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Facilitators and barriers to evidence adoption for central venous catheters post-insertion maintenance in oncology nurses: a multi-center mixed methods study

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Abstract

Background The post-insertion maintenance of central venous catheters(CVCs)is a common, vital procedure undertaken by nurses. Existing literature lacks a comprehensive review of evidence adoption for CVCs post-insertion maintenance specifically within the oncology context. This investigation assessed evidence-based practice by oncology nurses in the care of CVCs, elucidating facilitators and obstacles to this adoption process.

Methods This was a sequential explanatory mixed methods study, executed from May 2022 to April 2023, adhering to the GRAMMS checklist. The study commenced with a cross-sectional study through clinical observation that scrutinized the adoption of scientific evidence for CVC maintenance, analyzing 1314 records from five hospitals in China. Subsequently, a semi-structured, in-depth interview with nurses based on the i-PARIHS framework was conducted to ascertain facilitators and barriers to evidence adoption for CVCs post-insertion maintenance. Fifteen nurses were recruited through purposive sampling. Descriptive statistics were used to summarize quantitative data, while content analysis was used to analyze qualitative data.

Results An overall compliance rate of 90.0% was observed; however, two domains exhibited a lower adoption rate of less than 80%, namely disinfection of infusion connector and disinfection of skin and catheter. Three barriers and two facilitators were discerned from the interviews. Barriers encompassed (1) difficulty in accessing the evidence, (2) lack of involvement from nurse specialists, and (3) challenges from internal and external environments. Facilitators comprised (1) the positive attitudes of specialist nurses toward evidence application, and (2) the formation of a team specializing in intravenous therapy within hospitals.

Conclusion There exists a significant opportunity to improve the adoption of evidence-based practices for CVC maintenance. Considering the identified barriers and facilitators, targeted interventions should be conceived and implemented at the organizational level to augment oncology evidence-based practice, especially the clinical evidence pertinent to infection control protocols.

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Keywords Central venous catheters, Evidence-based practice, Facilitators, Barriers, Oncology nursing

Background

Catheter technology has evolved to accommodate the multifaceted medical necessities of disparate patient populations [1]. Central venous catheters (CVCs) instruments essential for chemotherapy, parenteral nutrition, hemodynamic monitoring, and other interventions, are often inserted into oncology patients [2, 3]. This insertion disrupts skin integrity, thereby heightening the susceptibility of patients to infections. Concurrently, the immunosuppression engendered by chemotherapy and radiotherapy [4, 5], amplifies the risk for CVC-associated complications, such as bloodstream infection, thrombosis, and catheter malfunction [3]. The estimated incidence of CVC-related infections in oncology patients ranges from 0.5 to10 per 1000 CVC-days [6, 7], with variations in the incidence of CVC-associated thrombi ranging from 27 to 66%, when assessed by routine screening venography [3, 8]. Unforeseen catheter removal necessitated by these complications, can induce anxiety, pain, helplessness, and apprehension regarding subsequent catheter injection [9].

Post-insertion management is pivotal in circumventing catheter-related complications, including infections, thromboses, and mechanical injuries. Numerous institutions and regulatory bodies have promulgated recommendations and guidelines to mitigate these complications [10–12]. Despite the critical nature of adherence to these protocols in clinical environments, compliance among healthcare professionals is frequently suboptimal, as evidenced by studies indicating merely 60% adherence to guidelines pertaining to CVC post-insertion management [13]. Remarkably, no extant research has reviewed nursing compliance for post-insertion management of CVCs within the context of Chinese oncology patients.

Evidence-based practice, a cornerstone of clinical care across various countries, including China, demands a progressive and time-consuming adoption process by healthcare professionals. Existing literature underscores a temporal span of 17 years for research findings to be integrated into clinical routines [14], with only half eventually achieving widespread acceptance [15]. Evidence-based nursing emphasizes that nurses should not only identify and implement best practices for patients, but also integrate these practices with their clinical experience [16]. This paradigm emphasizes that nurses should synergize best-evidence practice with clinical experience, ensuring that implementation is a confluence of optimal evidence and consideration of patient's unique situation, medical requirements, resource accessibility, environmental conditions, collaborative dynamics, and potential hindrances [17, 18].

Examined through the lens of implementation science, the adoption of clinical practice guidelines for CVCs encounters various challenges and obstructions. These include the inherent complexity of the evidence, the multifaceted nature of the healthcare environment, financial constraints, personnel receptivity, and organizational policies [19–21]. Ascertaining facilitators and barriers to evidence adoption for CVCs post-insertion maintenance represents an essential and foundational step in transmuting optimal evidence into tangible clinical practice. In this context, the i-PARIHS (integrated Promoting Action on Research Implementation in Health Services) framework serves as a prominent model in implementation science, illustrating pathways for successful guideline promotion and assimilation within clinical settings, by focusing on innovation, recipients of change and context, as well as facilitation impacts [22, 23].

The i-PARIHS framework was employed to navigate our qualitative interview, delineating the facilitators and barriers to compliance with the evidence-based practice in post-insertion maintenance for CVCs within oncological contexts. This framework, multi-dimensional in its construct, elucidates the modalities through which successful promotion and implementation of guidelines may transpire in clinical environments [24]. Within the i-PARIHS framework, four core components are instrumental for translating evidence into practice. These components are encapsulated in the framework's core conceptual equation: SI=Facn(I+R+C) (SI: Successful Implementation of evidence; Facn: Facilitation; I: Innovation; R: Recipients; C: Context) [25]. Within this equation, 'innovation' encompasses not only the intervention itself, but also the underlying evidence informing it. 'Recipients' denote those individuals or collectives affected by or exerting influence over the implementation process, while 'context' integrates both the internal and external environmental variables. Additionally, 'facilitation' alludes to specific elements that may expedite the translation of evidence-based practice [25–27]. The successful implementation of evidence into clinical practice is conceptualized as a resultant synthesis of innovation, recipients, context, and facilitation [27]. In oncology nursing, the i-PARIHS framework can assist cancer nurses in exploring the determinants of evidence-based nursing and integrating the best evidence or innovations into clinical settings, enabling cancer nurses to deliver

high-quality supportive cancer care through facilitating factors such as multidisciplinary cooperation and resource integration. For example, Roberts et al [28] conducted a descriptive mixed method in supportive cancer care and evaluated the utility of the i-PARIHS framework for introducing patient-reported outcome measures into oncology patients. In the qualitative segment of this investigation, we sought to harness the i-PARIHS framework to dissect the nuanced interplay of these components, thereby enriching our comprehension of the implementation dynamics governing post-insertion management for CVCs within oncological settings.

Presently, literature is deficient in studies investigating the adoption of scientific evidence in post-insertion management for CVCs within the Chinese oncology nursing community. Moreover, few have applied the i-PARIHS framework for evaluation purposes [25, 29, 30]. To redress this scholarly deficiency, the present study endeavored to appraise the adoption of scientific evidence in post-insertion management for CVCs by oncology nurses in China. Crucially, we harnessed the i-PARIHS framework to delineate facilitators and barriers to evidence adoption for CVCs post-insertion maintenance, employing qualitative interviews, as an exemplary method to garner profound insights into these influential factors.

Methods

Design

This investigation comprised a sequential explanatory mixed-methods study spanning multiple centers, conducted between May 2022 to April 2023. It commenced with a cross-sectional study from May 2022 to January 2023, followed by a qualitative study from February 2023 to April 2023. In the qualitative phase, a deductive method based on the i-PARIHS framework was used to explore barriers and facilitators to evidence adoption for CVCs post-insertion maintenance. Compliance with the GRAMMS checklist was maintained throughout the process.

Sample and sampling

The parallel mixed methods sampling [31] and purposive sampling strategy were used to select suitable participants, the informants of the interview were a subset of the quantitative study. For the quantitative part, nurses who fulfilled this inclusion criteria were included: caring patients having an established cancer diagnosis with a CVC, defined as a catheter introduced into the internal jugular vein, subclavian vein, or femoral vein. Regarding the qualitative study, the inclusion criteria for informants were: (1) involvement in the observation study; (2) completion of national or provincial specialized intravenous nurse training courses (exceeding 3 months) and attainment of corresponding qualifications; (3) registration as nurses delivering intravenous therapy for a period surpassing 5 years post-qualification; (4) direct care provision to cancer patients; and (5) voluntary participation in the interviews with informed consent. Exclusion criteria were applied to nurses who had resigned from hospital settings. Data saturation was realized upon conducting interviews with 15 informants.

Setting and data collection

The investigation encompassed oncology wards across five hospitals in China, namely Henan Cancer Hospital, Zhengzhou Central Hospital, Luohe Central Hospital, Sanmenxia Central Hospital, and Pingdingshan Hospital. Each of these tertiary-level hospitals housed approximately 1000–3000 beds. All CVCs within these institutions were positioned by designated venous catheterization centers following a uniform protocol. Additionally, oncology ward nurses underwent specific training on the post-insertion management of CVCs.

In the quantitative phase, to assess the evidence adoption for CVCs post-insertion maintenance within oncology wards, an audit team was formed, which comprised five nursing managers and ten intravenous therapy nurse specialists from five research centers. The audit members were from different parts of different organizations and had no working relationship with the nurses being evaluated. The research team also devised an audit checklist to scrutinize the adoption of scientific evidence in the post-insertion management of CVCs and conducted clinical observation. The audit checklist encompassed 30 items, stratified into 10 distinct domains: (1) hand hygiene, (2) assessment, (3) infusion connector disinfection, (4) infusion connector replacement, (5) infusion device replacement, (6) confirmation of in-situ catheter, (7) catheter and skin disinfection, (8) catheter dressing and fixation, (9) flushing, and (10) catheter covering. Supplementary file 1 delineates the checklist in detail. All participating oncology nurses were subsequently assessed through clinical observation utilizing this checklist to ascertain their adherence to scientific evidence in post-insertion management. Audit criteria were dichotomized, with "yes" signifying compliance with recommended practice, and "no" indicating deviation therefrom. The evaluation commenced with the audit team screening the medical records of all patients within the oncology wards. Upon identification of patients diagnosed with cancer and inserted with CVC, a designated audit member came to the ward to appraise the adherence to scientific evidence in post-insertion management of CVCs by the patient's primary nurse, utilizing the checklist via clinical observation.

In the qualitative phase, a series of in-depth semi-structured interviews were administered by the first

author, who was a nursing manager and hailed from different departments with the informants. All informants will be informed of the quantitative findings before the interview to ensure the continuity of the two research phases. The interviews were conducted either face-to-face in a meeting room of the informants' ward or online (e.g. WeChat video calls or Tencent conferences), contingent upon the informants' preference. A semi-structured interview guide was meticulously crafted by researchers predicated upon the i-PARIHS framework and the findings in the quantitative phase. This guide was subsequently pilot-tested on two intravenous therapy nurse specialists. Supplementary file 2 elucidates the guiding inquiries of the finalized semi-structured interview guide. Before acquiring written consent, the informants were thoroughly apprised of the study's purpose and content. All interviews were diligently audio-recorded, with individual durations averaging 45 min, and ranging from 32 to 56 min.

Data analysis

Quantitative data analysis

Quantitative data procured from the cross-sectional study were analyzed using IBM SPSS v26.0. Descriptive statistics were deployed, where continuous variables were elucidated by means and standard deviations, and categorical variables by frequencies and percentages. The sample size calculation adhered to the audit checklist's item count, guided by the formula [32]: n=[Max(number of items)×(10∼15)]×[1+(10%∼15%)]. With the checklist comprising 30 items and an anticipated attrition rate of 15%, the minimal requisite sample size amounted to 518.

Qualitative data analysis

The qualitative data stemming from the interviews were scrutinized through content analysis, supported by Nvivo 10. Preliminary to the analysis, audio recordings were verbatim transcribed. A six-phase coding process was diligently followed [33]: (a) data familiarization; (b) initial code generation; (c) thematic code search; (d) theme review; (e) theme definition and naming; and (f) final analysis production. To obviate subjective bias, interview transcripts were separately coded by two researchers, well-versed in qualitative research. The data analysis employed a deductive reasoning process based on the four components of the i-PARIHS framework, including innovation, recipients, context, and facilitation. Similar codes were categorized, and interrelated categories were amalgamated to discern major themes. Subsequent dialogue and revision by the two coding researchers and the first author led to a consensus, culminating in the translation of the codebook into English by the first author.

Ethical considerations

This investigation was sanctioned by the Medical Ethics Committee of Henan Cancer Hospital (Number 2023-KY-0014). All participants were apprised that their involvement was voluntary, with strict confidentiality maintained concerning personal information, accessible solely by the research team. Moreover, adherence to the principles of the Helsinki Declaration was stringently upheld. In this study, our targeted participants were nurses who have provided care for patients with a confirmed cancer diagnosis with CVCs. Therefore, patients were not involved in the study. Screening of the patient's medical records was solely to facilitate the identification of eligible nurses, which would not involve any personal information about patients. Informed consent to participate was obtained from all the participants.

Rigors

Rigorous in the quantitative part was upheld by multiple strategies. Firstly, the developmental process of checklists allowed wide input from diverse sources regarding the checklist content [34, 35]. To ensure board sources of input to the checklist content, our team exhaustively examined pertinent evidence-based practice guidelines, expert opinions, and national and local health policies endorsed by various professional entities, including the Infusion Nursing Society [11], National Health Commission [36, 37], National Institute of Hospital Administration [38], Chinese Nursing Association [12]. The checklist further embodied salient recommendations for CVC management as stipulated by the NICE guideline [39]. The research team extracted, collated, and integrated the evidence on CVC maintenance therein into a preliminary checklist. In addition, expert testing was employed to ensure the feasibility. Two CVC specialists from the Intravenous Infusion Therapy of the Chinese Nursing Association appraised and refined the items to validate the checklist's feasibility, and the final checklist was formed. Secondly, the audit members were thoroughly briefed regarding the study's objectives, content, and procedures to ensure comprehension. Besides, comprehensive training was provided to all audit members on the checklist to evaluate the assimilation of scientific evidence in post-insertion management of CVCs, thereby enhancing inter-rater reliability.

To uphold the rigor in the qualitative part, we adhered to the criteria outlined by Guba and Lincoln [40]. Credibility was promoted by having a researcher with extensive experience in conducting qualitative research to conduct the interviews. A concerted effort to mitigate recall bias and errors through field notes and recording equipment to capture the interview process. Subsequent verbatim transcription in Mandarin was conducted within 24 h of the interviews to ensure the accuracy of the findings.

Interview transcripts were separately coded by two researchers, well-versed in qualitative research. Similar codes were categorized, and interrelated categories were amalgamated to discern major themes. Dialogue and revision by the two coding researchers and the first author led to a consensus. Additionally, throughout the interview process, the interviewer adopted empathetic techniques, including a non-judgmental stance, honoring all responses, fostering a supportive environment for the informants to divulge their emotions, and keen observation of salient non-verbal cues such as facial expressions, gestures, postures, and eye contact. To ensure transferability, purposive sampling was used to maximize the diversity of the informants in characteristics such as age, education level, and years of experience. To procure rich data and invaluable insights into informants' experiences, informants were reassured that they could articulate their perspectives without fear of judgment or reprisal. Regular consultations were held to assess the data, allowing the researchers to understand the data and avoid potential misinterpretations. To enhance both dependability and confirmability, triangulation was employed to ensure that the results aligned with informants' perceptions and experiences. Three supplementary intravenous therapy nurse specialists were enlisted to validate the findings. Their eligibility was aligned with those in the qualitative interviews. Initial engagements involved inviting the three specialists to review a thematic representation of our preliminary findings, with clarifications furnished by the interviewer. Subsequently, these specialists were encouraged to query and feedback on the tentative results and to reflect and notate comments. Transcripts were then examined employing qualitative methodologies congruent with phenomenological design. Following this process, concurrence was reached within our research team that the nurse specialists' evaluations substantiated our delineated themes, subthemes, and interpretations.

Table 1 The background characteristics of the included nurses ($n=1314$)

Variables	Frequency	Percentage
Gender		
Female	1265	96.3%
Male	49	3.7%
Years of work, mean = 8.3, SD = 4.1		
<5	378	28.8%
5–10	764	58.1%
>10	172	13.1%
Educational level		
College degree	674	51.3%
Bachelor's degree	578	44.0%
Master's degree	62	4.7%
Nurse career title level		
Nurse	259	19.7%
Primary Nurse	533	40.6%
Nurse-in-charge	495	37.7%
Associate Chief Nurse	27	2.1%
Working department		
Medical oncology department	610	46.4%
Surgical oncology department	349	26.6%
Radiotherapy oncology department	255	19.4%
Intensive care unit	69	5.3%
Other departments	31	2.4%

Results

Cross-sectional study

Background characteristics of nurses evaluated for the adoption of scientific evidence for post-insertion management of CVCs

During the designated study period, 1314 nurses were included in the evaluation. Table 1 delineates the demographic and professional characteristics of the participants. A significant majority of the participants, 96.3% were female, the mean tenure of working experience stood at 8.3 years, 51.3% of participants possessed a college degree, 40.6% were classified as primary nurses, and a substantial 92.4% originated from departments specializing in medical oncology, surgical oncology, or radiotherapy oncology.

Adoption of scientific evidence in post-insertion management for CVCs

Table 2 encapsulates the adoption of scientific evidence for post-insertion management of CVCs by oncology nurses. A total of 1,314 field observations were conducted by the evaluation team throughout the study. The cumulative adoption rate was calculated at 90.0%. Within the evaluation checklist's 10 categories, half were found to have adoption rates less than 90%, including hand hygiene, preoperative assessment, infusion connector disinfection, confirmation of in-situ catheter, and skin and catheter disinfection. Specifically, two categories exhibited a lower adoption rate of less than 80%, namely disinfection of infusion connector and disinfection of skin and catheter. Furthermore, of the 30 checklist items, 14 recommendations were identified with an adoption rate falling below 90%, including specific practices related to disinfection, blood flow management, and post-transfusion procedures. Four items that achieved less than an 80% adoption rate were the disinfection of the infusion connector, skin, and catheter.

Qualitative study

Background characteristics of the informants

Table 3 delineates the demographic attributes of the informants who partook in the interviews. Among them, the mean age was 34.0 years, with 14 females and 9

Table 2 The checklist and clinical practice status of CVC maintenance ($n=1314$)

Item	Yes		No	
	n	%	*n*	%
1. Hand hygiene*	-	87.7	-	12.3
1.1 Before operation	1141	86.8	173	13.2
1.2 During operation	1145	87.1	169	12.9
1.3 After operation	1171	89.1	143	10.9
2. Assessment before operation*	-	87.4	-	12.6
2.1 Assess the puncture point and surrounding skin for signs of infection	1163	88.5	151	11.5
2.2 Assess catheter fixation, catheter function and necessity of indwelling	1133	86.2	181	13.8
3. Infusion connector disinfection*	-	79.3	-	20.7
3.1 Use alcohol cotton pads to wipe and disinfect cross section of the infusion connector and its periphery for 5 ~ 15 s	1080	82.2	234	17.8
3.2 Connector can be used after disinfectant is naturally dried	1002	76.3	312	23.7
4. Infusion connector replacement*	-	93.0	-	7.0
4.1 Replace at least every 7 days	1283	97.6	31	2.4
4.2 Infusion connector should be replaced when there is blood or drug residues, or suspected contamination, damage or disengagement	1162	88.4	152	11.6
5. **Infusion device replacement***	-	93.2	-	6.8
5.1 Infusion device should be replaced after 24 h of infusion	1289	98.1	25	1.9
5.2 Infusion device should be replaced every 4 h when infusing special drugs (such as propofol, fat emulsion, etc.)	1160	88.3	154	11.7
6. **Confirming of in-situ catheter***	-	87.6	-	12.4
6.1 Draw back blood to check if the catheter is in situ	1256	95.6	58	4.4
6.2 Blood return should be unobstructed before infusing of irritant and corrosive drugs	1047	79.7	267	20.3
7. Catheter and skin disinfection*	-	79.0	-	21.0
7.1 Wipe and disinfect the skin and catheter with the puncture point as the center, the skin disinfection area is larger than the dressing area (15 cm*15 cm)	1029	78.3	285	21.7
7.2 Use 75% alcohol to disinfect 3 times first, then use chlorhexidine gluconate alcohol cis-reverse-shun disinfection 3 times	850	64.7	464	35.3
7.3 Disinfectant is natural dried, do not use antibacterial ointment or emulsion at the puncture site	1234	93.9	80	6.1
8. Catheter dressing and fixation*	-	93.7	-	6.3
8.1 Sterile gauze dressing should be replaced every 2 days	1252	95.3	62	4.7
8.2 Sterile transparent dressing should be replaced at least every 7 days	1294	98.5	20	1.5
8.3 Replacement should be implemented when there is bleeding, exudation at the puncture point, or the dressing is curled, loose, wet, contaminated or damaged in integrity	1199	91.2	115	8.8
8.4 Choose sterile transparent dressing and cover the puncture site with the puncture point as the center	1247	94.9	67	5.1
8.5 Sterile transparent dressing should be pasted without tension	1139	86.7	175	13.3
8.6 For patients with skin lesions and allergies who are not suitable for adhesive dressings, gauze or functional dressings can be used	1282	97.6	32	2.4
8.7 Replacement time should be marked on outside of the dressing	1204	91.6	110	8.4
9. Flushing*	-	93.9	-	6.1
9.1 One-time single-dose normal saline should be used as flushing fluid, and the volume of flushing fluid should be at least twice of the volume of the catheter and additional devices	1271	96.7	43	3.3
9.2 Use 10 ml or more syringe, or pre-filled catheter flusher to flush tube	1258	95.7	56	4.3
9.3 Flush the tube fully after blood transfusion or infusion of special drugs (such as propofol, fat emulsion, etc.)	1124	85.5	190	14.5
9.4 Flush the tube at least once every 7 days during intermittent period	1279	97.3	35	2.7
9.5 Flushing with pulse technology "push-stop-push", do not flush the tube forcibly when encountering resistance	1239	94.3	75	5.7
10. **Catheter covering***	-	96.3	-	3.7
10.1 Cover the tube with normal saline or 0-10U/ml heparin solution	1242	94.5	72	5.5
10.2 The tube covering solution should be covered with positive pressure for one person, one needle, one tube, one agent, one using	1290	98.2	24	1.8

Notes: *referring that the result of category is the mean of the sub-items

Table 3 The background characteristics of informants ($n = 15$)

Variables	Frequency
Gender	
Female	14
Male	1
Age, years, mean = 34.0, SD = 7.1	
<30	2
30–40	10
>40	3
Educational level	
College degree	2
Bachelor's degree	9
Master's degree	4
Marital status	
Married	14
Single	1
Nurse career title level	
Primary Nurse	1
Nurse-in-charge	6
Associate Chief Nurse	8
Years as nurse, mean = 13.7, SD = 5.2	
0–10	2
11–20	5
21–30	7
>30	1
Years as specialist nurse, mean = 8.1, SD = 4.6	
5–10	3
11–15	7
>15	5
Interview methods	
Face-to-face interview	11
Online interview	4

Table 4 The main themes of qualitative interview mapping to the i-PARHIS framework

Determinants	Themes	Subthemes	Mapping to i-PARHIS
Barriers of Compliance	Difficulty in accessing the evidence	Insufficiency of Training on Research Skills for Appraisal and Synthesis of Evidence	Innovation
		Clinical Applicability of Evidence	
		Sustainability in Applying the Evidence	
	Lack of Involvement from Nurse Specialists	Absence of Participation in the Evidence-Translation Process	Recipients
		Insufficiency of Nurse Specialists to Oversee the Quality of Care	
		Difficulty in Achieving Consensus with Medical Staff	
	Challenges from Internal and External Environments	Inadequate Atmosphere for Internal Change	Context
		Paucity of External Support	
Facilitators of Compliance	Positive Attitudes of Specialist Nurses Toward Evidence Application		Facilitation
	Formation of a Team Specializing in Intravenous Therapy within Hospitals		

holding a bachelor's degree. Additionally, 12 had served in the specialized role of a CVC nurse for more than 11 years.

Barriers to compliance

Through an analysis of the semi-structured interviews, three barriers were discerned that may hinder the adoption of scientific evidence in post-insertion management for CVCs within oncology settings, mapping to three components of i-PARIHS framework of innovation, recipient, and context, shown in Table 4.

Theme 1: Difficulty in accessing the evidence (Innovation)

Subtheme 1: insufficiency of training on research skills for appraisal and synthesis of evidence

Concurrent with the evolution of evidence-based practice, the proliferation of high-quality evidence continues to unfold. A significant proportion of informants recognized the critical role of evidence-based practice in patient outcomes, they concurred that accessing high-quality evidence constitutes the preliminary stage of evidence-based practice. The informants expressed a keen motivation to acquire knowledge on optimal post-insertion management strategies for CVCs. Nonetheless, they were confronted with a paucity of training on research, resulting in uncertainty regarding where to locate evidence and how to evaluate its quality amidst an expanding volume of available evidence. The evidence at hand was occasionally disjointed or even contradictory, thereby posing challenges to the informants in synthesizing it to guide their clinical practice. As articulated by one informant:

> *"The landscape of evidence concerning post-insertion management for CVCs is in a constant state of flux. Regrettably, my knowledge remains anchored to guidelines published several years prior. Although I aspire to familiarize myself with the most current guidelines, I am at a loss as to where to obtain them." (N.5).*

Another informant stressed the need for institutional support, stating:

"It would be beneficial if the hospital could facilitate research training or directly identify and disseminate the pertinent guidelines. We could then integrate these guidelines into our practice." (N.7).

Yet another shared a similar sentiment, remarking:

"With the myriad of evidence available for post-insertion management, I often encounter fragmented evidence across various channels, such as WeChat accounts. Lacking training in research, I find myself uncertain of the reliability of these pieces of evidence and, consequently, refrain from applying them." (N.9).

Subtheme 2. Clinical applicability of evidence

The informants predominantly emphasized that the clinical applicability of evidence was a decisive factor influencing the feasibility of implementation. Specifically, they stressed that the evidence must be aligned with patient needs and seamlessly integrated into clinical environments. Certain occurrences, such as blood oozing at the puncture site after coughing, rendered some recommendations impracticable. Without careful adaptation, the direct application of recommended practices could present frontline nurses with considerable obstacles, leading to a loss of motivation. An informant in the semi-structured interview highlighted this, stating:

"According to the latest guidelines for CVC care, immediate replacement is mandated in cases of exudation. Yet, it is common for patients to cough after surgery, thus, blood oozing is inevitable. The consequent necessity to repeatedly change dressings not only escalates the nursing workload but also meets with disapproval from patients. Therefore, this recommendation is virtually infeasible to implement." (N.8).

Another informant expressed similar concerns, saying:

"Changes to workflows, such as methods of catheter disinfection, changed after implementing the new practice. The initial adaptation was challenging. Regular training and reinforcement are imperative to secure compliance. Additionally, a flowchart could serve to elucidate the procedures involved in executing the new practice." (N.10).

One more informant also noted:

"The guideline prescribes a specific area for disinfection, yet the suitability of this may vary depending on the anatomical location of CVC insertion. Thus, the stipulated size of the disinfection area is often impractical in a clinical context. Adhering to it rigidly would augment the complexity of our operations." (N.6).

Subtheme 3: sustainability in applying the evidence

The interviews revealed that although training on post-insertion maintenance for CVCs had been conducted within hospitals and oncology departments, the sustenance and enhancement of its application were predominantly contingent on nursing managers. A glaring absence of corresponding policies and oversight mechanisms to encourage compliance with post-insertion management in oncology settings was evident. Furthermore, there was a notable deficiency in understanding the potential adverse health ramifications for patients should the post-insertion management for CVCs not be adhered to. The absence of prompt feedback on post-insertion management consequently attenuated the nurses' impetus to integrate evidence into practice. As elucidated by an informant:

"Our superiors mandated the implementation of post-insertion management for CVCs. However, compliance was fleeting, as the emphasis was not sustained. Consequently, we reverted to our original practices." (N.7).

Another informant expressed a similar sentiment, stating:

"It (post-insertion management for CVCs) only lasted for a period of time and then we stopped. Indeed, we have relied on our established practices for an extensive duration without encountering complications." (N.3).

Yet another informant suggested an enhancement in oversight, remarking:

"The monitoring framework for post-insertion management necessitates reform. Specifically, integration with our extant monitoring system is advisable to preclude redundancy in workflow and diminish workload. Additionally, reciprocal monitoring between nurses on day and night shifts could more adeptly pinpoint issues with CVCs." (N.11).

Theme 2: lack of involvement from nurse specialists (recipients)

Subtheme 1. Absence of participation in the evidence-translation process

Some informants disclosed their exclusion from the process of crafting hospital regulations and workflows. Consequently, these specialists were impeded from conveying their insights and strategies to nursing managers, who occupied roles pivotal to policy development. This rendered them incapable of refining post-insertion maintenance for CVCs in alignment with the most judicious

evidence. As articulated by an informant as an intravenous treatment nurse specialist:

> *"The hospital mandated adherence to their newest guideline for post-insertion management for CVCs. However, discerning a distinction between this purported latest iteration and the current version is elusive, given our non-involvement in the guideline's development." (N.1).*

This perspective was reiterated by another nurse specialist, who lamented:

> *"While the utilization of the best evidence is commendable, I find myself perplexed. We are marginalized during the policymaking process for CVC management. Those responsible for the guideline's formulation lack the pertinent expertise." (N.13).*

Subtheme 2. Insufficiency of nurse specialists to oversee the quality of care

A prevalent sentiment among the informants was the inadequate presence of intravenous treatment nurse specialists within their institutions. This scarcity hindered the provision of sufficient oversight for less-experienced nurses, thereby posing challenges to the maintenance of care quality in post-insertion management. During a semi-structured interview, an informant expressed the dilemma succinctly:

> *"My responsibilities preclude devoting sufficient time to ensuring the proper execution of post-insertion management for CVCs within my ward, given the sheer magnitude of routine tasks. My ability to focus on this particular issue (post-insertion management) is consequently constrained." (N.7).*

Another informant lamented the challenges inherent in the singular role of intravenous therapy nurse specialist within the ward:

> *"I stand as the sole intravenous therapy nurse specialist in our ward, and the daily completion of routine tasks forces me into overtime to supervise juniors and instruct them on post-insertion management. My capacity to focus on this task (post-insertion management) is thus compromised." (N.15).*

Additionally, another informant articulated the distractions that impede the care process:

> *"While engaged in post-insertion management, my focus is incessantly diverted by other routine tasks. Consequently, I find myself unable to concentrate fully on the care process, resulting in certain steps being inadvertently overlooked." (N.14).*

Subtheme 3. Difficulty in achieving consensus with medical staff

Several informants elucidated that the domain of intravenous therapy was heavily influenced by medical staff, a fact that emerged as a major barrier to changing the current practice of post-insertion management. The tendency of doctors to concentrate exclusively on insertion procedures, neglecting post-insertion maintenance, exacerbates this issue. Correspondingly, the specialized expertise of nurses in providing post-insertion management often goes unrecognized in the formulation of hospital policies. Therefore, achieving consensus on necessary alterations to post-insertion maintenance based on the evidence proves arduous. For instance, an informant conveyed:

> *"My involvement in the management team is dictated by my professional role, yet I have remained excluded from the development of hospital-wide policies, focusing solely on managing my department. This is because doctors dominated the hospital management team." (N.3).*

Another informant resonated with this sentiment, emphasizing:

> *"To effect meaningful changes to post-insertion management for CVCs, the endorsement of doctors, particularly department heads, is indispensable. Their support would considerably facilitate the integration of novel practices." (N.2).*

Furthermore, an informant pointed out the doctors' lack of concern:

> *"While numerous physicians elect to insert CVCs into cancer patients for the administration of chemotherapy, their attentiveness to post-insertion management is minimal, sometimes even diminishing its significance." (N.9).*

Theme 3: challenges from internal and external environments (context)

Subtheme 1 inadequate atmosphere for internal change

The majority of informants, having participated in assorted programs aimed at amending current practices, observed a discernible lack of vigor in the climate for change within hospitals. This tepidity failed to galvanize

frontline nurses to embrace new methodologies, especially as their primary focus was anchored on patient safety. As long as existing practices yielded improvements in patient outcomes without adverse events, nurses exhibited little motivation to explore innovations. At the managerial echelon, the informants noted an absence of multidisciplinary collaboration in enhancing post-insertion management for CVCs, coupled with a deficient incentive structure for change. Even among intravenous therapy nurse specialists, consensus on the mission to promote the adoption of best practices remained elusive. An informant elaborated:

> *"Nurses are more concerned about patients' safety. They are more conservative about innovations. The implementation of a broad-scale program to alter current practices is inherently intricate, encompassing various facets and necessitating extensive communication and coordination with diverse stakeholders." (N.4).*

Another informant articulated a nuanced observation, stating:

> *"We have discerned that the standards of post-insertion management leave much to be desired. This deficiency is not amenable to superficial remedies; it mandates that nursing leaders devise systematic strategies to sustain change and galvanize universal participation." (N.10).*

Further elaboration was provided by another informant, who commented on the cultural constraints within the hospital:

> *"Our hospital gets our own culture. The senior staff do not advocate for changing our practices according to scientific evidence as long as the current practices bring benefits to patients." (N.12).*

Subtheme 2 paucity of external support

A consensus among informants underscored the significance of support from nursing managers and leaders in enhancing post-insertion maintenance for CVCs. Their guiding policies shape the procedural approach; however, several informants expressed concerns that this managerial support, though overtly positive, lacked substantial backing in terms of regular training and resource allocation. Moreover, the incorporation of the best available evidence in post-insertion management for CVCs necessitates specific materials such as connectors and disinfectants. This requirement might burden the department's budget, thereby hindering effective adoption. In the interview, one informant mentioned:

> *"Things are not so simple. The hospital (department) does not provide necessary equipment for post-insertion management, such as special kit sets. This complicated the whole process. It is very difficult for us to work." (N.7).*

Another informant, specializing in intravenous therapy, expressed the desire for more conducive working conditions:

> *"As an intravenous therapy nurse specialist, I yearn for the hospital to allocate space for work focused on service enhancement. At present, I am still tasked with routine duties. Specialists ought to be entrusted with more complex responsibilities. Allotting more time to these intricate tasks, rather than routine work, would undoubtedly elevate the quality of post-insertion management for CVCs." (N.6).*

Further insights were provided by another informant, who suggested:

> *"Should the hospital initiate a dedicated nursing clinic for intravenous infusion, or foster opportunities for intellectual discourse, it would facilitate the acquisition of skills in post-insertion management, thereby augmenting the overall quality of nursing care." (N.8).*

Facilitators of compliance

Two facilitative elements were identified in the quest for compliance with post-insertion maintenance for CVCs, shown in Table 4.

Theme 1: positive attitudes of specialist nurses toward evidence application

Most informants asserted that their professional identity can be enhanced through the adoption of evidence-based practice. Specifically, by altering the existing protocols on CVC management, the informants perceived a greater recognition and appreciation of their contributions by nursing leaders, colleagues, patients, and patients' families. This affirmation of their professional identity consequently augmented their sense of self-worth. The informants also posited that the promotion of evidence-based practice could demonstrate to other nurses that their professional growth was not confined to administrative roles but extended to specialized patient care. An informant elucidated:

"After completing my specialist training, I returned to my hospital to contribute to the development of CVC management guidelines. Now, everyone who encounters problems in CVC management, they will seek for my advice." (N.10).

Additional insights were provided by other informants:

"Everyone acknowledges my work and my passion. It is a kind of achievement." (N.11).
"Nurse specialists in intravenous therapy serve not merely as practitioners performing injections and infusions but also as educators and facilitators, imparting advanced knowledge to peers and patients, and assuming leadership within the department." (N.2).

Theme 2: formation of a team specializing in intravenous therapy within hospitals

The informants indicated that their hospitals had instituted professional teams to oversee post-insertion maintenance for CVCs. Particularly after receiving specialization, these nurses are empowered to scrutinize care quality and impart relevant training to their colleagues. When frontline nurses are tasked with post-insertion maintenance for CVCs, these trained specialists can offer guidance and feedback, thereby enhancing the quality of care. An informant shared during a semi-structured interview:

"Having worked only a few years, I began to acquire knowledge about CVC management through a training course at my hospital. This instruction has greatly expanded my understanding and skills." (N.4).

Another informant reflected on the specialized care required for cancer patients:

"Cancer patients represent a unique cohort, exhibiting a wide variation in medical conditions. When I encounter complexities in providing CVC care, I often consult the professional group on intravenous therapy. The guidance from nurse specialists is invariably insightful and greatly facilitates my practice." (N.6).

Discussion

The deployment of CVCs is linked with catheter-associated complications in oncology patients, which may culminate in extended hospital stays and augmented morbidity and mortality rates, thereby constituting a substantial menace to patient safety and escalating healthcare expenditures. In China, nurses are exempted from inserting CVCs but are mandated to administer post-insertion maintenance. Evidence implementation in post-insertion maintenance for CVCs is imperative for nurses engaged in oncological settings to mitigate the aforementioned perils and ramifications [41].

The quantitative findings in the present research revealed an overall adoption rate of 90.0% concerning evidence adoption in post-insertion maintenance for CVCs in oncology environments. The high rate of evidence adoption was potentially influenced by the inclusion of oncology patients rendered immunocompromised through radiotherapy and chemotherapy. This, in turn, necessitates heightened attention by oncology nurses to infection control protocols during all aspects of CVC management. Although this figure was promising, this study also revealed that there was still room for improvement in the current practice to achieve the expected targets of evidence-based practice. We found that 14 out of 30 practices enumerated in the evaluation checklist did not achieve 90% adoption rate among oncology nurses. These findings were consistent with studies in the West demonstrating unsatisfactory compliance rates in post-insertion management for CVCs [42, 43]. Notably, the poorest adoption (<80%) of evidence-based practices were primarily related to infection control, particularly the disinfection of infusion connector, skin, and catheter, which are associated with complications of catheter-related bloodstream infections and deserve to be heeded. The quantitative data provided more precise information on identifying the weak and critical segment of post-insertion maintenance for CVCs. As in any evidence implementation project, evaluating the pivotal clinical questions and identifying the key segments is crucial for promoting evidence-based clinical translation and implementation [44]. Consequently, the results highlighted a clear and effective avenue for improvement, which is developing targeted and addressed implementation strategies for disinfection control in the future to enhance the quality of post-insertion maintenance for CVCs in China.

One feature of this study is the continuity and consistency of the quantitative and qualitative research. All informants were a subset of the quantitative phase and involved in the quantitative study before providing their specifically targeted insights and opinions. The outcomes of the clinical observation serve to delineate the specific challenges, laying the groundwork for an in-depth analysis of hindrances and further devising targeted strategies for amelioration [45]. Additionally, successful evidence implementation is regarded as an outcome resulting from the quality and type of innovation, the characteristics of context, recipients who are influenced or implement the innovation, and how the innovation is facilitated [46].

Guided by the i-PARIHS framework, the qualitative dialogues were deductively reasoned into four key elements of the clinical implementation of evidence, including innovation, recipients, context, and facilitation [47]. Facilitators and barriers to adopting scientific evidence in post-insertion maintenance for CVCs among oncology nurses were further clarified using this framework.

The qualitative data identified the difficulty in accessing the evidence was a main barrier to evidence practice in CVCs post-insertion maintenance, mapping to the innovation in the i-PARHIS framework. Knowledge deficit in the evidence may result in low compliance with CVCs maintenance [48]. In the field of CVCs post-insertion maintenance, the large amount of evidence published does not represent an increase in nurses' knowledge. Continuous training is necessary to promote best practices in CVC maintenance, not just in knowledge and key points in each procedure, but in the ability to appraise and synthesize evidence. Of the identified barriers to innovation, the clinical applicability of evidence was persistently mentioned by informants, which emphasized that the evidence should be modified, tailored, or refined to fit local context or needs [49]. Especially some evidence practices related to infection control, e.g. suggested size of the disinfected area, naturally dried waiting after disinfection, seemed hard to apply in clinical operations with workload. Continuous monitoring and periodic revisions to post-insertion management protocols for CVCs are essential to ensure clinical applicability [50]. Additionally, nurses were concerned with the increased budget resulting from the evidence-based practices related to the inflection control measures. For instance, the cost of a recommended disinfectant, i.e. chlorhexidine gluconate alcohol is 3 to 4 times more expensive than general disinfectants. Therefore, facilitators should be preoccupied with evidence that may increase clinical costs and develop strategies in advance to ensure the sustainability of CVC maintenance evidence application. At the same time, these phenomena were the possible reasons for the quantitative results that most infection control measures in post-insertion management failed to achieve at least 80% adoption rates.

Nurses are the major recipients, responsible for evidence adoption for CVCs post-insertion maintenance. Fortunately, all informants in our qualitative study manifested a positive attitude toward adopting scientific evidence in post-insertion management for CVCs. This is significant, as delineated by Ferrara et al [42, 51], attitudes of healthcare workers were crucial to promote adherence to guidelines. Notwithstanding the positive attitudes of our informants, they did mention the difficulties in participating in the evidence-translation process and hospital policymaking, thus hindering the adoption of evidence in post-insertion management for CVCs. This phenomenon is particularly pronounced in China, attributing to medical dominance. Relative to the medical profession, nursing is a comparatively nascent discipline [52]. Furthermore, a conventional societal perception prevails that nurses are subordinate to physicians, possessing diminished autonomy within healthcare environments [53]. This perception, combined with an inherently hierarchical structure, diminishes nurses' participation in policymaking, resulting in their perspectives on post-insertion management for CVCs being marginalized within hospital policy. Encouraging multidisciplinary involvement will provide more opportunities and facilities for specialist nurses to be better involved in addressing such situations. It would be beneficial to expand the scope of involvement by working more closely with the medical team, organizational managers, and patients, who are all key stakeholders in promoting evidence-based practice for CVC maintenance [54]. One potential approach is the establishment of nurse-led multidisciplinary teams for CVC or the creation of specialist clinics, which can facilitate communication and collaboration with the medical teams and utilize the professional value of specialist nurses.

Aligning with the i-PARIHS framework, the context includes the external and internal environment or organizational culture [25]. Workload as a barrier should be mentioned, especially since the research settings in this study are tertiary public hospitals with more than 1000 beds. Previous systematic reviews [55] explicitly indicated that a lower nurse-to-patient ratio was associated with an increased risk of healthcare-associated infections, which was the single significant predictor for bloodstream infections related to CVCs [48]. The correlation between workload and catheter infection control is also indirectly illustrated considering the low infection control implementation rate in this study's quantitative results. Moreover, a lack of CVC-maintained required materials, such as CVC maintenance kits and chlorhexidine gluconate alcohol, can also decrease compliance with evidence-based practice. This perspective is consistent with another study from China [56], which focused on implementation strategies for CVC maintenance in pediatric intensive care units. External support and negotiation from the medical insurance finance, healthcare organization, materials supply department, and nursing department, cannot be ignored. Financial allocations should be strategically increased to avail the necessary human resources and materials for implementing evidence-based practices in CVC management, e.g. purchasing recommended disinfectants or materials. Furthermore, a positive culture can promote the application of innovation, thereby facilitating change [56]. Within the internal culture, another finding in the study was that managers or frontline specialist nurses were more

conservative towards the change and emphasized priority on patient safety. These are misconceptions about change and safety, need to be reversed by the implementation facilitator by creating an adequate atmosphere for change through best-evidence training, demonstration of excellent practice, and performance or moral incentives.

The significance of identifying facilitators is to enhance the facilitators in implementation strategies to increase the uptake of evidence-based clinical innovations [57]. Two main facilitators of evidence practice for CVC maintenance emerged in this present study. Informants indicated the positive attitudes of specialist nurses toward evidence application, as well as constituting a specialized team focused on CVCs within all research sites, had the potential efficacy in promoting evidence practice for CVC maintenance. Previous literature also supported the effectiveness of such professional teams in enhancing evidence adoption in various clinical practices and settings [58, 59]. Nevertheless, a consideration warranting scrutiny is that forming such professional teams necessitates professional training, iteration of knowledge and concept, and communication with and support from management to better leverage the influence of the academic team in the hospital. Consequently, further investigations and well-developed operational mechanisms are warranted to leverage the role of professional teams comprehensively in evidence-based practice.

Strengths and limitations

To our best understanding, this was the first study that adopted a sequential explanatory mixed method based on the i-PARIHS, an implementation science framework, to scrutinize the integration of scientific evidence in post-insertion maintenance for CVCs and identify facilitators and barriers to the evidence adoption within oncological settings in China. An additional virtue pertains to the expansive scale of the research, executed across five medical centers and encompassing 1,314 clinical observations. Such a voluminous dataset conferred robustness and precision in the estimation. Notwithstanding these strengths, certain limitations must also be acknowledged. Firstly, the trustworthiness of the quantitative data from the cross-sectional study might be compromised as the audit checklist did not undergo a psychometric properties test notwithstanding some evidence suggesting that it might not be necessary for the audit checklist [34, 35]. Secondly, we did not apply advanced statistical methods to analyze the data as the current analysis could achieve the study objectives. However, advanced statistical methods may be useful to verify some identified facilitators and barriers in evidence adoption, and hence future studies are recommended to do so. Thirdly, this study was conducted in hospitals in China. Due to the difference in organizational structures and cultural beliefs between China and Western countries, which might affect the generalizability of findings in overseas. Fourthly, the semi-structured interviews were conducted by a nurse manager, which might affect the willingness and perceptions of informants to share their opinions due to power imbalance. Lastly, this study adopted different methods, i.e., face-to-face and online platforms to conduct interviews. There might be differences in the study results due to the interview techniques.

Conclusions

This research has bridged an existing gap in the literature, unearthing that the aggregate adoption rate of evidence in post-insertion management for CVCs by nurses within the oncology setting stood at 90.0%. Among all the advocated practices, infection control protocols were the least adopted. Employing the i-PARIHS framework, we identified two facilitators, including the positive attitudes of specialist nurses to evidence application and formation of a team specializing in intravenous therapy within all sites; as well as three barriers mapping to three elements in the i-PARIHS framework, including difficulty in accessing the evidence, lack of involvement from nurse specialists and challenges from internal and external environments. Stemming from these recognized facilitators and obstructions, tailored interventions must be strategized and instituted at an organizational stratum to enhance the execution of the guideline, with particular emphasis on the clinical evidence pertinent to infection control.

Abbreviations

CVCs	Central Venous Catheters
i-PARIHS	Integrated Promoting Action on Research Implementation in Health Services

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

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Author contributions

FNY, KYHo, LWG designed the study. FNY, QL conducted the literature search and wrote the initial proposal. FNY, KYHo, TM analyzed the data and interpretation of data. FNY and KYH drafted the manuscript. YW, LQ L, XXY, NX, YLG contributed to the data collection process. XXX, HYS, LWG, FKYW, KKWL reviewed and provided expert opinions. All authors read and approved the final manuscript.

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Data availability
The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate
This investigation was sanctioned by the Medical Ethics Committee of Henan Cancer Hospital (Number 2023-KY-0014). Informed consent to participate was obtained from all the participants in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Jamshidi R. Central venous catheters: indications, techniques, and complications. Semin Pediatr Surg. 2019;28(1):26–32.
2. van den Bosch CH, van Woensel J, van de Wetering MD. Prophylactic antibiotics for preventing gram-positive infections associated with long-term central venous catheters in adults and children receiving treatment for cancer. Cochrane Database Syst Rev. 2021;10(10):Cd003295.
3. Schiffer CA, Mangu PB, Wade JC, Camp-Sorrell D, Cope DG, El-Rayes BF, Gorman M, Ligibel J, Mansfield P, Levine M. Central venous catheter care for the patient with cancer: American Society of Clinical Oncology clinical practice guideline. J Clin Oncology: Official J Am Soc Clin Oncol. 2013;31(10):1357–70.
4. Zitvogel L, Apetoh L, Ghiringhelli F, Kroemer G. Immunological aspects of cancer chemotherapy. Nat Rev Immunol. 2008;8(1):59–73.
5. Chen DS, Mellman I. Oncology meets immunology: the cancer-immunity cycle. Immunity. 2013;39(1):1–10.
6. Böll B, Schalk E, Buchheidt D, Hasenkamp J, Kiehl M, Kiderlen TR, Kochanek M, Koldehoff M, Kostrewa P, Claßen AY, et al. Central venous catheter-related infections in hematology and oncology: 2020 updated guidelines on diagnosis, management, and prevention by the Infectious Diseases Working Party (AGIHO) of the German Society of Hematology and Medical Oncology (DGHO). Ann Hematol. 2021;100(1):239–59.
7. Sun Y, Bao Z, Guo Y, Yuan X. Positive effect of care bundles on patients with central venous catheter insertions at a tertiary hospital in Beijing, China. J Int Med Res. 2020;48(7):300060520942113.
8. Verso M, Agnelli G. Venous thromboembolism associated with long-term use of central venous catheters in cancer patients. J Clin Oncology: Official J Am Soc Clin Oncol. 2003;21(19):3665–75.
9. Pan M, Meng A, Yin R, Zhi X, Du S, Shi R, Zhu P, Cheng F, Sun M, Li C, Fang H. Nursing interventions to reduce peripherally inserted central catheter occlusion for Cancer patients: a systematic review of literature. Cancer Nurs. 2019;42(6):E49–58.
10. Llapa-Rodríguez EO, Oliveira JKA, Melo FC, Silva GGD, Mattos MCT, Macieira VP Jr. Insertion of central vascular catheter: adherence to infection prevention bundle. Revista brasileira de enfermagem. 2019;72(3):774–9.
11. Gorski LA, Hadaway L, Hagle ME, Broadhurst D, Clare S, Kleidon T, Meyer BM, Nickel B, Rowley S, Sharpe E, Alexander M. Infusion Therapy Standards of Practice, 8th Edition. *Journal of infusion nursing: the official publication of the Infusion Nurses Society* 2021, 44(1S Suppl 1):S1-s224.
12. Sun Hong CL, Guo Caixia Y, Qiaofang L, Xuying Z, Gaiting M, Zanhong C, Ying X, Hong. Feng Bilong, Wang Lei: Expert consensus on venous catheter maintenance/Intravenous Therapy Committee of Chinese Nursing Association. Chin J Nurs. 2019;54(9):1334–42.
13. Lin FF, Murphy N, Martinez A, Marshall A. An audit of central venous catheter insertion and management practices in an Australian tertiary intensive care unit: a quality improvement project. Intensive Crit Care Nurs. 2022;70:103217.
14. Elliott JH, Turner T, Clavisi O, Thomas J, Higgins JP, Mavergames C, Gruen RL. Living systematic reviews: an emerging opportunity to narrow the evidence-practice gap. PLoS Med. 2014;11(2):e1001603.
15. Ayatollahi H, Zeraatkar K. Factors influencing the success of knowledge management process in health care organisations: a literature review. Health Info Libr J. 2020;37(2):98–117.
16. Chen Q, Halili X, Castro AR, Zhao J, Chen W, Li Z, Tang S, Wang H. Differences in evidence-based nursing practice competencies of clinical and academic nurses in China and opportunities for complementary collaborations: a cross-sectional study. J Clin Nurs 2022.
17. Nilsen P, Bernhardsson S. Context matters in implementation science: a scoping review of determinant frameworks that describe contextual determinants for implementation outcomes. BMC Health Serv Res. 2019;19(1):189.
18. Dryden-Palmer KD, Parshuram CS, Berta WB. Context, complexity and process in the implementation of evidence-based innovation: a realist informed review. BMC Health Serv Res. 2020;20(1):81.
19. Ridde V, Pérez D, Robert E. Using implementation science theories and frameworks in global health. BMJ Global Health. 2020;5(4):e002269.
20. Pfadenhauer LM, Gerhardus A, Mozygemba K, Lysdahl KB, Booth A, Hofmann B, Wahlster P, Polus S, Burns J, Brereton L, Rehfuess E. Making sense of complexity in context and implementation: the context and implementation of Complex interventions (CICI) framework. Implement Science: IS. 2017;12(1):21.
21. Lin CC, Xu X. A Leap from evidence to practice: implementation science in Cancer nursing. Cancer Nurs. 2019;42(4):259–60.
22. Byrnes A, Young A, Mudge A, Banks M, Clark D, Bauer J. Prospective application of an implementation framework to improve postoperative nutrition care processes: evaluation of a mixed methods implementation study. Nutr Dietetics: J Dietitians Association Australia. 2018;75(4):353–62.
23. Yakovchenko V, Bolton RE, Drainoni ML, Gifford AL. Primary care provider perceptions and experiences of implementing hepatitis C virus birth cohort testing: a qualitative formative evaluation. BMC Health Serv Res. 2019;19(1):236.
24. Elam ME, Louis CJ, Brindle ME, Woodson J, Greece JA. Using i-PARIHS to assess implementation of the Surgical Safety Checklist: an international qualitative study. BMC Health Serv Res. 2022;22(1):1284.
25. Cao S, Gu M, Feng M, Jia Y, Zhao Y, Chen S, Zhu L, Bo S, Zhao Q. Implementation of evidence in preventing medical device-related pressure injury in ICU patients using the i-PARIHS framework. J Nurs Adm Manag. 2022;30(1):318–27.
26. Peel NM, Hornby-Turner YC, Osborne SR, Henderson A, Hubbard RE, Gray LC. Implementation and evaluation of a standardized nurse-administered Assessment of Functional and Psychosocial issues for patients in Acute Care. Worldviews evidence-based Nurs. 2021;18(3):161–9.
27. Alostaz Z, Rose L, Mehta S, Johnston L, Dale C. Physical restraint practices in an adult intensive care unit: a prospective observational study. J Clin Nurs 2022.
28. Roberts NA, Janda M, Stover AM, Alexander KE, Wyld D, Mudge A, Group IPPiCPISW. The utility of the implementation science framework Integrated Promoting Action on Research Implementation in Health Services(i-PARIHS) and the facilitator role for introducing patient-reported outcome measures (PROMs) in a medical oncology outpatient department. Qual Life Res. 2021;30:3063–71.
29. Gu Y, Hu Y, Zhang H, Fu W, Yang Y, Latour JM. Implementation of an evidence-based Guideline of Enteral Nutrition for infants with congenital heart disease: a controlled before-and-after study. Pediatr Crit care Medicine: J Soc Crit Care Med World Federation Pediatr Intensive Crit Care Soc. 2020;21(6):e369–77.

30. Qin X, Yu P, Li H, Hu Y, Li X, Wang Q, Lin L, Tian L. Integrating the best evidence into nursing of venous thromboembolism in ICU patients using the i-PARIHS framework. PLoS ONE. 2020;15(8):e0237342.
31. Creswell JW, Clark VLP. Designing and conducting mixed methods research. Sage; 2017.
32. Jianhua W. Practical Medical Research Methods: Beijing. People's Health Publishing Company; 2003.
33. Braun VaC V. Using thematic analysis in psychology. Qualitative Res Psychol. 2006;3(2):77–101.
34. Van de Velde S, Kunnamo I, Roshanov P, Kortteisto T, Aertgeerts B, Vandvik PO, Flottorp S. The GUIDES checklist: development of a tool to improve the successful use of guideline-based computerised clinical decision support. Implement Sci. 2018;13:1–12.
35. Burian BK, Clebone A, Dismukes K, Ruskin KJ. More than a tick box: medical checklist development, design, and use. Anesth Analgesia. 2018;126(1):223–32.
36. WS/T 433–. 2013, Operating Standards for Intravenous Treatment Nursing Techniques[S] [http://www.nhc.gov.cn/wjw/pjl/201412/806fe9a7171e4cf584c0d40ed093dfa7.shtml].
37. National Health Commission of the People's Republic of China. Guidelines for the prevention and control of vascular catheter-related infections issued by the General Office of the National Health Commission(2021 Edition). [http://www.nhc.gov.cn/yzygj/s7659/202103/dad04cf7992e472d9de1fe6847797e49.shtml].
38. National Institute of Hospital Administration. Quality Control Toolkit for Preventing Intravascular Catheter-Related Bloodstream Infections (Trial Version) [https://niha.org.cn/prod-api/web/normal/downloadDetail/853]
39. Macmillan T, Pennington M, Summers JA, Goddard K, Zala D, Herz N, Peacock JL, Keevil S, Chalkidou A. SecurAcath for securing peripherally inserted Central catheters: a NICE Medical Technology Guidance. Appl Health Econ Health Policy. 2018;16(6):779–91.
40. Cope DG. Methods and meanings: credibility and trustworthiness of qualitative research. In: *Oncology nursing forum: 2014;* 2014.
41. Panepinto R, Harris J, Wellette J. A review of best practices related to Intravenous Line Management for nurses. Nurs Clin N Am. 2021;56(3):389–99.
42. Ferrara P, Albano L. The adherence to guidelines for preventing CVC-related infections: a survey among Italian health-care workers. BMC Infect Dis. 2018;18(1):606.
43. Dedunska K, Dyk D. Prevention of central venous catheter-associated bloodstream infections: a questionnaire evaluating the knowledge of the selected 11 evidence-based guidelines by Polish nurses. Am J Infect Control. 2015;43(12):1368–71.
44. Moullin JC, Dickson KS, Stadnick NA, Albers B, Nilsen P, Broder-Fingert S, Mukasa B, Aarons GA. Ten recommendations for using implementation frameworks in research and practice. Implement Sci Commun. 2020;1:1–12.
45. Wan GY, Yuan H, Xue H, Li HQ, Hu HY, Zhang XY. Assessment of compliance with oral nutritional supplementation and exploration of barriers and facilitators for patients after gastrectomy: a mixed-methods study. J Adv Nurs. 2021;77(6):2845–59.
46. Balbale SN, Hill JN, Guihan M, Hogan TP, Cameron KA, Goldstein B, Evans CT. Evaluating implementation of methicillin-resistant Staphylococcus aureus (MRSA) prevention guidelines in spinal cord injury centers using the PARIHS framework: a mixed methods study. Implement Science: IS. 2015;10:130.
47. Duan Y, Iaconi A, Wang J, Perez JS, Song Y, Chamberlain SA, Shrestha S, Choroschun K, Hoben M, Beeber A, et al. Conceptual and relational advances of the PARIHS and i-PARIHS frameworks over the last decade: a critical interpretive synthesis. Implement Science: IS. 2022;17(1):78.
48. Matlab AA, Al-Hussami MO, Alkaid Albqoor M. Knowledge and compliance to prevention of central line-associated blood stream infections among registered nurses in Jordan. J Infect Prev. 2022;23(4):133–41.
49. Gillespie BM, Latimer S, Walker RM, McInnes E, Moore Z, Eskes AM, Li Z, Schoonhoven L, Boorman RJ, Chaboyer W. The quality and clinical applicability of recommendations in pressure injury guidelines: a systematic review of clinical practice guidelines. Int J Nurs Stud. 2021;115:103857.
50. Parker V, Giles M, King J, Bantawa K. Barriers and facilitators to implementation of a multifaceted nurse-led intervention in acute care hospitals aimed at reducing indwelling urinary catheter use: a qualitative study. J Clin Nurs. 2020;29(15–16):3042–53.
51. Ferrara P, Stromillo L, Albano L. Awareness, attitudes, and practices toward Meningococcal B Vaccine among pediatricians in Italy. Med (Kaunas Lithuania) 2018, 54(6).
52. Frachel RR. A new profession: the evolution of public health nursing. Public Health Nurs (Boston Mass). 1988;5(2):86–90.
53. Freund T, Everett C, Griffiths P, Hudon C, Naccarella L, Laurant M. Skill mix, roles and remuneration in the primary care workforce: who are the healthcare professionals in the primary care teams across the world? Int J Nurs Stud. 2015;52(3):727–43.
54. Eisman AB, Quanbeck A, Bounthavong M, Panattoni L, Glasgow RE. Implementation science issues in understanding, collecting, and using cost estimates: a multi-stakeholder perspective. Implement Sci. 2021;16(1):75.
55. Mitchell BG, Gardner A, Stone PW, Hall L, Pogorzelska-Maziarz M. Hospital staffing and health care–associated infections: a systematic review of the literature. Joint Comm J Qual Patient Saf. 2018;44(10):613–22.
56. Wang W, Fu Q, Shen W, Xu Y, Wang L, Chun X, Shi Y, Lin J, Zhao Y, Gu Y. Using the i-PARIHS theoretical framework to develop evidence implementation strategies for central venous catheter maintenance: a multi-site quality improvement project. JBI Evid Implement. 2024;22(2):195–204.
57. Bauer MS, Kirchner J. Implementation science: what is it and why should I care? Psychiatry Res. 2020;283:112376.
58. Hammarskjöld F, Berg S, Hanberger H, Taxbro K, Malmvall BE. Sustained low incidence of central venous catheter-related infections over six years in a Swedish hospital with an active central venous catheter team. Am J Infect Control. 2014;42(2):122–8.
59. Ferreira JDN, Dos Santos KB, Siqueira EC, Gomes EP, Martini L, Fraga JBP, Lima MAM, Poveda VB. Central venous catheter insertion in adult patients: a best practice implementation project. JBI Evid Implement. 2020;19(3):296–305.

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