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ORIGINAL RESEARCH

Intern-Nursing Students' Knowledge of Vascular Catheter-Associated Infections and Its Associated Factors: A Cross-Sectional Survey in China

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Background: Medical personnel contact with the patient closely, and their knowledge of vascular catheter-associated infections (VCAIs) is closely related to the prevention of VCAIs. Researchers mainly pay attention to the VCAIs knowledge of doctors and nurses but rarely pay attention to the nursing students in the hospital internship stage.

Purpose: To investigate the current situation of knowledge of intern-nursing students in VCAIs, and analyze its influencing factors.

Patients and Methods: 843 intern-nursing students were selected from 10 hospitals in five regions of eastern, western, southern, northern, and central China from June 26 to July 31, 2023, using a two-stage random sampling method. A self-designed questionnaire with good reliability and validity was used to investigate their knowledge of VCAIs, and *t*-test, multiple linear regression analysis, and Welch *t*-test were used to analyze the collected data by using SPSS Statistics 26.0 (IBM Corp., Armonk, NY).

Results: Intern nursing students' mean score of VCAIs knowledge was 48.66 (SD=15.77), with a score below 60 (unqualified) accounting for 75.4%, a score of 60–79 (qualified) accounting for 19.7%, a score of 80–89 (good) accounting for 3.6%, and a score of above 90 accounting for 1.3%. Students who attended VCAIs training three or more times had higher scores than those who did not attend training (B: 4.706, p=0.001), knowledge scores of students with a bachelor's degree or above were higher than those with junior college degree or below (B: 8.479, p<0.001), students who interned in tertiary hospitals had higher scores than those practicing in secondary hospitals (B:12.381, p<0.001) and scores of students in hospital training were significantly higher than study independently (B:4.116, p=0.007).

Conclusion: Intern-nursing students have a relatively low level of knowledge about VCAIs. It is recommended to strengthen clinical systematic and standardized training, improve the knowledge mastery level of intern-nursing students, and enhance their ability to handle VCAIs.

Keywords: catheter-related bloodstream infections, intern-nursing students, knowledge, vascular catheter-associated infections

Introduction

Central venous access devices (CVADs) are essential to clinical therapies; they include central venous catheters, peripherally inserted central catheters, implantable venous access ports, and hemodialysis vascular access devices.[1] CVADs are frequently used in parenteral nutrition, chemotherapy, immunotherapy, hemodynamic monitoring, and blood purification, which build effective venous catheters for treatment.[2–5] CVADs may cause some complications; vascular catheter-associated infections (VCAIs) are one of the most frequent problems associated with CVADs.[6,7]

VCAIs describe the occurrence of microorganisms that have been found in blood but are also present at the catheter's tip or in blood samples obtained via the catheter.[8] It mostly consists of catheter-related bloodstream infections (CRBSI) and

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catheter-related local infections (CRLI). The following elements contribute significantly to the development of VCAIs: catheter type and use, insertion site, medical staff catheterization expertise, frequency of catheterization, duration of catheterization, patient condition, previous history of bloodstream infection, and application of preventive measures.[9–11] High incidence rates are a defining feature of VCAIs; the daily CRBSI infection rate in the United States of America is 1.7 ‰, whereas it ranges from 2.8 ‰ to 11.2 ‰ in China.[12] About 60% of hospital acquired bloodstream infections, or fungemia, are caused by vascular catheters.[13] VCAIs can drastically lengthen hospital stays, raise treatment expenses, alter patient prognoses and raise patient mortality.[14] The all-cause mortality rate caused by VCAIs is up to 40%.[15] Guidelines suggest that we can prevent and control VCAIs using currently available knowledge and techniques.[9,16] Interventions to prevent VCAIs include hand hygiene, aseptic principles, training for medical staff on catheterization and maintenance, patient health education, drug prevention, selection of catheterization sites, ultrasound guided implantation and vascular access management (vascular access selection, catheter type selection, catheter fixation and dressing replacement, flushing and sealing techniques, removal of unnecessary catheters).[17,18] These preventive measures require the participation and implementation of clinical healthcare staff.

Intern nursing students who participate in clinical nursing practice will take part in the vascular catheter maintenance in their daily internship work. Intern nursing students' knowledge of VCAIs will also affect their capacity to recognize and treat VCAIs and have an impact on the quality of nursing care. The investigation of clinical nursing staff's awareness, prevention and control knowledge of VCAIs, as well as the analysis of factors that affect the knowledge level of VCAIs, and the impact of intervention measures on VCAIs prevention and control knowledge and practice, are the main areas of focus of previous research.[19,20] However, evidence of current status of intern nursing students' knowledge of VCAIs was limited. In light of this, this study conducted a cross-sectional survey on the intern nursing students' knowledge of VCAIs in China. A self-designed questionnaire was used to examine the intern nursing students' knowledge of VCAIs and influencing factors. The findings may provide nursing management departments with a theoretical foundation for carrying out targeted training for clinical nursing students, creating efficient prevention strategies, and reducing the incidence rate of VCAIs.

Materials and Methods

Research Design

A cross sectional study was conducted in China from June 26 to July 31, 2023.

Participants

The research object of this study was 843 intern nursing students from Chinese hospitals. The inclusion criteria were: (1) age ≥ 18 years old; (2) voluntary participation in this study; and (3) intern nursing students had obtained or currently pursuing a full-time junior college degree or above. Exclusion criteria: (1) non-Chinese participants.

Sample Size and Sampling Techniques

The sample size of the study was estimated using the formula $n=(\mu_{\alpha/2})^2\Pi(1-\Pi)/\delta^2$, where π= population rate, δ=tolerance error, $\mu_{\alpha/2}$= standard normal variate (at 5% type 1 error ($p < 0.05$) it is 1.96)). As the overall knowledge of intern-nursing students about VCAIs is unknown, assume Π= 0.5, if the tolerance error is 0.05, α= 0.05, then $\mu_{\alpha/2}$=1.96, so the estimated sample size calculated by substituting these values is 384. Taking into account a 20% non-response rate, an estimated sample size of 480 was needed.

We recruited participants by using a two-stage random sampling method. The specific sampling method was as follows: In the first stage, a random number table method was used to randomly select one municipality or autonomous region or province from each of the five regions in eastern, western, southern, northern, and central China, totaling five municipalities or autonomous regions or provinces (Zhejiang, Qinghai, Guangxi, Inner Mongolia, and Hunan province). In the second stage, a random number table was used to randomly select 5 tertiary hospitals and 5 secondary hospitals from the 5 municipalities or autonomous regions or provinces selected in the first stage, totaling 10 hospitals. Recruit

intern nursing students who meet the inclusion criteria from sampled hospitals based on the principles of informed consent and voluntary participation.

Research Tools

The "Knowledge of Vascular Catheter-associated Infections (VCAIs) Questionnaire" (Appendix 1) was developed based on a literature review,[2,9,21–24] focus group discussion, the Delphi method, and a predictive test. The first part is the collection of basic information, including hospital level, hospital type, gender, age, education, department, frequency of training, whether they had VCAIs nursing experience, and ways of acquiring VCAIs knowledge. The second part is a survey questionnaire for intern nursing students' knowledge of VCAIs, including four dimensions: the concept of VCAIs, the causes of VCAIs, VCAIs prevention and treatment measures, and VCAIs management measures. Each dimension has secondary entries, totaling 10 secondary entries: concept of VCAIs include the definition of VCAIs, clinical manifestations of VCAIs, and clinical diagnosis of VCAIs. The causes of VCAIs include infection routes of VCAIs, risk factors of VCAIs, and pathogens of VCAIs. VCAIs prevention and treatment measures include prevention measures for VCAIs before catheterization, prevention measures for VCAIs during catheterization, and prevention measures for VCAIs after catheterization. VCAIs management measures are described as management requirements and strategies. The topics of all items are single-choice questions. The correct answer will get 4 points, and the wrong answers will get 0 points. There are 25 questions in total, and the full score is 100 points. The higher the score, the better the intern nursing students' knowledge of VCAIs. According to the distribution of scores, the results are divided into four levels: unqualified (<60 points), qualified (60–79 points), good (80–89 points), and excellent (≥90 points). After pre-testing, the questionnaire has good reliability and validity. The Cronbach's alpha coefficient is 0.802, the KMO (Kaiser Meyer Olkin) is 0.996, and the Bartlett's test P value is <0.05, indicating that this questionnaire can be used to investigate the current status of intern-nursing students' knowledge about VCAIs.

Data Collection

Firstly, the researchers contacted the directors in charge of teaching in the nursing departments of each hospital to explain the research purpose, significance, inclusion and exclusion criteria, and obtained informed consent before conducting this study. Based on the principles of informed consent and voluntary participation, we commissioned the teaching directors to recruit intern clinical nurses who meet the inclusion and exclusion criteria in the selected hospitals according to the research inclusion and exclusion criteria. The questionnaire data was collected by four postgraduate students from June 26 to July 31, 2023. We arranged online training for eligible intern nurses in batches, introducing the significance, purpose, methods, potential benefits, and questionnaire filling methods of this study. Online questionnaire surveys linked to Wen Juan Xing (a questionnaire collection website in China) were sent to the teaching directors of each hospitals included. Hospitals assisted in the distribution of questionnaire links to collect data. The questionnaire system can only submit answers once to prevent duplicate responses. Before submitting, participants must fill out all questions according to relevant prompts to ensure that the questionnaire is fully collected. After collecting data, two researchers re-examined the data and removed invalid questionnaires (the time for filling in questionnaire was too short and the answers to the questionnaire were all consistent). In this survey, 858 questionnaires were ultimately collected, and after excluding invalid questionnaires, 843 questionnaires were collected, with an effective recovery rate of 98.25%.

Quality Control

20 intern nurses participated in the pre-test of this questionnaire, and we made certain modifications to the questionnaire items or expressions based on their feedback, forming the final questionnaire. Therefore, the questionnaire entries are concise and easy to understand. In addition, the questionnaire entries are only used to understand the intern nursing students' knowledge of VCAIs and do not involve sensitive issues. To ensure the credibility of the survey results, 20 participants in the pre-test were ultimately excluded from the actual study. The selection of participants strictly follows the inclusion and exclusion criteria to reduce the risk of selection bias. The questionnaire filling is set as mandatory to ensure the response rate of each item in the questionnaire. In addition, the participants anonymously filled out this questionnaire, and other personal information collected in the questionnaire is strictly

confidential, accessible only to researchers, and used only for this study. Finally, we explained to the participants that the results of filling out the questionnaire would not affect their internship performance or other comprehensive evaluations.

Ethics Consideration

All processes of this study follow the Declaration of Helsinki and have obtained approval by the Ethics Committee of Xiangya School of Nursing, Central South University (Ethics Review and Approval No. E2023142). The data collected during the research is strictly confidential.

Statistical Analysis

IBM SPSS Statistics 26.0 (IBM Corp., Armonk, NY) was used for data analysis. Descriptive statistics (mean, standard deviation (SD), frequency, percentage) were used to summarize the overall characteristics of participants and knowledge scores of the participants. The knowledge scores were normally distributed; hence, an independent sample *t*-test was employed for comparing knowledge scores between the two groups. For comparisons involving three groups or more, one-way analysis of variance (ANOVA) was used when the data met the assumption of homogeneity of variance, and Welch Test was used when the data did not meet the assumption of homogeneity of variance. Multiple linear regression analysis was used to analyze the influencing factors of the knowledge scores of VCAIs among intern nursing students. $P<0.05$ (2-tailed) indicates statistical significance.

Results

Characteristics of Participants

A total of 843 valid questionnaires were collected through online distribution. Among the 843 clinical intern nursing students, 84 were male (10.0%) and 759 were female (90.0%). The age of participants ranges from 18 to 25 years old; the average age was 21.43 (SD = 1.12). A total of 528 students obtained a bachelor's degree or above, accounting for 62.6%, and 315 students (37.4%) have a junior college degree or below. There are 375 (44.5%) nursing students interned in tertiary hospitals and 468 (55.5%) nursing students interned in secondary hospitals. 798 nursing students (94.7%) interned in general hospitals, and a total of 45 nursing students (5.3%) interned in specialized hospitals. Intern nursing students were mainly interned in internal medicine (36.2%) and surgery medicine (18.9%). 14.6% intern nursing students have not received VCAIs training; 45.4% participants received 1–2 VCAIs training; and 40% nursing students took part in more than three times VCAIs trainings. 222 participants have nursing experiences of VCAIs patients, accounting for 26.3%; the remaining 621 (73.7%) do not have nursing experiences of VCAIs patients. 543 nursing students acquire knowledge of VCAIs thorough training organized by school, accounting for 64.4%; 110 nursing students (13.0%) acquire knowledge of VCAIs thorough training organized by hospitals; and 190 nursing students study independently, accounting for 22.5%. The detailed information is shown in Table 1.

Knowledge Score of Participants on VCAIs

The questionnaire survey shows that the VCAIs knowledge score of clinical intern nursing students is 16–96 points, with a mean score of 48.66 (SD = 15.77) out of 100. The scores are mainly concentrated below 60 points, with < 60 points (unqualified) accounting for 75.4%, 60–79 points (qualified) accounting for 19.7%, 80–89 points (good) accounting for 3.6%, and ≥ 90 points (excellent) accounting for 1.3%. The mean accuracy rate of intern nursing students' knowledge is 55.4%. The mean score of conceptual dimension is 8.76 (SD = 4.74), with an accuracy rate (number of accurate questions/ full number of questions) of 44%; the mean score of the etiology dimension is 9.02 (SD = 3.35), with an accuracy rate of 75%; the mean score of VCAIs prevention and control measures is 27.71 (SD = 10.83), with an accuracy rate of 45%; and the mean score of VCAIs management measures is 3.16 (SD = 2.63), with an accuracy rate of 40%. The scores of secondary items in each dimension are shown in Table 2.

Table 1 Demographic Characteristics of Intern-Nursing Students (n=843)

Categories		Number	Proportion (%)
Education	Bachelor degree or above	528	62.6
	Junior college or below	315	37.4
Sex	Male	84	10.0
	Female	759	90.0
Hospital level	Tertiary hospital	375	44.5
	Secondary hospital	468	55.5
Hospital type	General hospital	798	94.7
	Specialized hospital	45	5.3
Department	Internal medicine	305	36.2
	Surgery medicine	159	18.9
	Gynaecology and obstetrics	68	8.1
	Pediatrics	56	6.6
	Others	255	30.2
Frequency of training	0	123	14.6
	1–2	383	45.4
	≥3	337	40.0
Whether they had VCAI nursing experience	Yes	222	26.3
	No	621	73.7
Ways of acquiring knowledge	Training organized by school	543	64.4
	Training organized by hospital	110	13.0
	Study independently	190	22.5

Table 2 Scores from Different Dimensions of Knowledge About VCAIs (n=843)

Knowledge Dimension	Secondary Entry	Scores $(\bar{x} \pm S)$	Accuracy
VCAIs concept	Definition	2.82±1.83	70%
	Clinical management	3.17±3.00	40%
	Clinical diagnosis	2.77±2.68	35%
VCAIs etiology	Infection route	3.49±1.34	87%
	Risk factors	2.54±1.93	63%
	Pathogenic bacteria	2.99±1.74	75%
VCAIs prevention and treatment measures	Prevention measures before catheterization	5.90±3.80	49%
	Prevention measures during catheterization	6.21±3.42	52%
	Prevention measures after catheterization	15.60±7.14	43%
VCAIs management measures	CRBSI management measures	3.16±2.63	40%

Notes: accuracy= number of accurate questions/ full number of questions.

Influencing Factors on the Knowledge Score of VCAIs Among Participants

The results showed that there were statistically significant differences in the VCAIs knowledge scores of intern-nursing students in terms of hospital level, education level, training frequency, whether they had VCAIs nursing experience, and ways of acquiring knowledge (all P <0.05). However, there was no statistical significance in terms of hospital type, sex, and rotating departments (all P >0.05) (Table 3).

Multiple linear regression analysis was performed using VCAIs knowledge score as dependent variable and variables that were statistically significant in univariate analysis as independent variables. Assignments of independent variables are shown in Table 4. The results showed that intern-nursing students who attended VCAIs training three times or more had significantly higher knowledge scores than those who did not attend training (B: 4.706, P=0.001). There was no significant difference in knowledge scores for those who participated 1–2 times. Knowledge scores of intern nursing students with a bachelor's degree or above were significantly higher than those with junior college degree or below

Table 3 Comparison of Scores on Knowledge of VCAIs Among Intern-Nursing Students with Different Demographic Characteristics (n=843)

General Data		Number	Score $(\bar{x} \pm S)$	t/F	P
Hospital level	Tertiary hospital	375	57.48±14.83	16.494[a]	<0.001
	Secondary hospital	468	41.60±12.64		
Hospital type	General hospital	798	48.54±15.77	−0.953[a]	0.34
	Specialized hospital	45	50.84±15.83		
Sex	Male	84	45.95±15.41	−1.663[a]	0.10
	Female	759	48.96±15.79		
Education	Bachelor degree or above	528	53.70±15.08	13.679[a]	<0.001
	Junior college or below	315	40.22±13.06		
Department	Internal medicine	305	49.57±15.48	1.844[b]	0.12
	Surgery medicine	159	48.20±16.03		
	Gynaecology and obstetrics	68	44.18±12.92		
	Pediatrics	56	47.57±14.65		
	Others	255	49.30±16.72		
Frequency of training	0	123	43.38±13.04	29.502[b]	<0.001
	1–2	383	46.12±13.88		
	≥3	337	53.48±17.36		
Whether they had VCAI nursing experience	Yes	222	50.63±17.86	1.993[a]	0.047
	No	621	47.96±14.90		
Ways of acquiring knowledge	Training organized by school	543	48.02±15.40	7.684[b]	0.006
	Training organized by hospital	110	54.07±19.81		
	Study independently	190	47.37±13.46		

Note: [a]t value, [b]F value.

Table 4 Assignment Status of the Respective Variables

Variables	Assignment Method
Hospital level	Tertiary hospital=1, secondary hospital=0
Education	Bachelor degree or above=1, junior degree or below=0
Frequency of training	The dummy variable was set using "0 time" as reference, dummy variable X1: 1~2 times=1, "0 time" "more than 3 times" =0 dummy variable X2: more than 3 times=1, "0 time" "1~2 times" =0
Whether they had VCAI nursing experience	Yes=1, No=0
Ways of acquiring knowledge	The dummy variable was set using "study independently" as reference, dummy variable X1: training organized by school=1, "study independently" "training organized by hospital" =0 dummy variable X2: training organized by hospital=1, "study independently" "training organized by school" =0

(B: 8.479, P<0.001). Intern nursing students who interned in tertiary hospitals had significantly higher knowledge scores than those practicing in secondary hospitals (B: 12.381, P<0.001). The scores of intern nursing students in hospital training were significantly higher than study independently (B: 4.116, P=0.007), and there was no significant difference in knowledge scores between school training and study independently. Moreover, the results of multiple linear regression analysis showed that whether they had VCAIs nursing experience had no significant difference on VCAIs knowledge (B: 0.974, P=0.35). The detailed information is shown in Table 5.

Discussion

We investigated the knowledge status and influencing factors of VCAIs among 843 intern nursing students from 10 hospitals in China. This study is the first to investigate the knowledge level of intern nursing students on VCAIs in China. By understanding intern nursing students' level of knowledge and the factors that affect it, we can establish a solid basis

Table 5 Multiple Linear Regression Analysis of the Factors Influencing the VCAIs Knowledge Scores of Intern-Nursing Students with Different Characteristics

Variables		B	SE	β	t	P
Constant		35.147	1.430		24.576	<0.001
Frequency of training	0 time	0				
	1–2times	0.272	1.348	0.009	0.202	0.84
	More than 3 times	4.706	1.380	0.146	3.410	0.001
Education	Junior college or below	0				
	Bachelor degree or above	8.479	0.974	0.260	8.710	<0.001
Hospital level	Secondary hospital	0				
	Tertiary hospital	12.381	0.945	0.390	13.097	<0.001
Whether they had VCAI nursing	No	0				
experience	Yes	0.974	1.038	0.027	0.938	0.35
Ways of acquiring knowledge	Study independently	0				
	Training organized by school	−0.125	1.091	−0.004	−0.115	0.91
	Training organized by hospital	4.116	1.536	0.088	2.680	0.007

Note: R^2=0.352, F=64.889, *P*<0.001.

for future nursing education in clinical practice, increase intern nursing students' capacity to prevent and handle VCAIs, and provide focused training for these students. The findings of this study showed that intern nursing students have a relatively poor level of VCAIs knowledge, with 75.4% of them being unqualified. Their level of knowledge is mostly impacted by their educational background, hospital level, frequency of training and ways of acquiring knowledge.

Results showed that intern nursing students had relatively poor knowledge of VCAIs, with a mean knowledge score of 48.66 out of 100. This finding aligns with Cicolini's study,[25] which indicated a relatively low level of clinical nurses' knowledge about the prevention of peripheral venous catheter-related infections, with a median score of 6 out of a maximum score of 10. The mean accuracy rate of intern nursing students' knowledge towards VCAIs was 55.4% in our study, consistent with the mean accuracy rate of nursing students' knowledge towards the peripheral venous catheter management (ie, 55.42%) reported by Simonetti.[26] However, our mean accuracy rate was higher than the overall correct rate of Chinese ICU nurses' knowledge of CRBSI prevention and treatment (ie,36.56%) reported by Chi Xiuwen.[19] This finding was inconsistent with our hypothesis that the clinical nurses should have better knowledge than the intern nursing students since they have had more clinical practice experience. This observed discrepancy may be attributed to variations in the measurement instruments utilized. Four aspects of VCAIs knowledge are measured by our questionnaire: the definition of VCAIs, their causes, prevention and treatment strategies, and management strategies. Whereas, Chi Xiuwen's study focused only on the prevention of CRBSI. In our study, the accurate rate of the causes of VCAIs was up to 75%, which may make our overall accurate rate higher than that identified among clinical nurses.

We discovered that intern nursing students have a significantly higher accuracy rate for the causes of VCAIs than the other three dimensions based on the accuracy rate of the questionnaire's various dimensions. This finding indicated that they have a better understanding of the causes of VCAIs. In line with our findings, Mlinar's study[27] indicated that while not all students possessed comprehensive knowledge of all risk factors related to the development of central venous catheter infection, a significant majority had a partial awareness of these risk factors. Specifically, 93.1% of full-time students and 91.2% of part-time students demonstrated some level of awareness regarding these risk factors. The recognition of risk factors of VCAIs benefits the prevention and discovery of VCAIs. However, the correct response rates for clinical diagnosis, clinical manifestations, management measures, preventive measures before catheterization, and preventive measures after catheterization were, respectively, 35%, 40%, 40%, 49%, and 43%, all below 50%, according to the scores of each secondary item in the questionnaire. The maintenance and management of vascular catheters, as well as the prevention and treatment of problems, are neglected by intern nursing students and nurses, who also lack a thorough understanding of how to detect VCAIs and their particular clinical complications.

The reasons for intern nursing students' poor knowledge on VCAIs may be fewer class hours arranged for vascular catheters and their complications in theoretical teaching,[28] inadequate education of nursing students has been considered as a barrier of evidence-based practice.[29] and nursing students' understanding of vascular catheters is not comprehensive enough.[30,31] Additionally, there are few opportunities for clinical interns to contact vascular catheters during clinical practice, and the teaching of prevention, treatment, and care of vascular catheter-related complications in clinical internships is also limited.[32] As a result, in order to enhance intern nursing students' understanding of VCAIs prevention and treatment knowledge and improve their coping ability of VCAIs, it is recommended to appropriately increase vascular catheterization-related courses in future theoretical teaching, particularly the weak parts (prevention and management of complications); moreover, it is advised to increase the opportunities for intern nursing students to learn vascular catheterization throughout the entire nursing cycle of patient,[32] as well as to combine examples, videos, simulated nursing rounds, classroom lecture and other methods.[33] Chambers's study shows that inter-professional peer teaching can achieve the effect of resource sharing and learning with each other, inter-professional peer teaching can also be applied to VCAIs knowledge teaching.[34]

According to the study's findings, intern nursing students who took part in VCAIs training at least three times scored much higher on knowledge tests than those who did not. This finding supports Almahmoud and other previous studies in that training can greatly improve the knowledge score.[28,32,35,36] The knowledge score of catheter-related infections of clinical nurse practitioners after training has significantly increased, and the incidence of catheter-related complications in patients is lower. However, the study by Chen Ying et al[37] revealed that there are substantial variations in training between departments and a lack of consistency and systematicity in the training given to nurses. As a result, it is advised that intern nursing students receive more training in vascular catheter-related information, particularly in the prevention and management of VCAIs. In order to improve intern nursing students' understanding and application of VCAIs prevention and control guidelines, it is also required to standardize training content and format, develop training forms, and boost clinical practical skills in practical operations.[38]

The study's findings demonstrated that diverse teaching approaches result in varying degrees of VCAIs knowledge mastery among nursing students, with hospital-organized intern nursing students scoring much higher scores than self-study. This is because hospital-organized training provides more exposure to clinical cases than self-study and can provide face to face training in ward, effectively integrating theory and practice, and improving intern nursing students' understanding of training knowledge.[38] The forms of training organized by hospitals are relatively diverse, and the adoption of assessment forms after training can enable nursing students to evaluate their mastery of knowledge. Therefore, the training mode organized by hospitals is better than that of self-study. It is reported that training can improve medical staff's awareness of preventing catheter-related bloodstream infections, and reduce the incidence of VCAIs.[37] In order to improve their mastery of VCAIs knowledge and strengthen their clinical application ability in VCAIs prevention and treatment, we suggest that internship hospitals organize more training on VCAIs knowledge, supplemented by a literature review to gain a deeper understanding of recent developments in VCAIs.

According to the study's findings, educational background has a significant influence on the VCAIs knowledge scores of intern nursing students. The Same is true of the research results of Liu Qifan et al[39] and Chi Xiuwen et al[19] the knowledge score of nurses with a bachelor's degree or above is higher than nurses with junior college or below. Nursing students with a bachelor's degree or above have significantly higher knowledge scores than those with a junior college degree or lower. The main reason may be that nursing students with higher educational backgrounds have a stronger foundation of knowledge learned on campus, and their learning and understanding of VCAIs are better than intern nursing students with lower educational backgrounds.

The results indicated that hospital level has a significant impact on the knowledge score of VCAIs among intern nursing students, the knowledge score among students interned in secondary hospitals is lower than students interned in tertiary hospitals. However, the results of other research[40,41] indicated that there was no statistical significance in hospital level. The inconsistent results may be due to the utilization of distinct assessment tools and the restricted sample sizes in the two prior investigations, particularly with regard to the secondary hospital participants (26 and 42, respectively). The main impact of hospital level on VCAIs knowledge among intern nursing students in this study is that nurses interned in secondary hospitals have fewer opportunities to access vascular catheter maintenance and receive VCAIs training than

those who interned in tertiary hospitals. Nursing students in secondary hospitals therefore have less understanding about catheter-related infections than interns in tertiary hospitals.

Limitations

Our research has certain limitations. (1) This study is a cross-sectional study, the causal relationships cannot be determined, so it is necessary to conduct longitudinal research in the future. (2) Self-reporting bias: because the study's survey was delivered online, we cannot be certain that every participant can take the survey seriously and truly. In order to meet social expectations, participants may have situations where they cannot answer truthfully, such as when searching for answers online. (3) We chose five provinces from eastern, western, southern, northern, and central China, but those five provinces may not fully represent the overall situation of China due to the regional differences, so we can increase the number of provinces or conduct national research in the future to deal with this problem. (4) Limitations of multiple linear regression analysis: the R^2 is 0.352, so the influence factors of this study can only explain 35.2% of the variation; there are still other influences factors that we did not pay attention to. Therefore, we should review the current status and influencing factors of VCAIs knowledge among other populations, consider factors that may affect the mastery of VCAIs knowledge among nursing interns, and conduct further research. (5) The actual number of respondents is significantly higher than the calculated sample size, potentially benefiting the statistical analysis by facilitating the identification of significant differences. Therefore, findings should be interpreted cautiously.

Conclusion

Inter nursing students have a low level of mastery of VCAIs knowledge, mainly influenced by factors such as hospital level, educational background, frequency of training and ways of acquiring knowledge. To improve the knowledge level of VCAIs prevention among intern nurses, it is recommended that managers and instructors who are in charge of intern teaching implement multi-channel training measures to provide homogeneous training on VCAIs knowledge for intern nurses. At the same time, teachers should pay close attention to the group of intern nurses who performed poorly in this survey and provide specialized education and training based on their individual needs. In order to help intern nursing students better understand VCAIs preventive and treatment knowledge and clinical application, the teaching teacher should simultaneously involve intern nursing students in the whole course management of clinical VCAI patients.

Author Contributions

JZ and JH conceptualized and designed the study. JH and BX collected and analyzed the data and drafted the manuscript. NY, SP, RX, GM and JZ assisted in the collection and collation of data and contributed to the interpretation of the manuscript, all authors contributed to the revision and critical review of the manuscript. All authors agreed to submit the manuscript to the journal and approved the final submitted version during each stage, and all authors agreed to take responsibility and be accountable for the contents of the article.

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