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Evaluating Nursing Students' Venipuncture and Peripheral Intravenous Cannulation Knowledge, Attitude, and Performance

A Two-Phase Evaluation Study

Orlaith Hernon, RGN, RCN, RNT, BSc, PgDip, MSc • Edel McSharry, RN, RNT, BNSc, MSc, EdD • Andrew J. Simpkin, BA, PhD • Iain MacLaren, BSc (Hons), PhD • Peter J. Carr, RN, BSc, MMedSc, PhD

ABSTRACT

Peripheral intravenous cannulation and venipuncture are among the most common invasive procedures in health care and are not without risks or complications. The aim of this study was to evaluate the current training provided to nursing and midwifery undergraduate students. Student knowledge, attitude, practice, and performance regarding these procedural skills were assessed. A knowledge, attitude, and practices survey was disseminated to final year nursing and midwifery students as the first phase of this study. For the second phase of the study, nursing students were video recorded and then observed performing the skill of peripheral intravenous cannulation in a simulated environment. Thirty-eight nursing and midwifery students completed the survey, and 66 nursing students participated in the observation study. Descriptive statistics were performed. The mean knowledge score was 7.2 out of 15.0, (standard deviation [SD] = 2.4), and the mean attitude score was 10.20 out of 18.00 (SD = 4.79). Qualitative data from the survey were categorized to demonstrate

Author Affiliations: *School of Nursing and Midwifery (Ms Hernon and Dr Carr), School of Mathematical and Statistical Sciences (Dr Simpkin), and Centre for Excellence in Learning & Teaching (Dr MacLaren), University of Galway, County Galway, Ireland; School of Nursing Health Science & Disability Studies ATU St Angela's, County Sligo, Ireland (Dr McSharry).*

Orlaith Hernon, RGN, RCN, RNT, BSc, PgDip, MSc, *is a registered general nurse, children's nurse, and nurse tutor. She is currently a PhD candidate in the School of Nursing and Midwifery, University of Galway, and was awarded a PhD scholarship in the area of teaching and learning technologies.* **Edel McSharry, RN, RNT, BNSc, MSc, EdD,** *qualified as a registered general nurse in 1986. Her clinical background was in medical surgical and critical care areas. Since 1998 she has held the roles of lecturer, programme director, head of school, and college president and has taught, devised, and managed the delivery of undergraduate and post-graduate courses. Her research interests include clinical education, preceptorship, use of technology in education, internationalization, and intercultural competencies.* **Andrew J. Simpkin, BA, PhD,** *is an associate professor of statistics at the School of Mathematical and Statistical Sciences at the University of Galway. His research focuses on longitudinal data analysis, functional data analysis, genomics, and data science. Dr. Simpkin has developed new methods for modeling high-dimensional data using functional data analysis and models for epigenetic change in genomics research, which are now used worldwide.* **Iain MacLaren, BSc (Hons), PhD,** *is the director of the Centre for Excellence in Learning & Teaching at the University of Galway. His research interests are in teaching methods, technologies, and policy in higher education. He is a graduate of Edinburgh and Durham universities.* **Peter J. Carr, RN, BSc, MMedSc, PhD,** *is an associate professor with the School of Nursing and Midwifery, University of Galway, and an adjunct senior research fellow with the AVATAR group, Griffith University, Queensland, Australia. He is a vascular access clinician and clinical researcher.*

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Corresponding Author: *Orlaith Hernon, RGN, RCN, RNT, BSc, PgDip, MSc, School of Nursing and Midwifery, University of Galway, University Road, Co. Galway, Ireland H91 TK33 (o.hernon1@universityofgalway.ie).*

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specific areas of focus for improving the training. The mean performance score was 16.20 out of 28.00 (SD = 2.98). This study provides valuable input to developing and enhancing evidence-based curricula. It can help educators and supervisors, in both academic and clinical settings, identify areas where clinical performance and education could be enhanced.
Key words: clinical skills education, nursing education, peripheral intravenous cannulation, venipuncture

INTRODUCTION

Peripheral intravenous catheter (PIVC) insertion and venipuncture are the most common invasive procedures performed in hospitals.[1,2] For the purpose of this study, *venipuncture* is defined as a procedure consisting of introducing a needle into a vein to obtain blood samples. *PIVC* is defined as a short flexible tube with a needle that punctures the peripheral vein, allowing for the administration of intravenous fluids or medications.[3] Despite their frequency, these procedures are not without risks or complications. Complications for PIVCs include phlebitis, infiltration, or serious life-threatening complications such as sepsis.[1,2] Similarly, complications, such as hematoma or nerve injury, can also occur from performing venipuncture.[3] A large number of patients receive peripheral intravenous therapy while they are in the hospital for the administration of intravenous fluids or medications.[4] When delivering all aspects of PIVC care, health care providers are encouraged to apply evidence-based guidelines to their practice to deliver safe and superior care and improve the outcomes for patients.[1,2,5] Those performing PIVC and venipuncture should be competent and knowledgeable in the procedures in order to perform them safely and effectively.[5]

In Ireland, a standardized approach for venipuncture and PIVC education for nurses and midwives was devised and has been a mandatory component of all undergraduate nursing and midwifery curricula since 2021.[3] It follows a "blended learning" approach consisting of the following: (1) an e-learning module, which provides background context and theory around the skills; (2) an online self-assessment test; and (3) a clinical skills demonstration and practice session (delivered and supervised by academic staff/faculty) in a simulated, nonclinical environment. Within 12 weeks, students undertake a minimum of 5 successful supervised practices in each of the skills in the clinical environment.[6] The aim of the blended program is to provide the necessary evidence-based knowledge to help nurses and midwives perform the procedures on patients safely, successfully, and confidently.[3]

This mandatory learning, education, and clinical skill demonstration reflecting a theory and practice link will be classified as "formal training" throughout this article. As this is a new addition to the curriculum in nursing and midwifery education in Ireland, it is important to ensure that the professions evaluate the educational, learning, and procedural impacts. Such evaluation is to the benefit of the students, the institution, and its curriculum, and ultimately, it is hoped, patient experience with these clinical procedures.

Aims

This study includes 2 phases with several aims in each phase. The first phase aimed to initially assess the knowledge, attitude, and practices of students on the topic of venipuncture and PIVC. Another aim was to explore their perceptions of the training and ascertain where improvements can be made to help enhance learning. The aims of the second phase of the study were as follows: (1) to evaluate nursing students' skill of PIVC insertion in a simulated environment; (2) to determine whether students were maintaining asepsis during the demonstration; and (3) to investigate whether students had opportunities in clinical practice to perform the skill under supervision. While it was not possible to carry out this research in the clinical environment, the simulated environment was deemed appropriate. When performing skills on manikins, students can focus solely on the skill and repeat the practice, helping to develop dexterity and knowledge without disruption or harming patients.[7] It is also a safe setting, since students will not meet unwell patients in the simulated environment.[8] This reported study was performed in the 2021/2022 academic year, the first year in which the skills of venipuncture and PIVC were introduced into the Irish undergraduate nursing and midwifery curriculum. Therefore, it was deemed an opportune time to evaluate the training program. In doing so, this study contributes to the evidence base for nursing and midwifery undergraduate students performing these invasive procedures.

Theoretical Framework

To evaluate the current teaching program, this study was guided by Kirkpatrick's evaluation model. The first level of the model, *reaction*, evaluates student reactions so that educators can assess how well the program was accepted and how to improve it for the future.[9] Students were asked in the survey their perception of the training provided. The second level of the model, *learning*, investigates what students have learned in terms of knowledge and skills.[9] A survey was designed to question the students on their knowledge and practice of the skills. The third level, *behavior or performance*, consists of assessing the ability of trainees in using their new knowledge and skills.[9] For this study, nursing student performances of inserting a PIVC were evaluated in a simulated environment. The fourth level of the model, *results*, considers the impact of a training program.[9]

For the present study, the intended impact of the training was that students would be able to perform the skill of PIVC in a clinical environment under supervision. This study sets out to ascertain the extent to which students were provided with any clinical practice opportunity.

METHODS

Study Design

This study follows a mixed-methods approach, including a descriptive cross-sectional online survey and an observational study.

Study Participants, Instruments, and Setting

Knowledge, Attitudes, and Practices Survey, Phase 1

Final-year nursing and midwifery undergraduate students from one Irish university were invited to complete the Knowledge, Attitudes, and Practices (KAP) survey in the first phase of this study. This questionnaire was disseminated to students after they completed their formal training, and the survey remained live for 4 months. Data were gathered through a third-party online survey platform, QuestionPro (Survey Analytics LLC, San Francisco, CA), which consisted of both closed- and open-ended questions. The survey was designed with the direction of the national guidance framework policy.[3]

Once the survey was designed, it was validated: both face and content validity were completed. For face validity, initially, and then content validity, the survey was sent to vascular access experts/educators and public and patient involvement members. Upon return of the surveys from each expert, the content validity index (CVI) was calculated to decide what elements were to remain in the survey and what was to be removed. Distinguishing content validity at both item level (I-CVI) and scale level (S-CVI) is important.[10] Content validity of individual items are measured using I-CVI, and the content validity of the overall scale is measured using S-CVI. A scale can be considered to have excellent content validity when it is composed of items with a minimum I-CVI of 0.78 and a minimum of 0.80 for S-CVI/Ave.[10,11] For this survey, only items with I-CVI of 0.80 or above were included in the final scale, and the S-CVI/Ave calculated for the scale was 0.89 (considered to have good content validity). Some items that were removed from the scale due to low scoring included demographic questions such as gender and age. An additional content expert reviewed the questionnaire and added questions such as the appropriate flushing technique and length of drying time required for the insertion site after cleaning. Other additions included the importance of correct cannula securement and whether PIVCs should be removed routinely or as clinically indicated.

The survey included 15 knowledge, 18 attitude, and 17 practice-related questions on the insertion and management of a PIVC or venipuncture. (See Supplementary Material at http://links.lww.com/JIN/A114 for the final survey.) Regarding the knowledge questions, one mark was provided if the question was answered correctly, with no marks given if answered incorrectly or not answered. Regarding student attitudes (or the general evaluations students have regarding their confidence of the skill and the importance or risk associated with the skill), one mark was provided if the question was answered positively. If a question was not answered or answered negatively, suggesting low confidence or low attitude of the importance or risk level of a particular topic, no marks were awarded. As these questions were asked using a 0 to 10 scale, answers scoring 6 or greater were deemed a positive response. Responses of less than 6 were deemed negative responses. Seventeen questions were compiled and noted to be practice-related. As students had only received formal training, the practice section of the survey was focused on evaluating student knowledge of correct practice and their practical training of the skills.

Observational Study, Phase 2

Final-year undergraduate nursing students were invited to take part in the observational study, the second phase of the study. As part of the assessment for their course, nursing students performed an objective structured clinical examination on the skill of PIVC. The performance of each student was video recorded and then evaluated. It was made clear to students that consenting to using their videoed performance for research purposes was an entirely optional component. The session was performed in a simulation laboratory that has fixed cameras to assist with recording. Placement of the cameras provided both an aerial perspective and a side-angled view of the room. The cameras also had a zoom function, which was required to observe the more intricate steps of the procedure. Low-fidelity simulation was used, using a task trainer, which provided flashback to students if they accessed the "vein." Students could perform the skill using their right or left hand, whichever their preference. The simulation room was set up with the manikin/task trainer on a surface with the clinical equipment laid out for the students.

Students were observed performing the skill of PIVC in a simulated environment, and these observations were recorded. The performance was then reviewed by the primary researcher and assessed against a task-specific checklist (Table 1) underpinned by the national guidance for intravenous cannulation and venipuncture training.[3] Data were collected for this study from the video-recorded observations of students' performances of PIVC in a simulated environment. Each student's performance was scored out of a total of 28 marks. Students received one score for each step that they completed correctly. For any steps that they did not complete correctly, they received no score. A step was considered completed incorrectly, naturally if it was completed incorrectly, but also if students required prompting or if they completed the step at the incorrect timepoint (Table 1).

TABLE 1

Task-Specific Checklist

Step	Task	Step	Task
1*	Perform hand hygiene	17*	Slowly advance the cannula fully
2*	Apply nonsterile gloves (appropriate size)	18*	Pull the introducer back slowly, while holding the cannula in position
3*	Disinfect manikin for minimum 30 seconds, and allow to dry	19*	Loosen and release the tourniquet while supporting the device in situ
4*	Dispose of used disinfectant wipe in the clinical waste discard bag	20*	Hold sterile gauze and place it under the cannula to hub
5*	Do not touch/repalpate site	21*	Apply digital pressure to the vein above the cannula tip and gently remove the stylet
6	If repalpated- hand hygiene and skin disinfection are to be completed again	22*	Dispose of all sharps in the sharps bin
7*	Apply tourniquet	23*	Attach primed short extension set to the cannula hub
8*	Remove needle guard and assess the device for faults	24*	Discard the gauze contaminated with blood into the yellow clinical waste bag
9*	Use nondominant hand to achieve skin traction	25*	Secure the cannula with sterile transparent semipermeable dressing
10*	Hold the cannula between your thumb and index finger and use the thumb to anchor the cannula hub	26*	Aspirate to check for blood flashback
11*	Position the cannula- bevel facing upwards	27*	Flush cannula with prescribed sterile sodium chloride
12*	Insert the cannula directly above the vein, through the skin (10-30 degrees)	28	Observe site for leakage or swelling and ask patient if they are experiencing any discomfort or pain
13*	When the cannula punctures the vein, in the cannula chamber observe for flashback	29	If needed, loop the extension set and secure with tape
14*	Lower the angle between the cannula and the skin	30*	Remove gloves and discard appropriately
15*	Advance the cannula along the lumen of the vein a further 2 mm	31*	Perform hand hygiene
16*	With the dominant hand, withdraw the introducer slightly (second flashback)		Steps with an * were allocated a mark and were included in the total marks.

Data Analysis

KAP Survey, Phase 1

Quantitative data were collected through closed-ended questions. Descriptive statistics, such as median, mean, standard deviation (SD), and range, were utilized to summarize the results of the KAP survey. Qualitative data were collected through open-ended questions. For knowledge-based, open-ended questions, the correct or incorrect answers were tabbed numerically and were descriptively analyzed. Student feedback and suggestions on areas for improvement were grouped and categorized into themes.

Observational Study, Phase 2

Descriptive statistics were performed regarding students' individual performance scores as per the task-specific checklist, then grouped together to give an overall mean performance score. The score reflected their ability to correctly complete the steps involved in the skill of PIVC in a simulated environment. Data were also grouped for each task in the checklist to give an overall percentage of the students who completed that step correctly or incorrectly. To avoid or reduce bias during this evaluation, the primary researcher recording the students and analyzing the data was not involved in the teaching or assessing of this skill. Basic coding was also used, and a code was generated for areas in which students broke asepsis. Frequency counts were performed to analyze the opportunities that students received in clinical practice to perform the skill under supervision. The Spearman rank correlation coefficient was also used to determine whether there was any correlation between the scores that students received in the simulated environment and the opportunities they had in clinical practice to perform the procedure on patients.

Ethical Considerations

This study was approved by the participating university research committee (reference No. 2021.10.009). Students were provided with an information leaflet for each phase of the study and, if happy to participate, were asked to provide consent for each phase.

RESULTS

KAP Survey, Phase 1

The response rate for the survey was 47% (n = 38); 79% of respondents were from the general student nurse cohort, and 21% of respondents were midwifery students.

Knowledge

The overall knowledge score was out of a possible 15 marks: the range of marks varied from 1 to 15, the mean score was 7.2 out of 15.0 (SD = 2.4), and the median was 7. The knowledge portion of the survey focused on students' understanding of the complications associated with the skills, indications for inserting a PIVC, and best practice principles surrounding both skills, as per the national framework. The following 4 complications were addressed in the questionnaire: phlebitis, hematoma, infiltration, and extravasation. Regarding phlebitis, 73.6% reported an acceptably correct answer. Regarding hematoma, 21.0% noted a suitable answer. In relation to infiltration and extravasation, 73.6% and 63.1% of students, respectively, noted this complication as the leakage of fluids into the surrounding tissue or fluids not going the intended route. However, regarding infiltration, only 13.1% noted that these fluids were nonvesicant/nonirritant. Similarly, with extravasation, 23.6% noted that these fluids were vesicant/irritant.

Students were asked if these procedures were a clean procedure or an aseptic procedure, and 68% incorrectly noted intravenous (IV) cannulation and 71% incorrectly noted venipuncture as clean procedures. In relation to cleaning the proposed site, when asked what they should disinfect the patient's skin with, 63.1% correctly selected the 2% chlorhexidine gluconate solution and 70% isopropyl alcohol option.[3] Students were asked how long (minimum) practitioners should disinfect the patient's skin and how long they would leave the site to dry: 68.0% correctly selected the 30 second option, and only 5.2% correctly noted that they would leave the site until the area is dry.[3]

When asked to provide 2 indications for requiring a PIVC, 81.5% noted 2 valid reasons in their answers, including patients requiring IV fluids, IV medication, such as antibiotics or chemotherapy, or requiring blood products. Students were asked the number of attempts a single operator should carry out before referring either task to a more skilled clinician. Most students, 60.5% for IV cannulation and 57.8% for venipuncture, responded correctly with 2 attempts. Regarding flushing technique, 39% selected the best practice national guidelines option of a push-pause technique.[3] Students were asked what order of blood draw they would perform when collecting certain blood samples. The question about taking blood cultures first, then coagulation, followed by urea and electrolytes, and then full blood count, was answered correctly by 31.5% of students. Regarding the importance of the order of blood draw, 52.6% referred to the prevention of cross-contamination.[3]

Attitudes

The overall attitude score was out of a possible 18 marks; the range of marks varied from 1 to 18, the mean score was 10.20 out of 18.00, (SD = 4.79), and the median was 11.

TABLE 2

Mean Scores of Attitudinal Questions

Question	Mean score
Importance of correct securement of a cannula	9.97
Confidence in identifying the difference between arteries and veins by palpation	5.34
Confidence in locating a patient's vein correctly	6.43
Confidence in choosing an appropriate PIVC site	6.32
Confidence in recognizing extravasation	6.34
Confidence in recognizing infiltration	6.78
Confidence in recognizing phlebitis	8.36
Confidence in performing venipuncture as per recommended order of blood draw	5.87
Importance of performing venipuncture successfully on the first attempt	7.95
Importance of performing IV cannulation successfully on the first attempt	8.00
Confidence in their ability to insert a PIVC	5.03
Confidence in their ability to perform venipuncture	5.42
Confidence in their ability to insert a PIVC on the first attempt	4.37
Confidence in their ability to perform venipuncture on the first attempt	4.86
The level of risk to the patient having a PIVC inserted	7.00
The level of risk in performing peripheral intravenous cannulation to the clinician inserting an IV cannula	5.47
The level of risk to the patient having venipuncture performed	5.92
The level of risk in performing venipuncture to the clinician	5.08

Abbreviation: PIVC, peripheral intravenous catheter; IV, intravenous.

Students were asked to rate attitude questions on a scale of 0 (not important/confident) to 10 (important/confident). The mean score of each attitudinal question is noted in Table 2.

Practices

Students were asked what vein location they were advised as the most appropriate. The guiding framework suggests to start with the most distal vein.[3] The e-learning module further elaborates that, ideally, PIVC should be performed on the most distal aspect of cephalic or basilic veins in the forearm[12] and that venipuncture should be performed on the median cubital vein in the antecubital fossa.[13] Table 3 demonstrates student responses alongside where they observe insertion sites in practice.

Students were asked at what stage they would call a second colleague to perform venipuncture/PIVC; 73.7%

TABLE 3

Insertion Sites

Venipuncture location: (n = 38)	PIVC location: (n = 38)	Students were asked where they have observed the most PIVCs placed (n = 38)
Back of the hand – 5% (n = 2)	Back of the hand – 5.2% (n =2)	Back of the hand – 39.5% (n = 15)
Forearm – 18% (n = 7)	Forearm – 47.4% (n = 18)	Forearm – 21% (n = 8)
Antecubital fossa – 74% (n = 28)	Antecubital fossa – 47.4% (n = 18)	Antecubital fossa – 39.5% (n = 15)
Don't know – 3% (n = 1)		

Abbreviation: PIVC, peripheral intravenous catheter.

correctly stated after the second attempt.[3] Students were asked if PIVCs should be removed routinely or as clinically indicated: 78.9% of students correctly noted that it would depend on clinical indication/clinical judgement.[3] Students were also asked if regular retraining should be provided regarding these skills and if evaluations should be carried out on the first-attempt success rates and the long-term success rates. Students, overwhelmingly, responded positively to these questions.

Evaluation of the Teaching Program

When students were asked if there is more that could be done on the training provided, 6 students appeared satisfied with their training, and 1 student responded that they were unsure. All other responses were focused on where updated training could be incorporated. These suggestions for improvements were collated and separated into 5 themes, as noted in Table 4.

Observational Study, Phase 2

The sample consisted of final-year internship student nurses. Sixty-six videos were analyzed. The mean performance score was 16.20 out of 28.00 (SD = 2.98), and the median was 16, with scores ranging from 8 to 23.

Performing the Technical Skill

Demonstrations were grouped using a grading system. This grading system was developed by the researchers, whereby if all steps were completed correctly, a grade of 100% would be awarded. Scores <39% were considered very poor performance, 40% to 49% were considered poor performance, 50% to 59% satisfactory performance, 60% to 69% good performance, and >70% considered excellent performance. Table 5 demonstrates the grading system and the number of students who obtained these grades. Table 6 further reports on the performance of each step of the task-specific checklist and the overall percentage of students who performed the specific steps correctly or incorrectly.

Maintaining Asepsis

Demonstrating the ability to apply infection control precautions while performing the procedure is a key learning outcome of the formal Irish authorities national blended learning program.[3] One of the subresearch questions for this study was to evaluate whether students were maintaining Aseptic Non Touch Technique (ANTT®) throughout the procedure. From video analysis, it appears only 12 students did not break asepsis throughout the procedure, with a

TABLE 4

Evaluation of the Training Program

Improved simulation	Clinical opportunities	Specific training areas	More practice opportunities in simulation lab	Retraining
Students want to upgrade from "*spongey manikins.*" "*More accurate simulations*" and "*better*" simulation models were requested to make the scenario "*as real as possible.*"	More opportunities to perform the skill in clinical practice were noted, to train "*on actual patients*" or "*real people*" and get more "*opportunities on the wards.*" Issues with obtaining opportunities included "*busy*" wards and the time not being available to "*facilitate*" training.	More specific training could be considered in conjunction with what was lacking in the quantitative section. Students' suggestions included how to locate a vein and the order of blood draw.	The most commented theme was the area of more practice. Students requested "*more practice,*" "*more training,*" "*more skills workshops,*" and requested them "*routinely,*" "*continual*" or "*frequently.*" It is evident that students wish to be "*given more time,*" "*more opportunities*" in "*simulation sessions*" and "*more simulations.*"	More training days or continuous training in PIVC for both staff and students was commented on by respondents.

Abbreviation: PIVC, peripheral intravenous catheter.

TABLE 5

Students' Grouped Grading

Performance	Number of students
<39% very poor performance	n = 6
40-49% poor performance	n = 3
50-59% satisfactory performance	n = 25
60-69% good performance	n = 24
>70% excellent performance	n = 8

large majority of students 82% (n = 54) breaking asepsis. Categories were applied to the main areas where asepsis was broken and grouped. Similar deviations were repeated by many students (Figure 1).

Opportunities in Practice

Students, after receiving their formal training and commencing clinical practice, are to perform the skill of PIVC under supervision. Therefore, another objective of this study was to investigate whether students were indeed provided with these opportunities in clinical practice. The number of opportunities that were available to students to insert a PIVC while in clinical practice is noted as frequency counts in Table 7.

Any correlation between the simulated performance scores of students with the number of opportunities they had to perform the procedure on patients in the clinical environment was assessed. The Spearman rank correlation coefficient was used, and a correlation of 0.03 was noted. Therefore, there is very little correlation between simulated performance and the number of practice opportunities in clinical practice.

DISCUSSION

The findings of this study suggest that there are deficits in the students' knowledge, attitudes, and practices regarding the skill of venipuncture and PIVC and in their performance regarding PIVC insertion. Collecting such data and undertaking a detailed evaluation providing an evidence basis on which to reform and enhance training and the curriculum seems justified. This study is reported with guidance from both the Checklist for Reporting of Survey Studies (CROSS)[14] and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[15]

Some of the learning outcomes expected of the learner after completing the formal learning program include demonstrating knowledge of complications and their management and noting the indications for performing these skills.[3] Phlebitis was the complication that students appeared to understand the best, with 73.6% providing a suitable answer. However, this is in stark contrast to the other complications. Only 21.0% of students provided a suitable answer to hematoma. In relation to infiltration and extravasation, only 13.1% and 23.6%, respectively, elaborated on the type of infusates. Students appeared to have a good grasp of the rationales for requiring a PIVC, with 81.5% providing 2 valid reasons. The mean knowledge score (7.2) would suggest that the knowledge of participants regarding these skills is low. Further teaching is warranted on students' knowledge of the flushing technique and the order of blood draw, as under 40% of students answered these questions as per recommended guidelines.[3] The findings of this study are reflective of other studies carried out that noted the knowledge levels of students are low or inadequate.[2,16,17]

Training programs should include strategies to support the students in building their confidence. Students were noted to have negative attitudes (mean score <6.00) in their confidence in performing both skills, with even less confidence in performing them on the first attempt. There was a low mean score in the students' confidence in performing venipuncture as per the recommended order of blood draw. This is consistent with the students' level of knowledge on the order of blood draw, as this knowledge question was answered correctly by fewer than half of the students. Internship nursing students having low-to-moderate levels of confidence regarding PIVC insertion and care is noted in the literature.[18] Confident students learn better, as they believe they have the capacity to learn and perform[19]; hence, improving confidence is an important part of successful learning.[20]

The second phase of this study focused on evaluating whether final-year student nurses, following a training program and working in clinical practice, were performing the skill of PIVC insertion as per best practice. Findings suggest that there is room for improvement in relation to students performing these skills. Providing a percentage breakdown of how the students performed each step provides educators with more in-depth data on where students incorrectly completed a step, deviating from best practice guidelines, and where training needs to be reinforced (Table 6). There was a knowledge deficit in the appropriate and timely use of the tourniquet, and it is, therefore, another area where more training is required. Regarding applying the tourniquet, 71% of students incorrectly completed this step, and when releasing the tourniquet, 85% of students completed this step incorrectly. Aspirating and confirming patency after securing dressing are also steps that could be highlighted as requiring more training: 93% and 83% of students, respectively, incorrectly completed these steps. It is important to reiterate that if a step was performed at the incorrect time point as per the task specific checklist, it was considered not done correctly.

Other studies have also focused on which particular steps were completed correctly and incorrectly.[21,22] Although there were some similarities with the findings of this reported study, there are also differences. The lowest performance scores in one study included hand hygiene

TABLE 6

Procedural Checklist and Results

	Subskill	Performed correctly	Performed incorrectly		Subskill	Performed correctly	Performed incorrectly
1	Perform hand Hygiene	91% of students	9% of students	12	When the cannula punctures the vein, in the cannula chamber, observe for flashback	79% of students	21% of students
2	Apply appropriately sized nonsterile gloves	82% of students	18% of students	13	Lower the angle between the cannula and the skin	42% of students	58% of students
3	Disinfect manikin skin and the selected vein for minimum 30 seconds, using back and forth strokes on area of 4-5 cm and allow to dry	89% of students	11% of students	14	Advance the cannula along the lumen of the vein a further 2 mm	41% of students	59% of students
4	Dispose of used disinfectant wipe in the clinical waste discard bag	44% of students	56% of students	15	With the dominant hand withdraw the introducer slightly (second flashback of blood along the shaft of the cannula to be seen)	33% of students	67% of students
5	Do not touch/repalpate site	82% of students	18% of students	16	Slowly advance the cannula fully	65% of students	35% of students
6	Apply tourniquet	29% of students	71% of students	17	Pull the introducer back slowly, while holding the cannula in position	52% of students	48% of students
7	Remove needle guard (and assess the device for faults)	100% of students performed this step correctly (It was not possible to ascertain if students assessed device for faults)	Not applicable	18	Loosen and release the tourniquet while supporting the device in situ	15% of students	85% of students
8	Use nondominant hand to achieve skin traction	33% of students	67% of students	19	Hold sterile gauze (by one corner) and place it under the cannula hub to absorb any blood spillage	36% of students	64% of students
9	Hold the cannula between your thumb and index finger and use the thumb to anchor the cannula hub	69% of students	31% of students	20	Apply digital pressure to the vein above the cannula tip and gently remove the stylet, activating the needle safety device	11% of students	89% of students
10	Position the cannula - bevel facing upwards	95% of students	5% of students	21	Dispose of all sharps in the sharps bin (at point of care)	86% of students	14% of students
11	Insert the cannula directly above the vein, through the skin (angle 10-30 degrees)	95% of students	5% of students	22	Attach primed t-connector/needlefree bung (connector)/primed short extension set to the cannula hub	89% of students	11% of students

(*continues*)

TABLE 6

Procedural Checklist and Results (*Continued*)

	Subskill	Performed correctly	Performed incorrectly		Subskill	Performed correctly	Performed incorrectly
23	Discard the gauze contaminated with blood into the yellow clinical waste bag	21% of students	79% of students	26	To confirm patency, flush cannula with prescribed sterile sodium chloride, using a push- pause technique and ending with a positive pressure	17% of students	83% of students
24	Secure the cannula with sterile transparent semipermeable dressing	38% of students	62% of students	27	Remove gloves and discard appropriately	92% of students	8% of students
25	Aspirate to check for blood flashback	3% of students	97% of students	28	Perform hand hygiene	89% of students	11% of students

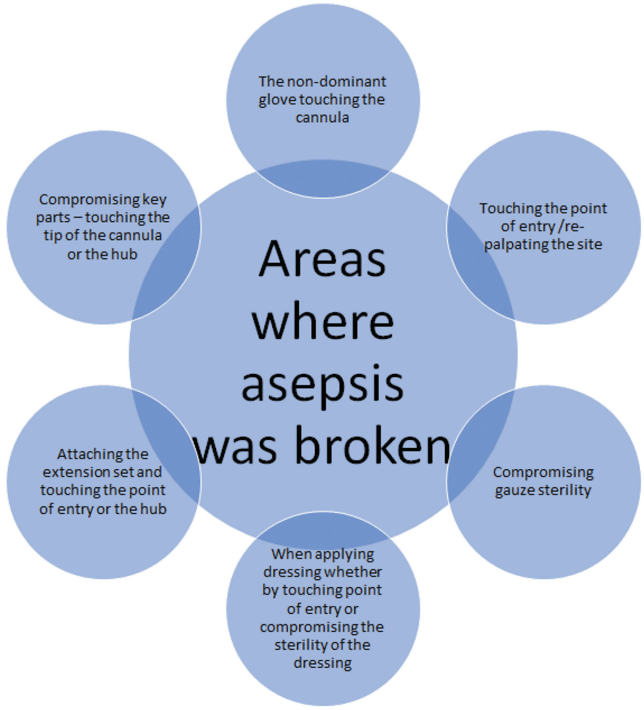

Figure 1 Areas where asepsis was broken.

postprocedure.[21] This contrasts with the current study, where hand hygiene, pre- and postprocedure, provided high percentages of being correctly performed by 91% and 89% of students, respectively. Similarly, the highest performance scores reported in one article included disinfecting the puncture site appropriately.[21] This task was also completed correctly by 89% of students in this presented study. Another article noted that the tourniquet handling was a step that all students performed correctly, which is in stark contrast to this current study.[22] Although the observation checklist and the presentation of findings differed among all studies, there is notable variation in identifying the highest and lowest performing steps.[21,22] This supports the value in undertaking local studies and assessments, as it can assist educators to evaluate where training can be improved for their students, tailored to their local context. Similarly, another study noted that by administering a protocol-based teaching program, it was effective in increasing the skill level of student nurses in PIVC. This protocol-based teaching program was designed based on the pretest knowledge and skill scores of students.[23] This further supports the recommendation that, by focusing on the steps that most students completed incorrectly, educators can tailor their training to reinforce these steps.

One area of skill performance that requires further training and reiteration is the skill of ANTT. There is a strong link between PIVC and infections if best practice standards are not adhered to.[5] From survey findings, more training could be directed at ensuring students understand that the procedure is to be carried out using ANTT.[3] In other areas of infection control, adequate knowledge was noted: over 60% of students noted the correct skin prepping solution

TABLE 7

Number of Opportunities to Insert a PIVC in Clinical Practice

No opportunities	1-4 Opportunities to insert a PIVC	5 or more opportunities to insert a PIVC
n = 25 (38% of students)	n = 28 (42% of students)	n = 13 (20% of students)

Abbreviation: PIVC, peripheral intravenous catheter.

and the length of time they should clean the skin. Most students in the observational phase broke asepsis, risking the introduction of infection, and such complications can risk patient safety.[24] Areas where asepsis was broken were identified, which highlights where future training should focus (Figure 1).

It is evident from the findings that opportunities to perform the skill were limited. Students in all nursing programs are expected to seek opportunities to practice their skills in a safe setting with support and supervision.[25] This study has shown that students are currently not getting adequate opportunity to perform the skill of PIVC in practice. The opportunity to translate theoretical and simulated clinical instruction into the clinical environment is concerning. Students are expected to, at minimum, perform 5 successful PIVC procedures as per the national standard.[6] Despite having clinical practice development and support staff to proctor undergraduate students, only 20% of students had enough opportunities to be able to attempt to meet the required standards. There is a need to address clinical opportunities in relation to students performing these skills, and it may be an area for future research consideration.

Some studies have shown that student anxiety while on clinical placement can influence their learning.[26] Specifically, regarding the skill of PIVC, negative emotions, such as nervousness, apprehension, and insecurity, were acknowledged.[8] Furthermore, a case study presented a student who withdrew from opportunities to practice PIVC due to anxieties.[27] This led to challenges for the student's learning. Further research may be required both internationally and locally to identify why clinical practice opportunities are not available and to ensure that students are supported to meet their learning outcomes and provide safe patient care.

Practicing on a manikin and on patients provides different opportunities for learning. If students miss the vein in the simulated environment, they can continue to practice the procedural steps, whereas students do not have this opportunity when they miss the attempt on a patient. Low-fidelity simulation, such as that used for this study, can contribute to experience in performing the skill and help students become familiar with equipment. However, it does not allow for the complexities and conditions that students would be presented with in the clinical environment.[22] Therefore, alongside simulated practice, ideally, students would perform and become competent in the skill in clinical practice. At the least, more opportunities to practice in the simulated environment would be beneficial.

A mixture of learning experiences can be used to teach clinical skills in nursing programs, such as clinical skill laboratories, simulation, and direct patient opportunities. Nurse educators can create effective learning experiences that develop clinical psychomotor skills.[28] A study regarding PIVC performance in medical students noted that students required a mean of 10.2 practices to gain competency or fluency in the skill.[29] The results from this reported study would suggest that student nurses do not have enough practice in clinical placement and should also be provided with more opportunities to practice the skill in a simulated environment. It is important that nursing students develop their competency in this skill, yet there are obstacles, such as time in the nursing program, which can limit the training of such skills.[30] Therefore, it may be worthwhile to include teaching strategies that are more student directed and do not add time pressures to educators. Risks of complications when inserting a PIVC are increasing due to the aging population and the intricacies of vascular access device technologies. The outcomes of this study and supporting literature would affirm the argument that it is no longer appropriate to simply have a one-off course on intravenous cannulation.[31] There is a need for more effective training and skills development opportunities to ensure confident, competent, and proficient practitioners who will play a crucial role in reducing the possibilities of patient complications.

LIMITATIONS

Generalizability is limited in both phases of the study due to the limited number of participants and that it was only carried out in one nursing school. In relation to the survey phase, another limitation includes students' opportunity to complete the survey within 4 months. Providing a shorter timeframe to complete the survey may be considered in the future, as a long timeframe could influence the students' level of learning as they are exposed to the procedures in practice. Also, in the second phase, the observation of the skill is completed in a simulated environment; therefore, considerations need to be made for elements of simulation that differ from clinical practice, such as the realism of the simulated limb, the complexities of patients, and not having a patient to communicate with. To provide more fidelity, the observation study could be conducted on human volunteers in the simulated environment. However, the ethics of causing harm for learning purposes ruled this out as an option.[32] Video recording within the clinical

environment would also offer a more holistic and realistic evaluation, although this was not possible within the authors' context. While low-fidelity simulation is effective, simulation needs to be enhanced to ensure that students attain what is needed to provide safe patient care.[22] Finally, this phase focused on objective measures of psychomotor performance. Communication skills were not assessed.

CONCLUSION

Findings from this study have identified opportunities for improvement in undergraduate nursing and midwifery students' peripheral intravenous cannulation and venipuncture training. Embedding regular detailed evaluations of training programs in key skills can provide rich evidence on which to further enhance the educational experience and professional outcomes. This study, using a combination of approaches (survey, knowledge assessment, practice, and analysis of video) has clearly identified specific areas for improvement and drawn attention to significant weaknesses in the knowledge and performance of students in the current program. The analysis clearly demonstrates the need for improved simulations, more opportunities to practice, and reinforcement of crucially important aspects such as breaking asepsis. It is essential that practitioners performing these skills in clinical practice are capable of doing so competently, with confidence in their knowledge and the benefit of having had sufficient opportunities to refine the psychomotor and safety aspects.

Taking into account the reality of the clinical environment and constraints on time and resources, there may be scope to more effectively use technologies combined with pedagogical strategies that include self-directed learning and assessment. Therefore, future research should test interventions that could improve students' knowledge and procedural performance. Finally, the research could explore opportunities and barriers to developing student competency for the most common vascular access device used in health care.

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