adverse events cost the Irish health

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service $92.26 million annually.[11] However, although the incidence of adverse events remains high, the reporting rate of adverse events is generally low worldwide, which remains a major challenge in patient safety management. In New Zealand, the missing rate of adverse events is as high as 91%.[12] In Vietnam, 34% of healthcare professionals admitted that they did not report adverse events.[13] Zhang et al retrospectively studied 100,000 cases of adverse events reported by Chinese medical institutions from 2015 to 2017 and observed that the reporting rate was low, few reported hidden events, majority of them were nonconsequential adverse events, and reporting quality was low.[14] Huang et al found that the reporting rate of adverse events in inpatients was only 25.28%.[15] Jiang and Liu conducted a questionnaire survey on 636 medical personnel from 30 hospitals in China and found that only 22.5% of them had reported adverse events.[16]

Adverse event reporting is related to individual perceptions and attitudes and is closely associated with the hospital's safety culture and training systems.[17] Previous studies have shown that training can be effective in reducing nurses' barriers to reporting adverse events and improving their reporting behavior.[18,19] WeChat-based tools have been widely used in nurse training due to their convenience and efficiency; however, the resulting training load may cause burnout among nurses, affecting their learning effectiveness and willingness to report.[20,21] Currently, optimizing training tools to reduce cognitive load, improve training efficiency, and enhance nurses' willingness to report adverse events is a critical issue that requires urgent solution.

Cognitive load theory (CLT) provides a theoretical framework for nurses' efficient training.[22] Cognition is a form of resource, and the process of learning and problem solving consumes cognitive resources.[23] "Cognitive load" occurs when the demand for cognitive resources exceeds available capacity.[24] Cognitive load is categorized into three types: intrinsic, extraneous, and germane load. Reducing the cognitive load generated during learning or work can enhance memory and improve learning and work efficiency.[25]

Several studies have been conducted on CLT in education and teaching.[26,27] In medical care, CLT has been applied to diet management of patients with gestational diabetes, internal fistula management of patients undergoing blood purification, and training of new nurses, yielding positive outcomes.[28–31] Educators can effectively manage the three types of cognitive load through instructional design. This includes optimizing internal cognitive load through knowledge training and other methods, reducing extraneous cognitive load by enhancing teaching presentation, and increasing germane cognitive load by promoting task execution or improving learning outcomes. These strategies help foster learners' initiative and enhance overall learning effectiveness.[32,33] Currently, no relevant studies have been conducted on the application of CLT in nurses' adverse event management training.

Therefore, this study aimed to explore an optimization method of WeChat-based training and interaction design based on CLT to reduce the cognitive load of nurses in training and learning processes, improve the learning effect, reduce the barriers in reporting adverse events among clinical nurses, enhance their willingness and behavior to report, and ultimately, promote the improvement of medical safety while providing a new perspective and solution for nursing training. We hypothesized that compared with conventional training methods, the CLT-based WeChat training platform significantly reduces barriers among nurses in reporting adverse events, enhances their reporting awareness and intention, and improves their reporting behaviors.

# Materials and Methods

## Trial Design

This was an open-label randomized controlled trial conducted in a public tertiary hospital in Handan City, Hebei Province, China.

## Participants

Clinical nurses working in the aforementioned public tertiary hospital (2059 beds) in Handan City, Hebei Province, between June and December 2023 were selected for this study. The inclusion criteria were as follows: nurses who had participated in frontline clinical nursing for ≥1 year, could use WeChat proficiently and independently, completed the questionnaire, provided informed consent, and voluntarily participated in the study. The exclusion criteria were as follows: Nurses who were not on duty during the survey period (maternity or sick leave) and those who refused to

participate in the survey. The dropout criteria were as follows: Nurses who were not present at the hospital during the study period due to work or vacation and those who requested withdrawal midway through the study. As of June 2023, the surveyed hospital employed 1235 registered nurses. Among them, 1163 nurses met the inclusion criteria.

## Ethical Considerations

The study was approved by the Ethics Committee of Handan First Hospital (NO.2020-K-81), and all participants signed an informed consent form after being informed of the ethical nature of the study and their rights.

## Sample Size

In this study, the sample size was calculated using nurses' barriers to reporting adverse events as the primary variable of interest. A previous study showed that Adverse event reporting barriers questionnaire scores of the experimental and control groups were 74.740 ± 5.213 and 76.538 ± 5.321, respectively.[17] The sample size was estimated using a two-sample mean comparison in a completely randomized design using PASS software, with a two-sided $\alpha = 0.05$ and $\beta = 0.10$. The required sample size for the two groups was 180 participants each. In consideration of loss to follow-up, the sample size was increased by 10%. The final sample size for the two groups was 200 participants each.

## Randomization and Masking

From 1163 eligible nurses, 400 participants were included via stratified random sampling to ensure proportional representation across departments (eg, internal medicine, surgery, and intensive care unit), age groups (≤30, 31–40, and ≥41 years), gender, work experience (≤1, 1–5, and ≥5 years), education levels (college, undergraduate, and postgraduate), titles (junior, senior, and chief nurses), roles (staff nurses and nursing managers), and employment types (permanent, contract, and probationary). Stratification variables were predefined based on hospital workforce demographics. Using SPSS 25.0, randomization was performed within each stratum to allocate 200 nurses to the experimental and control groups, respectively. This approach ensured balanced representation of key demographic and professional characteristics in both groups.

After grouping, we created two separate WeChat groups for the experimental and control groups. Participants were added to their respective groups individually, and group membership was strictly controlled. The WeChat groups were managed by a researcher as the administrator, and training content was posted exclusively within each group. To prevent cross-group communication, the following measures were implemented:

(1) Access restrictions: Participants in one group could not view or join the other group. The experimental group's WeChat platform accounts (based on CLT) required unique login credentials, ensuring exclusive access to their training materials. (2) Explicit instructions: Nurses in both groups were informed during the consent process that discussing training content with colleagues outside their assigned group could compromise the study's validity. They were reminded periodically to maintain confidentiality. (3) Monitoring and moderation: Group administrators monitored discussions to prevent cross-group sharing. Any attempts to share materials externally were flagged and addressed immediately. (4) Temporal separation: Training sessions and content releases for the two groups were staggered to minimize overlap in participation times, reducing opportunities for informal discussions. Because the study was open label, the interventions were not masked to the participants or investigators.

## Operational Definitions

Adverse events are defined as unintended injuries or complications caused by healthcare management, rather than patients' underlying disease.[34]

Adverse events in nursing are any nursing-related events (eg, falls, wandering, injuries, suicides, pressure injuries, and nursing-related hospital infections) caused by inadequate monitoring, unobserved signs of early complications, medical errors, incorrect nursing interventions, lack of communication, and incomplete over-reporting of patients.[35]

Reporting barriers refer to the difficulties and obstacles encountered by nurses when reporting adverse events; for example, issues related to their intention to report, their attitudes toward reporting, and their perception of the hospital's

safety culture. These barriers can affect the rate at which adverse events are reported and thus negatively affect the optimization and improvement of the patient safety management system.[36]

Reporting intention describes a nurse's desire or willingness to complete an adverse event reporting by filling the reporting forms, reporting to the superior, or discussing with colleagues.[37]

Reporting awareness refers to nurses' knowledge and understanding of adverse event reports.[38]

## Training Methodology

### Trainers

The trainers in both groups comprised members of the nursing department, unit head nurses, and members of the nursing adverse event team. The experimental group was assigned two project coordinators who were responsible for recording, screening, and uploading of instructional videos on adverse events; modularizing; periodically allowing access to learning materials; and making timely adjustments based on nurses' feedback and learning progress.

The standardized roles of coordinators included providing technical support (eg, uploading materials and managing access permissions) and monitoring progress but were not involved in data collection, analysis, or outcome assessment. Their tasks were predefined as part of the CLT-based intervention protocol to ensure consistency across participants. This clarification ensured that coordinator activities were procedural and noninterventional, minimizing bias risks.

### Training Content

The training for nurses in both groups included the following five chapters: (1) Fundamentals of nursing adverse events (definition, classification, purpose, and significance); (2) Processes of nursing adverse event reporting; (3) Specialized practical chapter, including types of adverse events such as pressure injuries, falls, unplanned extubation, and assessing errors; (4) "Lessons learned from the past can guide one in the future"—sharing of particularly interesting cases; and (5) Anonymous reporting and good incident reporting.

## Training Methods

### Control Group

Routine training methods were used, including the creation of WeChat training group chat. (1) Every 2 weeks, centralized lectures on nursing adverse event theory were conducted, followed by a theoretical knowledge assessment at the end of the course; (2) Every 2 weeks, practical demonstration was performed in accordance with the demonstration–practice–skills assessment model; (3) Self-study: A knowledge library was established, and all relevant theoretical material and training operation videos were uploaded to the nurse training WeChat group for independent learning; (4) Periodic roundtable discussions were held within the department to brainstorm, analyze, and address typical nursing adverse event cases; (5) Quarterly nursing adverse event warning and education conference was held, with the nursing adverse event group members analyzing and explaining typical cases in depth; (6) Improving the safety culture of the hospital and encouraging nurses to report good incidents and hidden incidents, with a reward of 50 RMB/case after verification. When nurses in the control group needed to conduct educational meetings or centralized lectures, the conference information would only be published in the WeChat group of nurses in the control group and notified to each participant. One-to-one check-in was also conducted at the meeting site according to the list of nurses in the control group to ensure that each nurse in the control group could attend the meetings accurately.

### Experimental Group

**Constructing an outline of the training program**: An outline of the training program for the management of nursing adverse event reporting based on CLT is shown in Table 1.

### Concrete Implementation of Training Programs

**(i) Optimization of the effects of presenting learning materials** (1) Interface design followed the principle of "less is more" and reduced unnecessary information and decorative elements to avoid taking up excessive cognitive resources of nurses. (2) Large fonts and eye-catching colors were used to highlight important actions or tips to ensure that key information was presented in a clear and prominent manner. (3) Appropriate use of diverse media such as images,

**Table 1** Outline of the Cognitive Load Theory-Based WeChat Platform Training Program on Nursing Adverse Event Reporting Management

| Type of Cognitive Load | Concept | Influencing Factors | WeChat Platform Training Measures |
|---|---|---|---|
| Intrinsic cognitive load | Depends largely on the characteristics of the learning content itself and the knowledge level of the learner | 1. Knowledge capacity of the training content;<br>2. Difficulty of training content;<br>3. Nurses' knowledge level and competence; | 1. Interface simplification, information volume reduction, and clear presentation of key information;<br>2. Optimization of learning materials, differentiation of modules, and gradation of difficulty;<br>3. Development of individualized learning plans based on the nurse's level of knowledge and ability, and recommendation of corresponding learning resources and tasks; |
| Extraneous cognitive load | Stems primarily from poor instructional design and teaching activities | 1. Forms of training;<br>2. Timing and frequency of training; | 1. Optimizing instructional design and presenting training content in a modular and hierarchical manner;<br>2. Sequencing presentation of training content to be organized, designed with orderly steps and navigation, gentle learning curve for nurses; |
| Germane cognitive Load | Related to the success of the student's efforts | 1. Intrinsic learning motivation, diagram construction, and automation;<br>2. Ability to monitor self-directed learning process. | 1. Transforming text into multimedia elements such as images, charts, and animations to enhance nurses' interest, engagement, and motivation for learning;<br>2. Provide case studies and discussions to increase nurses' willingness to report;<br>3. Establishment of evaluation and incentive mechanisms, implementing real-time feedback. |

diagrams, and animations instead of text-only descriptions to facilitate memorization and proper understanding of information. (4) To ensure homogeneity of the learning materials, members of the nursing adverse event team rehearsed and recorded an operational video of the adverse event reporting process. (5) The reporting process simulation operation was designed by constructing an intuitive and clear step-by-step and navigation system, such as using breadcrumb navigation or step-by-step indicators to guide the user to the current location and subsequent steps, to improve the navigation experience and enable nurses to quickly master the steps of reporting adverse events in a virtual scenario.

**(ii) Optimization of teaching design, phased set up, and providing timely feedback** (1) The training content was structured into modules and hierarchical levels, progressively increasing in difficulty and complexity. Module 1 explained the basics of nursing adverse events; Module 2 described the nursing adverse event reporting process; Module 3 focused on specialized practical training, including adverse event-specific reporting exercises for pressure injuries, falls, unplanned extubations, and checking errors; Module 4 included notable case studies; and Module 5 was an overall nurse competency enhancement training, including anonymous reporting and good incident reporting. (2) Opening module learning in stages. The nursing department initially set the schedule outline of the opening of the module, where each time before the lecture, the coordinator posted the learning resources (lecture courseware and operating video) on the "Lessons learned from the past can guide one in the future" WeChat training platform and automatically updated to remind the nurses of independent learning; the time of access to each module was adjusted according to the feedback and progress of nurses. (3) Setting-up clear milestones and real-time feedback. The training module defined clear learning objectives and checkpoints for each section to achieve real-time feedback. The training offered immediate evaluation and guidance on nurses' answers and actions during the learning process. Features such as automatic correction and explanation of the rationale helped nurses identify and correct errors promptly. Feedback reinforced accurate knowledge and operations, enabling nurses to track their progress through comparisons. Additionally, completing each stage provided a sense of achievement, fostering intrinsic motivation to learn.

**(iii) Developing personalized learning plans** Nurses were free to contact the coordinator to obtain relevant permissions; select corresponding learning modules and paths according to their knowledge level, ability, learning pace, and needs; and adjust the difficulty and depth of subsequent learning tasks according to learning progress and stage-by-stage feedback to ensure that the learning plan was tailored to the individual's ability.

**(iv) Stimulating learning motivation in nurses** (1) An online discussion platform was created, with virtual Tencent meetings held every 2 weeks. Nurses were invited to share their views and experiences, fostering a learning community. (2) Nurses were encouraged to engage in continuous learning and participation through e-certificates, badges, or points awarded based on their testing and learning performance. (3) A leaderboard and a list of outstanding learners were created to foster interaction and competition among nurses, enhancing their motivation to learn and report adverse events.

**(v) Establishment of an evaluation and monitoring mechanism** (1) At the end of each month, the program coordinator reviewed nurses' online learning records and held book report and progress exchange meetings to monitor training progress dynamically. (2) A phased assessment approach was implemented, aligning each evaluation with the corresponding training module. The assessments covered both theoretical knowledge and practical skills through multiple methods, including multiple-choice questions, case studies, and simulation exercises. This comprehensive approach ensured a thorough evaluation of nurses' understanding of adverse event reporting and the effectiveness of the learning process.

## Survey Tools

### General Information Questionnaire

The questionnaire collected basic information such as department, gender, age, education level, title, position, years of experience, and nature of employment.

### Adverse Event Reporting Barriers Questionnaire

This questionnaire was revised by Evans et al[39] and translated into Chinese by Tian et al[37] to evaluate healthcare providers' self-perceived barriers to reporting adverse events, as in clinical departments. The questionnaire comprised three dimensions: punitive culture, reporting processes, and significance of reporting, with 22 entries scored on a 5-point Likert scale (1 = strongly agree, 5 = strongly disagree), with a total score ranging from 22 to 110. A higher score indicates a lower barrier to reporting adverse events by nurses and a greater tendency to report. The questionnaire's Cronbach's α coefficient was 0.886, with a construct validity of 0.943.

### Adverse Event Reporting Awareness Questionnaire

The questionnaire was originally developed by Vincent et al[40] in the UK and translated into Chinese by Tian et al[37] to assess nurses' reporting awareness of adverse events. The questionnaire comprised eight items with binary scoring of "yes" scoring 1 point and "no" or "do not know" scoring 0 points. The total score ranged from 0 to 8 points, and a higher score indicated greater adverse event reporting awareness among nurses. The Cronbach's α coefficient was 0.758, and the construct validity was 0.703.

### Adverse Event Reporting Intention Questionnaire

This questionnaire was designed by Throckmorton and Etchegaray[41] in 2007 and translated into Chinese by Tian et al[37] to evaluate nurses' intention to report five categories of adverse events of varying severity (potential vulnerability, no harm caused, causing minor harm but no treatment required, causing moderate harm, causing severe harm, or even death). Each category included three reporting methods and was scored using a binary scale, with "yes" scoring 1 point and "no" or "unclear" scoring 0 points. A higher score indicated higher willingness to report adverse events. The Cronbach's α coefficient of the questionnaire was 0.862, with a construct validity of 0.831.

### Adverse Event Reporting Habits Questionnaire

The questionnaire comprised five entries, of which item 5 was an open-ended question scored on a Likert scale of 4 (1 = never report, 4 = always report, and no score for not applicable), with a total score ranging from 0 to 16. A higher score indicates that clinical nurses reported pressure injuries, falls, unplanned extubation, and checking errors with greater frequency and had better reporting habits. The Cronbach's α coefficient for the questionnaire was 0.826 and construct validity was 0.769.

### Data Collection

The completed questionnaires were collected anonymously online using Questionnaire Star platform (https://www.wjx.cn, Changsha Ranxing Science and Technology, Shanghai, China), and questions could only be answered once using the same IP address or WeChat account. The time to complete the questionnaires was limited to 20 min, and the questionnaire could not be submitted until all questions were completed. All researchers were uniformly trained before administering the questionnaire. General information was collected through Questionnaire Star at the time of enrollment of the participants, and adverse event reporting barriers, intentions, awareness, and habits questionnaires were collected 12 weeks after the intervention. During the survey, study participants were informed about the contents of the questionnaire and the requirements for completing the questionnaire. The questionnaire was administered only after participants had gained a complete understanding of the content. The researchers validated the completeness of the questionnaire, addressing any unclear responses through immediate clarification. Data entry was conducted by two individuals and cross-verified for accuracy.

## Statistical Methods

SPSS 25.0 software was used for data analysis. Normally distributed data were described as mean ± standard deviation, and groups were compared using the *t*-test. Non-normally distributed data were expressed as median and quartiles, and groups were compared using nonparametric tests. Qualitative data were presented as frequency, proportion, or percentage, and intergroup comparisons were made using chi-square and Fisher's exact test. A difference with $P < 0.05$ was considered statistically significant.

# Results

Initially, 1163 nurses met the inclusion and exclusion criteria, and 400 nurses were included in the study, with 200 nurses in each group. During the study period, three nurses withdrew from the experimental group, of which one withdrew during the study, one was transferred to another job, and one was on sick leave. Four nurses withdrew from the control group, of whom two withdrew during the study and two were on sick leave. Finally, 393 nurses were included, with 197 in the experimental group and 196 in the control group (Figure 1).

## Baseline Data

The general data of nurses in the two groups included gender, age, years of work experience, initial education level, title, role, and nature of employment. No statistically significant differences ($P > 0.05$) were observed between the general data of the nurses between the two groups (Table 2).

## Comparison of Barriers to Reporting Nursing Adverse Events Between the Two Groups

In the experimental group, the total scores for barriers to reporting adverse events and in the dimensions of punitive culture, reporting process, and reporting significance scores were 93.87 ± 6.85, 48.88 ± 4.68, 21.53 ± 4.15, and 23.40 ± 2.11, respectively, whereas the corresponding scores of the control group were 72.07 ± 6.67, 34.20 ± 6.02, 20.06 ± 3.25, and 17.36 ± 2.92, respectively. The total score of the barriers for reporting adverse events, punitive culture, reporting process, and reporting significance scores of the nurses in the experimental group were significantly higher than those of the control group ($P < 0.01$) (Table 3).

## Comparison of nursing adverse event reporting awareness, reporting intentions, and reporting habits between the two groups

The data of the two groups of nurses' adverse event reporting awareness, reporting intention, and reporting habits did not conform to normal distribution after testing; hence, nonparametric tests were performed. The results showed that the scores of nurses' adverse event reporting awareness, reporting intention, and reporting habits in the experimental group (8.00 [7.00, 8.00], 15.00 [15.00, 15.00], and 15.00 [15.00, 16.00], respectively) were significantly higher than those in the control group (7.00 [6.00, 8.00], 15.00 [13.25, 15.00], and 15.00 [12.00, 16.00], respectively) ($P < 0.01$; Table 4).

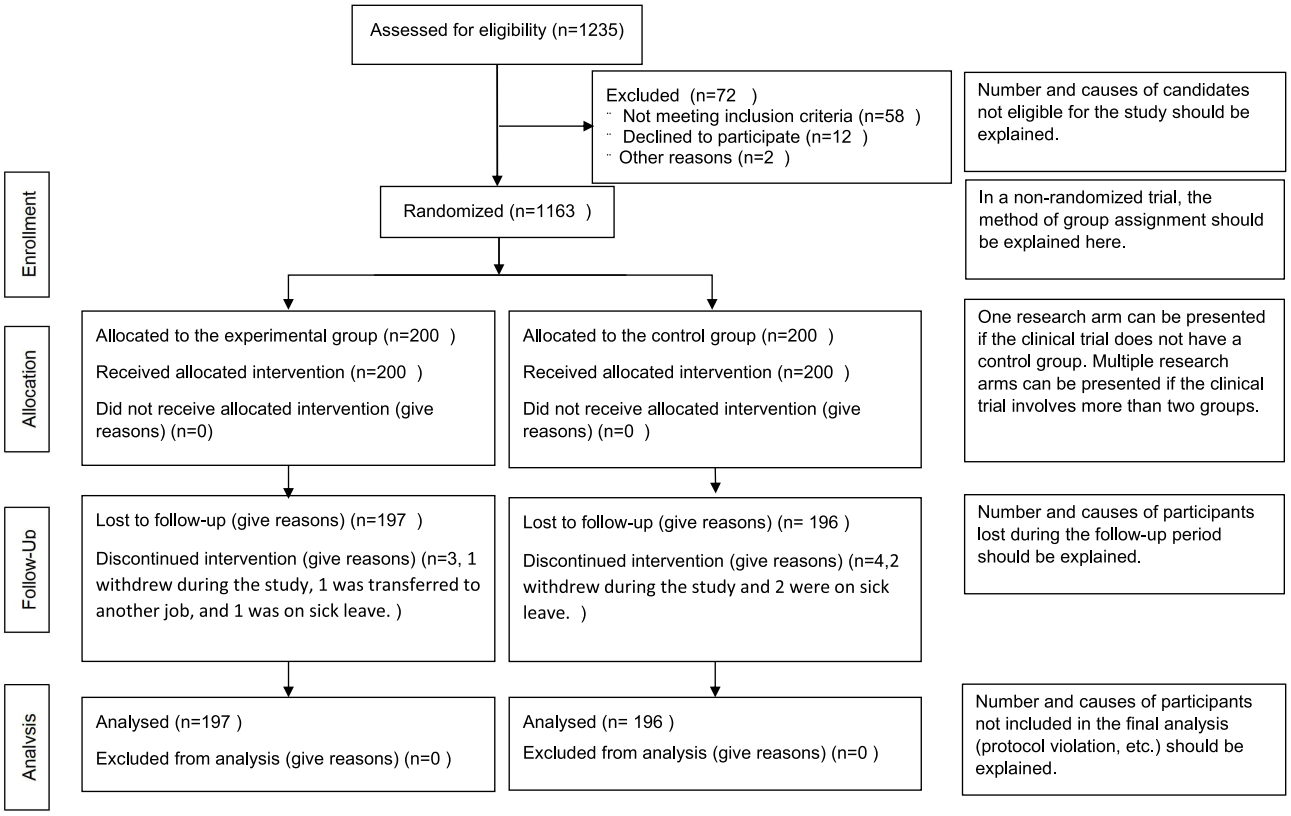


**Figure 1** CONSORT 2010 flow diagram.

## Comparison of Nurses' Responses to Nursing Adverse Events of Different Severity Levels Between the Two Groups

When responding to nursing adverse events of various severity, the only exception to statistically significant differences between the groups was in "reporting to the head nurse" for medium-severity incidents (P = 0.302). However, the experimental group demonstrated significantly higher rates of "submitting an adverse event report", "reporting to the head nurse", and "discussing with colleagues" than those in the control group regardless of the severity of the adverse event (P < 0.01; Table 5).

**Table 2** Comparison of General Information of Nurses in the Two Groups

| Variable | | Control group (n = 196) | Experimental Group (n = 197) | Test Statistic | P-value |
|---|---|---|---|---|---|
| Sex (n [percentage, %]) | Male | 15 (7.65) | 13 (6.60) | 0.165[a] | 0.685 |
| | Female | 181 (92.35) | 184 (93.40) | | |
| Age (years, M ± SD) | | 31.81 ± 6.684 | 32.96 ± 6.993 | −1.664[b] | 0.097 |
| Years of work experience (n [percentage, %]) | <1 year | 9 (4.59) | 3 (1.52) | 4.734[a] | 0.316 |
| | 1–3 years | 31 (15.82) | 35 (17.77) | | |
| | 3–5 years | 31 (15.82) | 31 (15.74) | | |
| | 5–10 years | 71 (36.22) | 63 (31.98) | | |
| | ≥10 years | 54 (27.55) | 65 (32.99) | | |

(*Continued*)

**Table 2** (Continued).

| Variable | | Control group (n = 196) | Experimental Group (n = 197) | Test Statistic | P-value |
|---|---|---|---|---|---|
| Initial education level (n [percentage, %]) | College and below | 24 (12.24) | 26 (13.20) | 1.473[a] | 0.479 |
| | Undergraduate degree | 119 (60.71) | 108 (54.82) | | |
| | Master's degree and above | 53 (27.04) | 63 (31.98) | | |
| Title (n [percentage, %]) | Nurse | 47 (23.98) | 32 (16.24) | 6.475[c] | 0.166 |
| | Senior nurse | 101 (51.53) | 102 (51.78) | | |
| | Chief nurse | 40 (20.41) | 52 (26.40) | | |
| | Deputy chief nurse | 8 (4.08) | 9 (4.57) | | |
| | Head nurse | 0 (0.00) | 2 (1.01) | | |
| Role (n [percentage, %]) | Nurse | 187 (95.41) | 183 (92.89) | 1.128[a] | 0.288 |
| | Nursing manager | 9 (4.59) | 14 (7.11) | | |
| Nature of employment (n [percentage, %]) | Permanent | 54 (27.55) | 41 (20.81) | 3.002[c] | 0.391 |
| | Contract | 129 (65.82) | 139 (70.56) | | |
| | Probation | 11 (5.61) | 13 (6.60) | | |
| | Other (including temporary) | 2 (1.02) | 4 (2.03) | | |

**Notes**: a, $\chi^2$ values; b, t-values; c, Fisher's exact test. M ± SD, mean ± standard deviation.

**Table 3** Comparison of Barriers to Reporting Nursing Adverse Events Scores Between the Two Groups of Nurses

| Variables | Control Group (n = 196) | Experimental Group (n = 197) | t-Value | P-value | Cohen's d |
|---|---|---|---|---|---|
| Barriers to reporting (M ± SD) | 72.07 ± 6.67 | 93.87 ± 6.85 | −31.986 | 0.000 | −3.22 |
| Dimension 1: Punitive culture (M ± SD) | 34.20 ± 6.02 | 48.88 ± 4.68 | −26.981 | 0.000 | −2.72 |
| Dimension 2: Reporting process (M ± SD) | 20.06 ± 3.25 | 21.53 ± 4.15 | −3.920 | 0.000 | −0.39 |
| Dimension 3: Reporting significance (M ± SD) | 17.36 ± 2.92 | 23.40 ± 2.11 | −23.465 | 0.000 | −2.38 |

**Note**: M ± SD, mean ± standard deviation.

**Table 4** Comparison of Nurses' Awareness of Reporting Nursing Adverse Events, Reporting Intention, and Reporting Habits Between the Two Groups

| Variables | Control Group (n = 196) | Experimental Group (n = 197) | Z-Value | P-value |
|---|---|---|---|---|
| Reporting awareness | 7.00 (6.00, 8.00) | 8.00 (7.00, 8.00) | −6.363 | 0.000 |
| Reporting intention | 15.00 (13.25, 15.00) | 15.00 (15.00, 15.00) | −6.670 | 0.000 |
| Reporting habits | 15.00 (12.00, 16.00) | 15.00 (15.00, 16.00) | −4.547 | 0.000 |

**Table 5** Comparison of Nurses' Responses to Nursing Adverse Events of Different Severity Levels in the Two Groups

| Nursing Adverse Event Level And Response | | Control Group (n = 196, %) | | Experimental Group (n = 197, %) | | Test Statistic | P-value |
|---|---|---|---|---|---|---|---|
| | | Yes | No or unclear | Yes | No or unclear | | |
| Potential loophole | Submission of adverse event reports | 159 (81.12) | 37 (18.88) | 189 (95.94) | 8 (4.06) | 21.273[a] | 0.000 |
| | Reporting to the head nurse | 179 (91.33) | 17 (8.67) | 196 (99.49) | 1 (0.51) | 14.990[a] | 0.000 |
| | Discussion with colleagues | 191 (97.45) | 5 (2.55) | 197(100.00) | 0 (0.00) | 7.002[b] | 0.008 |
| Did not cause injury | Submission of adverse event reports | 153 (78.06) | 43 (21.94) | 191 (96.95) | 6 (3.05) | 32.134[a] | 0.000 |
| | Reporting to the head nurse | 174 (88.78) | 22 (11.22) | 195 (98.98) | 2(1.02) | 17.859[a] | 0.000 |
| | Discussion with colleagues | 182 (92.86) | 14 (7.14) | 196 (99.49) | 1 (0.51) | 11.783[a] | 0.001 |
| Causes minor injuries that do not require treatment | Submission of adverse event reports | 173 (88.27) | 23 (11.73) | 194 (98.48) | 3 (1.52) | 16.584[a] | 0.000 |
| | Reporting to the head nurse | 187 (95.41) | 9 (4.59) | 197(100.00) | 0 (0.00) | 12.735[b] | 0.000 |
| | Discussion with colleagues | 185 (94.39) | 11 (5.61) | 196 (99.49) | 1 (0.51) | 8.648[a] | 0.003 |
| Resulted in moderate injury | Submission of adverse event reports | 187 (95.41) | 9 (4.59) | 196 (99.49) | 1 (0.51) | 7. 570[b] | 0.006 |
| | Reporting to the head nurse | 193 (98.47) | 3 (1.53) | 196 (99.49) | 1 (0.51) | 1.067[b] | 0.302 |
| | Discussion with colleagues | 189 (96.43) | 7 (3.57) | 196 (99.49) | 1 (0.51) | 5.187[b] | 0.023 |
| Causing serious injury or death | Submission of adverse event reports | 188 (95.92) | 8 (4.08) | 197(100.00) | 0 (0.00) | 11.298[b] | 0.001 |
| | Reporting to the head nurse | 191 (97.45) | 5 (2.55) | 197(100.00) | 0 (0.00) | 7.022[b] | 0.008 |
| | Discussion with colleagues | 185 (94.39) | 11 (5.61) | 195 (98.98) | 2(1.02) | 6.491[a] | 0.011 |

**Note**: a, $\chi^2$ value; b, Fisher's exact test.

# Discussion

This study aimed to explore an optimization method of WeChat platform training and interaction design based on CLT to reduce the cognitive load of nurses in the training and learning process, improve the learning effect, reduce the barriers to report adverse events among clinical nurses, enhance their willingness and behavior to report. The above results showed that the scores of nurses' adverse event reporting barriers, adverse event reporting awareness, intention, and habits in the experimental group were higher than those in the control group, showing that WeChat training combined with CLT improved the learning effect of nurses' adverse event knowledge and skills.

## Cognitive Load Theory-Based WeChat Platform Training Reduced Barriers Among Nurses to Report Adverse Events

The results in Table 3 demonstrated that the total scores of nurses' barriers for reporting adverse events, punitive culture, reporting process, and reporting significance scores in the experimental group were significantly higher than those in the

control group ($P < 0.01$). These findings indicate that the barriers to reporting among nurses in the experimental group were lower than those in the control group. In other words, nurses in the experimental group were more inclined to report adverse events, which is consistent with the findings of Wang et al,[42] who applied CLT to interaction design, interface design, and learning of online learning platforms.

Content design focused on three key aspects: enhancing interaction on the online learning platform, simplifying the interface by removing unnecessary information, and modularizing learning content to improve learning efficiency and instructional quality. First, through modular, interactive, and personalized learning on the WeChat platform, nurses were able to gain a clearer understanding of the importance of adverse event reporting in ensuring patient safety and improving nursing care quality.[43,44] This increased understanding helped reduce nurses' hesitations and barriers during the reporting process. Second, the WeChat training platform's anonymous reporting function and the design of a positive community feedback mechanism helped reduce nurses' concerns about possible negative consequences.[45] Furthermore, through typical case-sharing discussions, nurses were able to gain a deeper understanding of the purpose and significance of adverse event reporting, which helped reduce their perceptions of a punitive culture and thus barriers to reporting.[46]

Although the training model yielded positive results in reducing nurses' barriers to reporting, our study was less effective in improving the "reporting process" dimension than that in the study by Liu et al.[47] This may be attributed to the optimization of the hospital's original reporting process in their study, thereby reducing the reporting pressure on nurses and reducing the barriers to reporting in this dimension. Moreover, their training content focused on hands-on practice and simulation exercises, whereas our study did not simplify the reporting process. This highlights the importance of implementing systematic changes in hospital processes and enhancing hands-on practice to drive behavioral change among nurses.

## Cognitive load theory-based WeChat platform enhanced nurses' reporting awareness and reporting intention levels as well as improved nurses' reporting habits

The results of the study showed that the nurses in the experimental group had significantly higher reporting awareness scores than those in the control group, indicating that this training method is effective in improving nurses' awareness level of reporting adverse events, which is consistent with the findings of Smith.[25] Their study showed a decrease in students' mental effort and intrinsic load when using the CLT combined with active learning strategies in nursing classrooms, as this instructional design allows learning activities to be presented in simple to complex ways. CLT principles were integrated into WeChat to make the process of information transmission and processing more precise, thus reducing unnecessary cognitive load and improving the learning efficiency of nurses. In addition, the WeChat platform's modular and hierarchical design, simplified interface, and detailed navigational steps helped nurses better retain relevant knowledge, enhancing their understanding and execution of adverse event reporting.[48,49]

The nurses in the experimental group also had significantly higher reporting intention scores than the control group. This may be attributed to the CLT-based WeChat training model, which stimulated nurses' intrinsic motivation through interactive case sharing, discussions, and feedback sessions, thereby enhancing their willingness to report adverse events.[43] In addition, the introduction of assessments and incentives provided positive feedback to nurses, which promoted reporting behaviors. This finding revealed the potential of this training model to motivate nurses to report adverse events and that nursing managers can improve the cohesiveness and efficiency of their nursing teams by introducing similar training platforms to facilitate communication and collaboration among nurses. However, a previous study revealed that although educational interventions can improve nurses' knowledge and skills, they do not always translate into actual reporting behaviors,[50] and the role of organizational culture and supportive work environments in contributing to nurses' reporting behaviors should not be overlooked.

In addition, the results of the study showed that the training model positively impacted nurses' adverse event reporting habits. By modularizing the four most common types of adverse events (pressure injuries, falls, unplanned extubation, and checking errors), establishing corresponding reporting process learning modules for each type, and conducting hands-on exercises, the organization and presentation of information was optimized to reduce the cognitive load on the students when processing the information. Clear navigation and immediate feedback during the learning

process improved nurses' understanding of the adverse event reporting process and enhanced nurses' engagement and learning motivation, which promoted better reporting habits.[51–54]

## Impact of Cognitive Load Theory-Based WeChat Training Platform on Nurses' Coping Styles in Response to Different Levels of Adverse Events

The results in Table 5 indicate that the CLT-based WeChat platform effectively improved nurses' ability to respond to different levels of adverse events. The platform helped nurses quickly recognize the severity of an incident and develop appropriate response strategies through modular learning, case studies, and immediate feedback. This design reduced the cognitive load on nurses when processing complex information and improved long-term memory and skill transfer through simulation exercises that closely resemble real-life situations.[55] Compared with previous studies,[47] the present study introduced an innovative application of CLT to a widely used social platform, which provided nurses with educational experiences that were more consistent with their work and learning needs and had a higher degree of flexibility and personalization compared with traditional training. These characteristics follow the current trend of digitalized education.[56,57] Therefore, clinical administrators should consider incorporating this type of training into continuing education and professional development programs for nursing teams to achieve continuous quality improvement and improve patient safety.

However, the results of the study showed that there was no statistically significant difference between the two groups of nurses in response to moderate injuries for "reporting to the head nurse." This is likely because nurses are already relatively experienced and aware of reporting moderate adverse incidents. Regardless of whether or not they have received training on the WeChat platform, they tended to act according to the established process, and this culture may have been internalized into the nurses' daily work habits, reducing the effect of training on reporting behavior.[58] In addition, the uneven distribution of the sample and factors such as workload, resource availability, and time pressure may affect nurses' reporting behaviors, masking differences in training effectiveness and leading to statistically insignificant results.[59,60] Future studies should consider these potential factors to more accurately assess the impact of training on nurse-reported behaviors.[61,62]

In recent years, some scholars have applied different training models to nurse safety training and achieved good results. Zhao et al[63] recorded standard operation videos and nursing adverse event case videos based on nursing safety training content and compiled loose-leaf textbooks. These resources were used in the nursing safety training of new nurses to effectively improve the safety awareness and adherence to standardized procedures. Zeng et al[64] believed that the occurrence of adverse events was mostly due to the failure to strictly abide by the core system. Therefore, they integrated theoretical knowledge with practical clinical work based on situational cognitive theory and developed a clinical training checklist covering 11 core nursing systems. This approach allowed junior nurses to learn in real clinical settings and complete nursing safety training through hands-on practice, yielding positive results. In addition, the mind map combined with the case teaching method, as studied by Li et al,[65] can stimulate new surgical nurses' interest and initiative in learning. This approach enhances their ability to construct knowledge independently, strengthens their understanding of clinical nursing safety, encourages critical thinking, facilitates cognitive transformation, and improves nursing safety awareness. Ultimately, it helps guide their safety behaviors, reducing the incidence of adverse events and ensuring patient safety.

Our findings support the hypothesis that the CLT-based WeChat training platform significantly reduces nurses' barriers to reporting adverse events and enhances their reporting behaviors. Thus, the integration of CLT into training platforms can be an effective strategy for improving patient safety and nursing care quality.

# Limitations

This study has the following limitations: First, the respondents were included from one tertiary hospital, which may limit the generalizability of the results. Second, because the duration of the intervention was short, there was a lack of long-term outcome assessment, and individual differences and organizational culture effects were not adequately considered. Third, this study did not use blinding, which may increase the intervention process and other bias in data collection and analysis. Fourth,

this study did not examine the barriers to reporting adverse events, cognitive levels, intentions, habits, or other related factors among nurses in both groups before the intervention. Additionally, the measurement of cognitive load was not included as an observation indicator. Finally, nurses' workload and department categories may also affect the research results.

We also acknowledge the limitation that the WeChat platform system design did not incorporate features to track module visit counts, individual learning time, progress, or test scores. The lack of module-specific engagement metrics (eg, time spent and completion rates) restricts our ability to analyze learning effectiveness. Future studies should integrate automated tracking systems to address this gap.

Future studies should expand the sample size, conduct long-term follow-ups, and consider multifactorial influences to enhance the study's breadth and depth.

## Conclusion

This study confirmed our hypothesis that a CLT-based WeChat training platform could effectively reduce barriers to adverse event reporting, enhance nurses' awareness and intention to report, and improve their reporting behaviors. Therefore, clinical administrators should consider incorporating this type of training into continuing education and professional development programs for the nursing teams. Furthermore, efforts should be made to create a safe organizational culture and a supportive work environment in contributing to nurses' reporting behaviors to achieve continuous quality improvement and improve patient safety.

## Ethics Approval and Informed Consent

This study was approved by the ethics review committee of the Handan First Hospital (No. 2020-K-81) and all participants provided written informed consent.

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## Author Contributions

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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