

Current Research Status of PICC Specialist Nurses' Catheter Maintenance Competency

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Abstract: The quality of PICC maintenance is a critical component in ensuring patient safety. While PICC is widely used in clinical settings, complications such as catheter-related infections and thrombosis continue to threaten patient safety and increase healthcare costs. Standardized maintenance relies heavily on the professional competence of PICC specialist nurses. This article systematically reviews the current research status, influencing factors, and improvement strategies related to the catheter maintenance competencies of PICC specialist nurses. It aims to raise awareness among healthcare professionals regarding the importance of PICC maintenance skills and to provide insights for future clinical development.

Keywords: PICC; Specialized Nurse; Maintenance; Review

1. Introduction

Peripherally Inserted Central Catheter (PICC) refers to a catheter inserted via peripheral veins with its tip positioned in the superior or inferior vena cava^[1]. As a critical vascular access technique, PICC has been widely adopted in clinical settings, providing safe and effective venous access for patients requiring long-term infusion, chemotherapy, or parenteral nutrition. However, various complications may arise during catheter indwelling, including catheter-related infections, occlusion, venous thrombosis, among others. Specifically, the incidence rates of PICC-related venous thrombosis reach 48.8%, catheter-associated skin injury 4.6%, catheter occlusion 3.4%, and catheter dislodgement 2.3%^[2-3]. These complications not only compromise treatment efficacy but may also increase patient discomfort and healthcare costs. Therefore, standardized catheter maintenance is crucial.

PICC specialist nurses, as primary practitioners and technical guides for catheter maintenance, directly influence catheter longevity and patient safety. As a specialized nursing technique, PICC is currently the only procedure authorized for nurses to perform independently^[4]. However, this technique demands high proficiency, evolves rapidly, and involves considerable difficulty and unpredictable risks, necessitating broad knowledge and advanced operational skills from nurses—highlighting the importance of training^[5]. Consequently, cultivating PICC specialist nursing talent remains a challenging priority, and enhancing their professional competence while ensuring workforce stability are urgent issues for clinical nursing educators^[6].

In recent years, with the expanding application of PICC technology, increasing attention has been paid to the training and management of PICC specialist nurses. Domestic hospitals have placed growing emphasis on PICC techniques, adopting diverse training methods^[7]. Nonetheless, in practice, variations persist in the catheter maintenance competencies of PICC specialist nurses due to multiple influencing factors. This article aims to comprehensively analyze current research on the maintenance competencies of PICC specialist nurses, explore contributing factors in depth, and provide a reference for further improving PICC care quality.

2. Research Status on Catheter Maintenance Competence of PICC Specialist Nurses

A study on nurses' knowledge, attitudes, and practices (KAP) regarding PICC revealed that approximately 55.01% of nurses achieved or exceeded the median knowledge score of 15 (range 0-20), with an accuracy rate of 75%. However, knowledge regarding risk factor assessment, signs and symptoms, as well as catheter removal and treatment remained limited. Additionally, 61.99% of nurses had participated in continuing education training courses. Over 97% of nurses held positive attitudes toward preventing PICC-related thrombosis, yet only 76.79% expressed strongly positive attitudes. More than 58% of nurses did not consistently perform well in risk factor assessment^[8]. In a survey of 4,110 nurses on PICC maintenance conducted by Xu B et al., the average score was 72.86 ± 14.86 . Among the participants, 83.5% achieved scores of 60 or above, while 34.1% attained good scores of 80 or above, indicating a moderate level of knowledge regarding PICC maintenance among nurses^[9]. The study also showed that the lowest accuracy rate was observed in dressing and needle-free connector replacement (0.52 ± 0.248), while the highest accuracy rate was in health education (0.94 ± 0.052), followed by catheter removal (0.81 ± 0.117), PICC flushing and locking (0.76 ± 0.222), and complication management (0.71 ± 0.167)^[9]. In a survey of 832 nurses across 11 tertiary hospitals and 26 secondary hospitals in China by Hu et al.^[10], the average score for PICC maintenance management was 79.77 ± 12.13 , with 60.8% of respondents reporting acceptable PICC maintenance practices. However, a study on the attitudes and knowledge of nurses in primary healthcare institutions in China regarding peripherally inserted central catheter maintenance revealed low correct response rates for most knowledge items (7.14-57.68%), with only three items achieving correct response rates above 90%^[11]. Gaps were particularly evident in areas such as the selection and application range of skin disinfectants, sterilization methods for spiral parts of infusion connectors, selection of types and volumes of flushing and sealing solutions, dressing change techniques, and management of various types of PICC-related complications. These deficiencies may be attributed to a lack of systematic PICC maintenance training.

Although theoretical scores improved immediately after specialized PICC training for nurses, a decline was observed one month post-training^[12]. Over time, the application of acquired knowledge and skills demonstrated a decreasing trend, failing to meet clinical demands. Furthermore, when assessing the application of training content through self-reporting by trainees, only 62% of the training content was immediately applied in work settings shortly after training, 44% remained applicable after six months, and 34% could still be applied by the end of one year^[13]. These findings highlight the need to emphasize sustained translation of training outcomes in standardized PICC training programs. It is crucial to develop dynamic process-based training management strategies that account for variations in training transfer influencing factors over time. Li Ying et al.^[14] used questionnaire surveys to assess the current state of PICC maintenance in tertiary Grade A hospitals in Shanghai. The study found that while many hospitals had implemented PICC programs, shortcomings persisted in terms of scope of popularization, resources of specialist nurses, information accessibility, and consistency in catheter maintenance practices. The authors recommended refining PICC maintenance standards, enhancing specialized training efforts, and promoting the specialization of PICC care.

3. Analysis of Factors Influencing PICC Specialist Nurses' Catheter Maintenance Competency

3.1 Individual Factors

Educational background and professional title are significant individual factors influencing PICC specialist nurses' catheter maintenance competency. Nurses with higher educational qualifications and senior titles generally demonstrate stronger learning capabilities and richer clinical experience, enabling them to better master and apply PICC maintenance knowledge and skills. Specifically, nurses holding "nurse-in-charge" titles showed higher PICC maintenance knowledge scores, while those with "staff nurse" titles also displayed relatively high knowledge levels^[11]. This phenomenon may be attributed to the fact that nurses in primary healthcare institutions often have fewer learning and exchange opportunities compared to those in larger hospitals, which paradoxically fosters greater self-driven acquisition of specialized nursing knowledge. Additionally, nurses with advanced titles frequently undertake clinical teaching responsibilities for trainees in PICC maintenance, further consolidating their expertise through instructional practice^[9].

Work experience and practical exposure significantly impact catheter maintenance proficiency. Nurses who regularly perform PICC maintenance operations demonstrate greater procedural fluency

and problem-solving ability compared to those with occasional practice. Female nurses scored higher in PICC maintenance knowledge than male colleagues, while nurses under 25 years old reported lower knowledge levels compared to those aged 45 or above^[9]. Nurses with over six years of nursing experience exhibited higher PICC maintenance knowledge scores than those with only one to three years of experience^[11]. Inexperienced nurses often prioritize basic nursing practices, potentially neglecting the acquisition of new techniques like PICC maintenance. Conversely, seasoned nurses typically handle clinical nursing tasks with greater efficiency, allowing them more time and energy to pursue additional specialized knowledge. However, Chopra et al.^[15] reported no statistically significant differences in knowledge among vascular access nurses based on years of experience, a finding potentially related to small sample size.

Attitude toward PICC maintenance constitutes another crucial factor influencing nursing practice. Studies indicate that participants with more positive attitudes toward PICC maintenance scored higher in practical implementation^[16]. Attitude serves as a predictive factor for maintenance practice quality—only when nurses fully recognize the importance of PICC maintenance for patient outcomes, understand the consequences of improper maintenance, and acknowledge their professional responsibility in the process can they effectively utilize their knowledge to enhance practice standards.

3.2 Training Factors

Systematic training is a critical factor influencing the catheter maintenance competency of PICC specialist nurses. Studies demonstrate that nurses who have received specialized training show significantly superior knowledge levels and operational skills compared to untrained counterparts^[16]. Those without prior PICC maintenance training reported lower knowledge levels, confirming training as an effective approach to enhance nurses' PICC maintenance knowledge—a finding consistent with results reported by Roslien et al.^[17] and Purran et al.^[18]. Through systematic and standardized PICC training, nurses acquire essential knowledge including vascular anatomy, ultrasound and radiological data interpretation skills, standard procedures for PICC catheter insertion and maintenance, and various emergency response and complication management protocols. This comprehensive training ultimately reduces catheter-related complications and improves patient safety^[19]. Research indicates that standardized professional knowledge training for PICC specialist nurses enhances their theoretical understanding and improves test scores, particularly in medical ethics, interpretation of latest intravenous therapy guidelines, vascular damage caused by special medications, standardized operational procedures for PICC catheterization and maintenance, and management of common complications^[7]. Xie Jianfang achieved an increase in PICC catheter maintenance knowledge awareness from 77.86% to 95.45% among community healthcare workers through theoretical training^[20]. He Xiaorong et al.^[7] found that while 83.3% of PICC specialist nurses scored above 60 points before training, systematic theoretical training increased the excellence rate from 0% to 88.9% upon training completion.

Training methods and content significantly impact training effectiveness. Although traditional theoretical instruction can convey knowledge, it often proves insufficient for developing practical operational capabilities. Li Dongmei et al.^[21] recommended implementing stratified training for PICC specialist nurses, wherein nurses with different professional titles receive training and assessment at varying depths and levels. This approach demonstrates positive significance for cultivating PICC specialist nursing talent by fully mobilizing and leveraging nurses' subjective initiative and enthusiasm.

3.3 Organizational and Managerial Factors

Hospital level and type are significant organizational factors influencing PICC specialist nurses' catheter maintenance competency. Nurses in tertiary hospitals generally demonstrate superior PICC maintenance capabilities compared to those in secondary hospitals, while nurses in general hospitals outperform those in specialized hospitals. This disparity may stem from more comprehensive training systems, greater practical opportunities, and stricter quality control mechanisms typically present in higher-level and general hospitals. Studies indicate that nurses in rural township hospitals, surgical departments, and orthopedics units show lower PICC maintenance knowledge levels compared to their counterparts in community hospitals and oncology departments^[11]. Community hospitals, located in urban areas, provide relatively more learning opportunities for nurses compared to rural township hospitals, potentially explaining their higher performance scores. In oncology departments, where many patients require chemotherapy, nurses tend to place greater emphasis on intravenous therapy management including PICC care. Additionally, nurses working in county-level hospitals report lower

PICC maintenance knowledge compared to those in provincial hospitals, possibly due to the relatively recent introduction of PICC maintenance technology in county facilities. In China, specialized nursing techniques like PICC catheterization and maintenance were initially implemented in provincial hospitals before being extended to municipal hospitals. In recent years, with increasing PICC utilization, more county-level hospitals have begun adopting PICC maintenance technology^[9]. However, clinical nursing management often lacks sustainable support. While initial training programs may receive substantial administrative attention and expectation, managers frequently focus more on program development than maintaining continuous implementation support, leading to diminished long-term effectiveness^[5].

The availability of PICC guidelines constitutes another critical organizational factor. Nurses working in units with established PICC guidelines are more likely to demonstrate competent maintenance practices. This finding can be attributed to guidelines providing evidence-based protocols that enable nurses to deliver standardized care rather than relying on personal experience. Consequently, we recommend that nursing managers implement strategies to ensure nurses have easy access to PICC guidelines, thereby facilitating evidence-based maintenance practices^[10].

4. Strategies and Recommendations for Enhancing PICC Specialist Nurses' Catheter Maintenance Competency

4.1 Strengthen Systematic Training

Establishing standardized training systems forms the foundation for enhancing PICC specialist nurses' catheter maintenance competency. Training content should comprehensively cover all aspects of PICC maintenance, particularly addressing weak areas including: selection and application range of skin disinfectants, sterilization methods for spiral parts of infusion connectors, selection of types and volumes of flushing and sealing solutions, dressing change techniques, and management of various PICC-related complications^[11]. Traditional teaching methods often prove monotonous, and outdated content fails to fully engage learners. Instructors should commit to transforming current training models and enriching curricular content to enhance training engagement. Research demonstrates that integrating "ideological and political education" into PICC technical training improves teaching effectiveness. Through various training approaches such as embedded revolutionary heritage education, ideological education concepts can be skillfully incorporated into training, achieving a synergistic effect where "1+1>2"^[6]. This approach helps trainees understand the responsibilities and values of PICC specialist nurses while improving educational outcomes.

Furthermore, virtual simulation platforms utilizing images, animations, ultrasound videos, and exercises through multi-screen sharing can effectively demonstrate key knowledge points that are difficult to simulate or comprehend through theoretical instruction alone, thereby strengthening trainees' understanding of operational procedures. This technology addresses core challenges in PICC training—"difficulty in deconstructing abstract concepts" and "challenges in observing critical operations"—through multi-screen interaction enabling stratified instruction^[22].

Implementing stratified training constitutes another crucial strategy for improving training effectiveness. Through layered training programs, nursing staff's training enthusiasm can be sustainably maintained, learning needs of nurses at different levels can be met, self-directed learning capabilities can be enhanced, and knowledge acquisition efficiency can be accelerated^[23]. Training content and methods should be differentiated based on nurses' educational background, professional title, and work experience. For junior nurses with lower titles, focus should be placed on basic knowledge and fundamental skills training, while senior nurses with higher titles should receive advanced training focusing on complication management and complex case analysis.

4.2 Optimizing Organizational Support Infrastructure

Establishing a specialist nurse certification system is a crucial means to enhance the professional competence of PICC specialist nurses. Through PICC specialist nurse certification, qualified nurses can receive formal accreditation and undergo regular knowledge and skill updates. Although the Chinese Nursing Association offers PICC specialist training programs granting certification to qualified participants, and a few large-scale hospitals and medical enterprises have established intravenous therapy committees and PICC teams to conduct training and issue certificates, China currently lacks a unified authoritative institution for PICC specialist nurse qualification certification^[24]. Most provincial,

municipal, and county health departments delegate PICC specialist training to tertiary Grade A hospitals^[25]. Due to the absence of a unified certification system and standards^[26], most certification examinations are organized by individual medical institutions offering training programs, resulting in varying assessment content and lack of standardized evaluation criteria. Cao Jing et al.^[27] found that only 45.76% of hospitals in China conduct recertification for specialist nurses. Song Huanhuan et al.^[28] pointed out that China lacks uniformity in both the frequency and institutions responsible for PICC specialist nurse recertification. Therefore, there is an urgent need to establish a national PICC specialist nurse certification system featuring "unified standards, authoritative certification, and long-term supervision" to standardize industry entry requirements and ensure professional quality.

Medical consortiums, defined as healthcare networks formed around a core tertiary hospital with strong comprehensive capabilities that integrates secondary hospitals and community health centers within a region to share responsibilities and benefits^[29], represent an important organizational support mechanism. Currently, China's high-quality nursing resources are predominantly concentrated in tertiary hospitals^[30]. Implementing medical consortium assistance models can facilitate the dissemination of medical resources to primary care levels and improve PICC maintenance capabilities among nurses in grassroots hospitals. This assistance model can effectively narrow the competency gap between nurses at different hospital levels, enhance overall nursing quality, improve management and care quality in primary hospitals, and ultimately increase patient accessibility and societal satisfaction with healthcare services^[31]. We should establish a medical consortium-based PICC specialized assistance system characterized by "core hospital leadership, primary care needs orientation, and capability improvement goals," promoting systematic enhancement of PICC maintenance capabilities in primary hospitals through multidimensional, regular collaboration mechanisms.

4.3 Promoting Individual Professional Development

Promoting self-directed learning represents a vital pathway to enhance PICC specialist nurses' catheter maintenance competency. Nurses should proactively acquire new knowledge and techniques to continuously advance their professional expertise. Autonomous learning capability serves as a crucial reflection of nurses' comprehensive competence—only through strong self-directed learning abilities can nurses effectively acquire knowledge and improve their knowledge structure^[32], thereby continuously upgrading their professional knowledge and skills. By combining organization-centered structured education with individual-driven unstructured autonomous learning where nurses plan and execute their own learning objectives, they can consistently assimilate new knowledge and information to enhance comprehensive competencies^[33]. Healthcare institutions should further expand continuing education pathways for PICC specialist nurses: On one hand, they should regularly organize diverse activities including specialized lectures, academic seminars, and clinical skills competitions to establish platforms for academic exchange and practical demonstration; On the other hand, they should establish dynamic guideline learning mechanisms that incorporate the latest domestic and international evidence-based research to promptly update essential elements of PICC technical guidelines and organize systematic learning sessions. These initiatives will continuously stimulate nurses' awareness of active learning and enthusiasm for professional advancement while ensuring standardized and safe PICC clinical practices. Additionally, administrators should focus on nurse development by enhancing their self-efficacy and autonomous learning capabilities to genuinely improve clinical nurses' core competencies and deliver high-quality nursing services to patients.

Enhancing reflective practice also contributes to improving catheter maintenance proficiency. Reflective practice represents an iterative process of learning, critical thinking, application, and re-evaluation within dynamic environments through practical experience^[34]. In nursing practice, this manifests as actively contemplating nursing professionalism, questioning perplexing events or phenomena, conducting evidence-based and clinical research on specific clinical problems to develop optimal solutions for application in nursing practice, thereby better addressing complex clinical challenges^[35]. This process facilitates continuous updating of knowledge and skills to achieve ongoing professional growth, and has been demonstrated to significantly enhance clinical nurses' technical skills, self-efficacy, and communication abilities. Therefore, PICC specialist nurses should systematically integrate reflective practice throughout the entire catheter maintenance process, employing a closed-loop strategy of "practice-reflection-evidence-based optimization" to achieve synergistic improvement of professional capabilities and nursing quality.

5. Conclusions

With continuous advancements in medical technology, PICC maintenance techniques and management strategies are constantly evolving. Through analyzing the current research status and influencing factors of PICC specialist nurses' catheter maintenance competency, this study found that while clinical nurses generally possess intermediate to advanced knowledge levels, significant deficiencies exist in critical areas such as complication identification and management, and flushing solution usage. Nurses' catheter maintenance competency is influenced by multiple factors including individual factors (education level, professional title, number of maintenance cases), training factors (systematic training, training methods), and organizational management factors (hospital level). Addressing these issues, this paper proposes strategies to enhance PICC specialist nurses' catheter maintenance competency, including strengthening systematic training, improving organizational support systems, and promoting individual professional development.

Future research should focus on how evolving technologies and methodologies impact nurse competency requirements and promptly adjust training content and methods accordingly. Simultaneously, cooperation and exchange between different regions and levels of hospitals should be strengthened to promote knowledge and experience sharing, comprehensively enhancing PICC specialist nurses' catheter maintenance capabilities. Most existing studies employ cross-sectional surveys lacking long-term follow-up and intervention research, making it difficult to establish causal relationships. Future research should adopt more rigorous designs such as randomized controlled trials to validate the effectiveness of various training models and management strategies. Furthermore, existing studies predominantly rely on self-reports and questionnaires, potentially subject to social desirability bias. Future research should employ more objective evaluation methods such as direct observation, skills assessment, and patient outcome evaluation to more accurately assess nurses' catheter maintenance competency. Additionally, a scientific, standardized, and efficient training and management system for PICC specialist nurses should be established to provide patients with safer, higher-quality nursing services, improve patient quality of life, and enhance overall medical standards.

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