

Nurses' Attitudes and Knowledge of Peripherally Inserted Central Catheter Maintenance in Primary Hospitals in China: A Cross-Sectional Survey

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Binbin Xu^{1,2}
Jinghui Zhang^{1,3}
Jianmei Hou²
Mengdan Ma²
Zhihong Gong²
Siyuan Tang²

¹Teaching and Research Office of Clinical Nursing, Xiangya Hospital of Central South University, Changsha, Hunan, People's Republic of China; ²Xiangya Nursing School, Central South University, Changsha, Hunan, People's Republic of China; ³National Clinical Research Center for Geriatric Disorders, Xiangya Hospital, Central South University, Changsha, Hunan, People's Republic of China

Background and Aim: The promotion of peripherally inserted central catheter (PICC) maintenance in primary hospitals can benefit discharged patients with PICCs living in remote areas a lot. Yet, no primary hospitals had introduced PICC maintenance technology in Hunan province, China. The present study aimed to evaluate nurses' attitudes and knowledge of PICC maintenance in primary hospitals in Hunan province, China.

Materials and Methods: From November 2018 to January 2019, a total of 560 nurses from 28 community hospitals and 28 township hospitals in 14 cities across Hunan were recruited in the present study. All nurses were registered nurses engaged in clinical work related to intravenous infusion, and their attitudes and knowledge of PICC maintenance were measured by a self-designed questionnaire that was based on literature review and expert consultation.

Results: The response rate was 93.6% (560 of 598). Almost all participants could realize the importance and necessity of PICC maintenance. More than 90% of the participants expressed interest in PICC maintenance and showed strong demands for relevant training. However, the nurses' correct response rate of most knowledge items was at a low level (7.14–57.68%), with only three items exhibiting the correct response rate of 90% or higher. The factors influencing the nurses' PICC maintenance knowledge included their nursing experience, professional title, work setting, and department.

Conclusion: Although nurses in primary hospitals had a positive attitude toward PICC maintenance, their knowledge level was unsatisfactory, which might be a barrier to the promotion of PICC maintenance technology in primary hospitals in Hunan province, China. Multiple parties should get involved and take measures to improve the nurses' PICC maintenance knowledge, including the government, nursing associations, large-scale hospitals, and primary hospitals themselves. Besides, new training models and dynamic assessment methods should be explored to improve training effectiveness in the future.

Keywords: attitudes, catheter maintenance, knowledge, nurses, peripherally inserted central catheter, PICC, primary hospitals

Introduction

The peripherally inserted central catheter (PICC) has been widely used in prolonged intravenous therapy and parenteral nutrition since it was introduced to China^{1–5} due to its clinical advantages, such as long indwelling time, reduced vascular damage, and convenient placement and removal.^{6–8} However, like other central venous access devices, PICCs are associated with several complications, including thrombosis^{4,5,9–11} local infection,⁴ bloodstream infection,^{9,10,12}

Correspondence: Jinghui Zhang
Teaching and Research Office of Clinical Nursing, Xiangya Hospital of Central South University, Changsha 410008, People's Republic of China
Tel +86 15874032339
Email zhangjh-1206@163.com

occlusion,^{4,5,8,9,13} and breakage.^{5,9} These complications may make PICCs fail before the completion of treatment, delaying the drug administration, increasing the financial burden on patients, and reducing their satisfaction. This could have a greater impact on cancer patients since the delays to chemotherapy cycles might reduce treatment efficacy and could affect subsequent survival.¹⁴ Fortunately, the risk of such harms may be offset and the safety of PICCs could be maximized by the appropriate PICC maintenance.^{15–18} PICC maintenance includes evaluation of PICC function, replacement of infusion connectors and dressings, PICC flushing and sealing, and health education. The Nursing Practice Standards for Intravenous Therapy¹⁹ states that the PICC should be maintained at least once a week during the treatment intermission.

In China, PICCs of discharged patients are mainly maintained by tertiary and secondary hospitals during the treatment intermission. It was reported that they also could be maintained by primary hospitals that contain less than 100 beds, providing preventive care, minimal health care, and rehabilitation services (typically township hospitals and community hospitals).^{20–22} Previous studies^{20–23} indicated that making the primary hospitals be PICC maintenance sites can benefit discharged patients with PICCs in rural areas and outer suburbs a lot since it allows patients in the treatment intermission to select the nearest primary hospitals to maintain their PICCs instead of returning to the original site where the PICC was placed. This ensures that PICC maintenance is more convenient and cost-effective.

In Hunan province, China, PICC maintenance is performed by the PICC maintenance alliance, which is a province-wide PICC maintenance service network covering 103 hospitals in 14 cities. However, all these hospitals are tertiary or secondary hospitals, which means the discharged patients with PICCs in remote areas cannot obtain PICC maintenance service in the neighborhood. How nurses of primary hospitals view PICC maintenance, and whether they are prepared to maintain PICCs for discharged patients are important and still unanswered questions.

To bridge this knowledge gap, we conducted a cross-sectional study to evaluate nurses' attitudes and knowledge of PICC maintenance in primary hospitals which may provide a reference for the promotion of PICC maintenance technology in primary hospitals in Hunan province, China.

Materials and Methods

Ethical Statement

The present study was approved by the Institutional Review Board (IRB) of behavioral and nursing research in School of Nursing of Central South University, Changsha, China. The IRB reviewed and approved the survey, and verbal informed consent was individually obtained from each participant before data collection.

Study Design and Setting

This cross-sectional study was conducted in 56 primary hospitals, including 28 community hospitals and 28 township hospitals in Hunan Province, China from November 2018 to January 2019.

Participants

In the present study, the participants were registered nurses (RNs) who were working in primary hospitals in Hunan province, China. The inclusion criteria were as follows: 1) RNs who engaged in clinical work related to intravenous infusion, 2) RNs with more than one year of work experience, and 3) RNs who can correctly understand the questionnaire content. The exclusion criteria were RNs who were receiving psychotropic substances due to mental or psychological illness, RNs who were absent from work during the data collection period due to illness, maternity leave, vacation, or any other reasons, or RNs who refused to participate in the survey after being informed.

Sample Size and Sampling Technique

The sample size was determined by the criterion that the sample size should be 5–10 times the number of questionnaire items. In the present study, the questionnaire included 45 items. Thus, the sample size was estimated to range between 225 and 450. We considered nonresponse and invalid response subjects and increased the sample size by 20%, corresponding to the range between 270 and 540.

Participants were enrolled through a stratified random sampling method and convenience sampling method. There are 14 cities in Hunan, and each city includes several administrative regions in the urban area and several surrounding counties. First, we randomly selected an administrative region and a county from each city, getting 14 administrative regions and 14 counties. Then, we selected two community hospitals from each administrative region and two township hospitals from each county

using a convenience sampling method, getting 28 community hospitals and 28 township hospitals. Finally, in 56 selected primary hospitals, we recruited RNs according to the study inclusion and exclusion criteria following the principle of informed consent and voluntary.

Observation Variables and Survey Instrument

In the present study, the observation variables were nurses' demographic information and their attitudes and knowledge of PICC maintenance. The demographic information was collected through a self-designed questionnaire (9 items), including gender, age, years of nursing experience, professional title, education level, work setting, and department.

Nurses' attitudes toward PICC maintenance were defined as views on the importance and necessity of PICC maintenance technology and related training, beliefs that a standardized PICC maintenance process will lead to a better outcome, their perception on the roles of nurses in primary hospitals in PICC maintenance for patients in remote areas, and their willingness to participate in PICC maintenance training. Nurses' knowledge of PICC maintenance included a basic understanding of: the concept of PICC maintenance, functional evaluation of PICC, the selection of skin disinfectants and disinfection range, the replacement of dressings and infusion connectors, the selection of the type and volume of flushing and sealing fluid, techniques for PICC flushing and sealing, management of PICC-related complications, and health education for patients with PICCs.

Nurses' attitudes and knowledge of PICC maintenance were measured through a self-designed questionnaire. We developed the questionnaire based on literature review.^{6,7,15,19,24–27} Additionally, we used the Delphi method to carry out two rounds of surveys for 20 experts in intravenous therapy and nursing management to revise the questionnaire items and assess the questionnaire's validity. Moreover, the pretest was carried out to make sure the questionnaire could be understood easily.

The questionnaire comprised two parts. The first part included 17 statements on PICC maintenance attitudes. A 5-point Likert scale was used and five options were set for each statement: strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. The participants were asked to report to what extent they agreed or disagreed with these statements. Since all 17 statements were described in positive terms, the higher the participants' level of agreement

on the statements, the more positive their attitudes toward PICC maintenance. If the participants chose "strongly disagree" or "disagree", their attitudes toward PICC maintenance were considered negative; if "neither agree nor disagree" was chosen, the attitude was considered neutralizing; if "agree" or "strongly agree" was chosen, the attitude was considered positive. The second part included 19 items to assess nurses' knowledge of PICC maintenance. All items were single choice questions. The correct answer was assigned a point of 1; otherwise, 0 was inserted, with the full score of 19. The item-level content validity index (I-CVI) of this questionnaire ranged between 0.80 and 1.00, with the average scale-level content validity index (S-CVI/Ave) of 0.945, indicating that the questionnaire had good validity. Beyond that, both parts have good internal consistency, with Cronbach's α of 0.945 (attitude part) and 0.771 (knowledge part).

Data Collection

The data were collected by four postgraduate students in our research group from November 2018 to January 2019. The specific steps used were as follows: initially, the investigators contacted the nursing managers in 56 selected primary hospitals and explained the purpose of the survey to obtain permission and support. At this stage, the investigators determined the total number of RNs in 56 primary hospitals, that was, 1, 177. Subsequently, the investigators selected the eligible participants according to the study inclusion and exclusion criteria following the principle of informed consent and voluntary with the help of the head nurses, and a total of 598 RNs were selected and recruited. Finally, the investigators sent the questionnaires to 598 recruited RNs through a popular online questionnaire platform in China, Wen Juan Xing, and instructed them to fill out.

Quality Control

To diminish the risk of selection bias, we determined clear inclusion and exclusion criteria of the research objects and selected the participants in strict accordance with these criteria. Besides, we ensured that the questionnaire was simple and did not involve sensitive questions to reduce the non-response rate, and we set that all questions must be answered before submitting the questionnaire when uploading the questionnaire to the background of Wen Juan Xing to decrease the invalid response rate. To control information bias (also called observational bias), we provided unified training for the investigators on the study inclusion and exclusion criteria, the questionnaire content, and how to fill out the questionnaire. Also, we

took measures to diminish the risk of repotting bias, including guaranteeing the anonymity of the participants and the confidentiality of data. We assured the participants that the questionnaire was answered anonymously, that their information would be kept confidentially and only be used for research, and that their scores of the questionnaire would not have any influence on their career and promotion as their employers could not see their scores.

Statistical Analysis

Descriptive statistics (frequency, percentage, mean, and standard deviation) were used to summarize the participant characteristics, and the attitude and knowledge score of PICC maintenance. The knowledge score among nurses in primary hospitals with different characteristics was compared using the Wilcoxon rank-sum test for two-group comparison and the Kruskal–Wallis *H*-test for multiple comparisons. The generalized linear model was used to identify the demographic factors influencing PICC maintenance knowledge since the dependent variable (the knowledge score) was not normally distributed. The gamma distribution was selected as the distribution of the dependent variable, and the logarithmic function was selected as the link function. All analyses were performed using SPSS V.22.0, and a two-tailed $P < 0.05$ was considered statistically significant.

Results

Participant Characteristics

A total of 598 nurses were eligible to answer the questionnaire, and 560 nurses completed it, with a response rate of 93.6%. Among the 560 respondents, the majority were women (95.2%). The largest age group ranged between 26 and 35 (59.5%) followed by those aged 25 and under (23.6%). The majority exhibited a junior professional title (75.6%) and an education level of undergraduate (64.3%). More than half (59.5%) were from township hospitals and nearly half (46.3%) worked in the internal medicine department. More than half (52.9%) reported receiving PICC maintenance training previously, but only 11.8% had gained PICC catheterization certification (Table 1).

Nurses' Attitude Toward PICC Maintenance

Almost all participants agreed that PICCs should be maintained regularly during both the treatment period and the treatment intermission (96.8%). More than 90% of the participants

agreed that the appropriate PICC maintenance correlated with PICC indwelling time and reduced risk of PICC-related complications, and about 85% were aware of the important role of primary hospitals in PICC maintenance; 97.5% of the participants believed that PICCs should be maintained according to a standardized process, and more than 90% understood the necessity for nurses in primary hospitals to master PICC maintenance knowledge and technique. Most participants believed that PICC maintenance training was a good way to improve nurses' relevant knowledge and skills (95.9%) and that regular PICC maintenance training should be conducted in primary hospitals (92.5%). About 90% of the participants expressed interest in PICC maintenance knowledge and training (Table 2).

Nurses' Knowledge of PICC Maintenance

The results of nurses' correct responses to all knowledge items are displayed in Table 3. Among 19 items, 3 items exhibited a correct response rate of 90% or higher, 2 items exhibited a correct response rate between 80% and 90%, and 3 items showed a medium level of correct response rate (66.07–70%). However, the correct response rate of most items was at a low level: 6 items exhibiting a correct response rate between 50.54% and 57.68%, 4 items exhibiting a correct response rate between 20.89% and 35.89%, and 1 item exhibiting the minimum correct response rate of 7.14%. As can be seen in Table 3, the items with the low level of correct response rate were related to the selection of disinfectant and disinfection range, the disinfection method of the spiral part of the connector, the selection of the type and volume of flushing and sealing fluid, the method of tearing off films, the right time to replace dressings and needle-free connectors, and the management of various types of complications.

Variation in the Score of PICC Maintenance Knowledge Based on Participant Characteristics

Univariate analysis showed that there were statistical differences in PICC maintenance knowledge score among nurses with different years of nursing experience, professional titles, education levels, work settings, and departments (all $P < 0.01$). The difference in the knowledge score was statistically significant between nurses who had obtained PICC maintenance training previously and those who had not received training ($P < 0.01$). The statistical difference in knowledge score was also found between nurses with PICC catheterization

Table 1 Nurses' Demographic Characteristics and Their Association with PICC Maintenance Knowledge Score (n=560)

Characteristic	N (%)	Score ($\bar{x}\pm s$)	Z/H	P value
Gender				
Male	533 (95.2)	10.70 \pm 2.96		
Female	27 (4.8)	11.00 \pm 2.79	-0.259 ^a	0.795
Age, years				
≤ 25	132 (23.6)	10.55 \pm 2.64		
26–35	333 (59.5)	11.03 \pm 2.76		
36–45	85 (15.2)	11.54 \pm 3.09		
>45	10 (1.8)	10.50 \pm 2.84	6.506 ^b	0.089
Years of nursing experience				
1–3	119 (21.3)	9.64 \pm 2.69		
4–5	63 (11.3)	10.13 \pm 2.41		
6–10	219 (39.1)	11.22 \pm 2.59		
>10	159 (28.4)	12.01 \pm 2.81	49.042 ^b	<0.001
Professional titles				
Nurse	160 (28.6)	9.97 \pm 2.68		
Senior nurse	263 (47.0)	10.97 \pm 2.69		
Supervisor nurse	124 (22.1)	12.15 \pm 2.66		
Co-chief nurse and above	13 (2.3)	12.69 \pm 2.63	44.183 ^b	<0.001
Education levels				
Technical secondary school	4 (0.7)	10.00 \pm 1.41		
Junior college	196 (35.0)	10.45 \pm 2.74		
Undergraduate	360 (64.3)	11.29 \pm 2.79	11.171 ^b	0.004**
Work settings				
Community hospital	227 (40.5)	11.93 \pm 2.97		
Township hospital	333 (59.5)	10.34 \pm 2.47	-6.735 ^a	<0.001
Departments				
Oncology department	181 (32.3)	11.91 \pm 3.02		
Internal medicine department	259 (46.3)	10.65 \pm 2.50		
Surgery department	50 (8.9)	10.54 \pm 2.79		
Gynecology and obstetrics department	38 (6.8)	9.92 \pm 2.57		
Orthopedics department	32 (5.7)	10.41 \pm 2.77	33.635 ^b	<0.001
Whether PICC maintenance training was obtained before?				
No	264 (47.1)	10.31 \pm 2.51		
Yes	296 (52.9)	11.58 \pm 2.90	-5.344 ^a	<0.001
Whether PICC catheterization certification had been gained?				
No	494 (88.2)	10.78 \pm 2.60		
Yes	66 (11.8)	12.52 \pm 3.63	-4.239 ^a	<0.001

Notes: ^aZ value; ^bH value; **P<0.01.

Abbreviations: PICC, peripherally inserted central catheter; N, number.

certification and those who without PICC catheterization certification (P <0.01) (Table 1).

Multivariate analysis showed that nurses with 6–10 years (B= 0.146, P<0.01) and more than 10 years of nursing experience (B= 0.144, P<0.01), and with a professional title of “Supervisor Nurse” (B=0.102,

P<0.01) got higher PICC maintenance knowledge score than those with 1–3 years of nursing experience, and with a professional title of “Nurse”. Nurses from township hospitals (B=-0.17, P<0.01), and working in the surgery department (B=-0.088, P<0.05) and the orthopedics department (B=-0.167, P<0.01) reported a lower level of

Table 2 Attitudes Toward PICC Maintenance (n=560)

Items	Strongly Disagree/ Disagree, N (%)	Neither Disagree Nor Agree, N (%)	Strongly Agree/Agree, N (%)
1. Patients with PICC need regular catheter maintenance during both the treatment period and the treatment intermission.	1 (0.2)	17 (3.0)	542 (96.8)
2. There is a correlation between indwelling time and the timely and correct PICC maintenance.	11 (2.0)	40 (7.1)	509 (90.9)
3. Timely and correct PICC maintenance can reduce the occurrence of PICC related complications.	1 (0.2)	24 (4.3)	535 (95.5)
4. PICC maintenance needs to be performed according to a standardized process.	1 (0.2)	13 (2.3)	546 (97.5)
5. Strict aseptic procedures in the process of PICC maintenance is essential to prevent PICC-related infections.	1 (0.2)	7 (1.2)	552 (98.6)
6. Choosing the right disinfectant and disinfection range is important to prevent PICC-related infections.	1 (0.2)	19 (3.4)	540 (96.4)
7. Using the correct flushing and locking techniques is essential to prevent PICC occlusion.	1 (0.2)	22 (3.9)	537 (95.9)
8. A comprehensive and systematic catheter function assessment contributes to the early identification of PICC-related complications.	2 (0.4)	23 (4.1)	535 (95.5)
9. Effective health education for patients with PICC contributes to PICC self-management.	7 (1.2)	11 (2.0)	542 (96.8)
10. Nurses in primary hospitals are also responsible to provide education on PICC daily management for patients with PICC and their caregivers.	20 (3.6)	31 (5.5)	509 (90.9)
11. Nurses in primary hospitals can play an important role in catheter maintenance for discharged patients with PICC.	23 (4.1)	64 (11.4)	473 (84.5)
12. It's necessary for nurses in primary hospitals to master the knowledge of PICC maintenance and complication management.	5 (0.9)	29 (5.2)	526 (93.9)
13. Nurses in primary hospitals need to master the PICC maintenance technique to better meet the needs of discharged patients with PICC.	4 (0.7)	22 (3.9)	534 (95.4)
14. Participation in PICC maintenance training is important for nurses in primary hospitals to improve relevant knowledge and skills.	3 (0.5)	20 (3.6)	537 (95.9)
15. PICC maintenance training should be conducted regularly in primary hospitals.	1 (0.2)	41 (7.3)	518 (92.5)
16. I am interested in learning knowledge of PICC maintenance.	7 (1.3)	46 (8.2)	507 (90.5)
17. I am willing to take an active part in PICC maintenance training.	1 (0.2)	38 (6.8)	521 (93.0)

Note: The 5-point Likert scale results were collapsed into strongly disagree/disagree, neither disagree nor agree, and strongly agree/agree.

Abbreviations: PICC, peripherally inserted central catheters; N, number.

PICC maintenance knowledge compared with those from community hospitals, and working in the oncology department (Table 4).

Discussion

In this survey of 560 nurses in primary hospitals across Hunan, we examined nurses' attitudes and knowledge of PICC maintenance. We found that nurses in primary hospitals had a positive attitude toward PICC maintenance, which had never been reported in China before. Our results revealed that nurses in primary hospitals had a correct understanding of the importance and necessity

of PICC maintenance technology. They believed that primary hospitals could play an important role in catheter maintenance for discharged patients with PICC. They were willing to learn and master PICC maintenance knowledge and skills, and they showed strong demands for PICC maintenance training. However, their knowledge was insufficient, consistent with that reported by Purran et al,²⁸ especially in the selection of skin disinfectants and disinfection range, how the spiral part of the infusion connector was sterilized, the selection of the type and volume of flushing and sealing fluid, how the dressings were replaced, and management of various types of PICC-

Table 3 Number and Proportion of Correct Responses to Items of PICC Maintenance Knowledge (n=560)

Items	Number	Proportion (%)
1. Which of the following is the content of PICC maintenance?	539	96.25
2. Which of the following are the preferred disinfectant and correct disinfection range for skin disinfection when replacing the dressing?	40	7.14
3. Which of the following is the incorrect method of tearing the film when replacing it?	283	50.54
4. Which of the following is the wrong time to replace the transparent dressing and infusion connector?	316	56.43
5. Which of the following is the incorrect method of sterilizing the spiral part when replacing the infusion connector?	117	20.89
6. What type of flushing fluid should be used after the infusion of blood products and fat emulsions? And what is the minimum volume?	147	26.25
7. Which of the following is the correct type and volume of sealing fluid when maintaining PICCs?	121	21.61
8. What kind of techniques should be used for tube flushing and locking when maintaining PICCs?	464	82.86
9. Which of the following is the incorrect intervention if PICC is accidentally completely dislodged?	473	84.46
10. Which of the following is the correct intervention for PICC occlusion?	392	70.00
11. Which of the following is the preferred auxiliary examination for PICC-related thrombosis?	390	69.64
12. Which of the following is the correct preventive measure for PICC-related infections?	530	94.64
13. Which of the following is the incorrect intervention for PICC breakage in vitro?	370	66.07
14. Which of the following is the first intervention for PICC breakage in vivo?	318	56.79
15. Which of the following is the incorrect intervention for phlebitis?	323	57.68
16. Which of the following is the correct intervention for contact dermatitis?	306	54.64
17. Which of the following is not true related to health education for discharged patients with PICC?	313	55.89
18. Which of the following is the wrong operation when removing the PICC?	509	90.89
19. If the patient suddenly develops signs and symptoms such as dyspnea, chest pain, hypotension, dysphoria, and sweating in the process of PICC removal, which of the following is the incorrect intervention?	201	35.89

Abbreviation: PICC, peripherally inserted central catheter.

related complications, which might be due to the lack of systematic PICC maintenance training. This might be a barrier to the promotion of PICC maintenance technology in primary hospitals. The situation requires the attention of nursing managers, and appropriate strategies should be taken to increase their knowledge.

Nurses with more than six years of nursing experience exhibited a higher PICC maintenance knowledge score than those with one to three years of nursing experience, inconsistent with the result reported by Chopra et al.²⁹ Their result demonstrated no statistical difference in the knowledge of vascular nurses based on years of experience, which was possibly attributed to the small sample size. The reason for our result might be that inexperienced nurses are often busy with basic care practice, ignoring the learning of new technologies such as PICC maintenance, while those with rich working experience are usually able to deal with clinical nursing work with high proficiency, making them have more time and energy to acquire additional knowledge on specialized nursing.

Our study showed that nurses with a professional title of “Supervisor Nurse” exhibited a higher PICC maintenance knowledge score than those with a professional

title of “Nurse”. This is not surprising as nurses in primary hospitals often have less study and communication opportunities than those in large-scale hospitals; thus, the opportunities are often given to nurses with high professional titles. This enables them to renew their knowledge constantly. However, the statistical difference in PICC maintenance knowledge between nurses with a professional title of “Co-chief Nurse” and those with a professional title of “Nurse” was not found. This might be due to the difference in their job responsibilities. In China, the nurses’ professional titles from low to high are “Nurse”, “Senior Nurse”, “Supervisor Nurse”, “Co-chief Nurse”, and “Chief Nurses”. “Nurse”, “Senior Nurse” and “Supervisor Nurse” usually engage in clinical nursing work, while the main responsibilities of “Co-chief Nurse” and “Chief Nurse” are nursing management.

Besides, nurses from township hospitals and working in the surgery department and the orthopedics department reported a lower level of PICC maintenance knowledge compared with those from community hospitals and working in the oncology department. In China, community hospitals are primary hospitals located in urban areas,

Table 4 The Generalized Linear Model of the Factors Influencing PICC Maintenance Knowledge (n=560)

Factors	B	SE	95% Wald CI		Wald χ^2	P value
			Lower	Upper		
Years of nursing experience						
1-3	0					
4-5	0.06	0.0393	-0.017	0.137	2.365	0.124
6-10	0.146	0.0353	0.077	0.215	17.091	<0.001
>10	0.144	0.0385	0.069	0.22	14.062	<0.001
Professional titles						
Nurse	0					
Senior nurse	0.026	0.031	-0.035	0.086	0.684	0.408
Supervisor nurse	0.102	0.0376	0.028	0.176	7.379	0.007**
Co-chief nurse	0.08	0.0768	-0.071	0.23	1.078	0.299
Education levels						
Technical secondary school	0					
Junior college	-0.027	0.1222	-0.267	0.212	0.051	0.822
Undergraduate	-0.014	0.122	-0.254	0.225	0.014	0.906
Work settings						
Community hospital	0					
Township hospital	-0.17	0.0251	-0.219	-0.12	45.72	<0.001
Departments						
Oncology department	.000					
Internal medicine department	0.028	0.0274	-0.026	0.081	1.022	0.312
Surgery department	-0.088	0.039	-0.164	-0.011	5.041	0.025*
Gynecology and obstetrics department	-0.058	0.0446	-0.145	0.03	1.676	0.195
Orthopedics department	-0.167	0.0474	-0.259	-0.074	12.379	<0.001
Whether PICC maintenance training was obtained before?						
No	0					
Yes	0.038	0.0221	-0.006	0.081	2.896	0.089
Whether PICC catheterization certification had been gained?						
No	0					
Yes	0.025	0.0343	-0.042	0.092	0.537	0.464

Notes: **P<0.01; *P<0.05. The independent variables in the generalized linear model were coded as the following: Years of nursing experience (1-3=1, 4-5=2, 6-10=3, >10=4), Professional titles (Nurse=1, Senior nurse=2, Supervisor nurse=3, Co-chief nurse=4), Education levels (Technical secondary school=1, Junior college=2, Undergraduate=3), Work settings (Community hospital=1, Township hospital=2), Departments (Oncology department=1, Internal medicine department=2, Surgery department=3, Gynecology and obstetrics department=4, Orthopedics department=5), Whether PICC maintenance training was obtained before?(No=0, Yes=1), Whether PICC catheterization certification had been gained?(No=0, Yes=1).

Abbreviation: PICC, peripherally inserted central catheter.

and township hospitals are located in rural areas. Nurses in community hospitals thus have relatively more learning opportunities. This might be the reason why nurses in community hospitals exhibited a higher score. Concerning the contribution of the parameter department, the reason for these observations may be related to the difference in the work emphasis of different departments. In the oncology department, nurses may pay more attention to intravenous therapy including PICC since many patients require chemotherapy. While in the surgery

department and the orthopedics department, nurses may focus more on surgery and rehabilitation.

A surprising result was that whether PICC maintenance training was obtained and whether PICC catheterization certification had been gained did not influence the PICC maintenance knowledge score of nurses in primary hospitals, inconsistent with previous studies.^{18,27-30} Many studies^{18,27,28,30} showed that systematic and standardized PICC training can improve nurses' PICC maintenance knowledge, effectively decreasing complications and

improving patient safety. Although the result reported by Chopra et al²⁹ demonstrated no statistical difference in the knowledge of vascular nurses based on certification status, they attributed this to the small sample size. The reason for our result may be that the PICC maintenance training obtained by nurses in primary hospitals was not systematic and standardized. Another probable reason is as follows: although nurses obtained systematic and standardized training and PICC catheterization certification, the lack of practical opportunities and dynamic assessments may lead to the forgetting of PICC maintenance knowledge. Therefore, the lack of effective PICC training, dynamic evaluation, and practical opportunities may be difficulties that need to be overcome in nursing education and nursing management.

The knowledge, attitude, and practice (KAP) model suggests that any practices (behaviors) are determined by the person's attitude and knowledge toward the behaviors.³¹ To promote the PICC maintenance practice in primary hospitals, providing more convenient and cost-effective PICC maintenance services for discharged patients in remote areas, it is urgent to improve the nurses' PICC maintenance knowledge. How to provide more learning opportunities and resources for nurses in primary hospitals, how to provide effective PICC maintenance training for them, and how to dynamically evaluate the training effect are issues that worth considering.

The present study has some strengths. To the best of our knowledge, it is the first study to provide data about nurses' attitudes and knowledge of PICC maintenance in primary hospitals in China since most previous studies on PICC maintenance focused on nurses in tertiary and secondary hospitals, especially nurses in Class Three Grade A hospitals. Besides, the survey instrument developed in the present study could be used to evaluate nurses' attitudes and knowledge of PICC maintenance in primary hospitals in the other regions of China, it also could be used in other countries with rural areas and territorial dimensions like those in China if it is translated and validated. However, some limitations of the present study worth reviewing. First, although the administrative regions and counties were selected randomly, the primary hospitals in each administrative region and county were selected using a convenience sampling method. Thus, selection biases may be a threat to our conclusion. Second, although the quality control procedure was used throughout the data collection and entry, potential information bias may have occurred

because the survey was based on self-reported data. Besides, although nurses' attitude toward PICC maintenance was extremely positive, it might be affected by social desirability factors and cannot represent their actual attitude. Thus, a qualitative study on the nurse's PICC maintenance attitude needs to be conducted in the future to verify the results of this study. Finally, this was a cross-sectional study in Hunan province, China. Even though the sample size was large enough (560) to ensure the statistical power to support the conclusions and the response rate of the survey was excellent (93.6%), the generalization of the results to nurses in primary hospitals in other areas of China is unclear, and similar studies should be conducted in other regions.

Conclusions and Future Recommendations

In conclusion, although nurses in primary hospitals had a positive attitude toward PICC maintenance, their knowledge level was unsatisfactory, which might be a barrier to the promotion of PICC maintenance technology in primary hospitals in Hunan province, China. Nurses' knowledge level of PICC maintenance was mainly influenced by their nursing experience, professional title, work setting, and department. Effective PICC maintenance training and dynamic evaluation are needed in the future to improve their PICC maintenance knowledge.

Based on the findings of the present study, we recommended multiple parties including the government, nursing associations, large-scale hospitals, and primary hospitals themselves to get involved and make a contribution: the government investing more funds in primary hospitals and playing a guiding role; nursing associations emphasizing the importance of primary hospitals in PICC maintenance and providing free training for nurses; large-scale hospitals establishing a regional PICC maintenance network, taking themselves as the regional center and providing technical support to primary hospitals in the region; primary hospitals actively seeking help and creating more learning opportunities for nurses. It is also recommended that new training models and dynamic assessment methods be explored to improve training effectiveness in the future.

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Disclosure

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