

## Effect of Blended Learning Program on Nurses' Knowledge and Practice regarding Peripheral Vascular Catheter Insertion for adult patients

Eman AbdelRazik AbdelHakim <sup>(1)</sup>, Asmaa Daifallah Mehany Mohamed <sup>(2)</sup>

Hend Mohamed Allam <sup>(3)</sup>, Ebtessam Aly Abd el Fatah Aly <sup>(4)</sup>

(1&4) Lecturer of Medical-Surgical Nursing, Faculty of Nursing- Minia University, Egypt.

(2) Lecturer of Medical Surgical Nursing, faculty of Nursing Beni-Suef University, Egypt.

(3) Lecturer of Medical Surgical Nursing faculty of Nursing Benha University, Egypt.

### Abstract

Peripheral intravenous catheter is the most common invasive hospital procedure applied worldwide and it is utilized for giving medications, intravenous fluids, as well as the blood products. **Aim:** To evaluate the effect of blended learning program on nurses' knowledge and practice regarding peripheral vascular catheter insertion for adult patient. **Design:** A quasi-experimental research design (pre/ post-test). **Setting:** The current research was conducted in two hospitals, Minia University hospital and Liver University Hospital at Minia City, Egypt. **Sample:** Convenience sample of all available registered nurses (200) who were caring for patients undergoing PIVC. **Tools:** Tool I: Demographic characteristics of the participated nurses Tool II: Structured interview questionnaire regarding nurses' Knowledge about Care and Maintenance of PIVC Tool III Nurses' practice Observational Checklists about care and maintenance of PIVC. **Results:** The study findings clarified that 89% of nurses had satisfactory total level of practice immediately after implementing the blended learning program compared to (10%) of them before its implementation and decreased to 75% in the follow up phase post program implementation. **Conclusion:** statistically significant difference was found between pre and follow up assessment regarding nurses' level of knowledge and practice post implementation of the blended learning program. **Recommendation:** Nurses need continuous education about care and maintenance of PIVC as well they need formal online education about the essential elements in caring and maintenance of PIVC and how to decrease its complications. Hospital nurses must support the blended educational approach to overcome the difficult in maintaining face to face education.

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**Keywords:** Blended learning, Peripheral intravenous catheter.

### Introduction

The peripheral intravenous catheter (PIVC) is a short catheter that inserted into the patient's peripheral veins for administering medications, intravenous fluids, or blood products and it is the most frequent hospital invasive procedure that applied globally. (Etafa, et al., 2020) Manual abilities, professional expertise, and understanding the anatomy and physiology of the vascular system are required for this procedure. (Qamar, et al., 2017). Nurses must be trained and supervised during insertion and care of PIVCs to gain the competence level in performing this procedure, which considered fundamental skills in the nursing curriculum. (Morgaonkar, et al., 2017). The content of nursing curriculum should emphasize that knowledge as well as abilities to gain it must depend on: vascular access device assessment, insertion skills, care, as well as management (Carr, et al., 2018)

Regarding particular practice problems, some authors recommended that emphasis on nurses training in caring and maintenance of PIVC, could improve nursing knowledge, skills, as well as confidence, and also helping in patient assessment, chosen of insertion site, applying the aseptic technique, preparation of the skin, maintain integrity dressing, as well as recognition of dressing technique, recording patient with PIVC-related complications in addition to compliance with the guidelines of best practice. (DeVries, et al., 2016). The lack of knowledge and practice among the medical professionals had been recognized as one of the main reasons of PIVC failure and poor sustainability. Evidence based practice recommended that knowledge, skills, and confidence during PIVC placement are connected with the success of the first-attempt, and patient complications are reduced when the procedure is performed by experienced caregivers, (Keleekai, et al., 2016)

Nurses should be certified as practical skill performance to assure quality of patient care. The possibility of patient injury exists along with a registered nurse who lack skill competency. Phlebitis, thrombosis, and inflammation all are complications that may occurred due to improper insertion of the catheter. Newly qualified nurses often leave the field due to improper skill performance, which could also lead to dissatisfaction, blunders, and time constraints for them. (Ravik, et al., 2017)

Complications associated with PIVC, such as phlebitis, infiltration, and total peripheral venous network depletion, rise significantly among patients, with occurrence rates ranging from 34.9% to 50%. so that it is important to implement an appropriate educational program to enhance nurses' skills and improve their abilities to offer patient complete care. There are various approaches used in teaching the nurses' clinical skills. In the recent document, there had been a significant emphasis in using different methods of education other than the typical face-to-face. Particularly among the health sciences field as nursing, pharmacy and psychology. These materials, however, had recently been introduced into nursing studies. Following that, a strategy for teaching the most important topics in a virtual platform, known as blended teaching. (Saiz- et al., 2020)

Blended learning describes as a teaching method that combines online digital materials with face-to-face instruction. (Lothridge, et al., 2013) It entails a methodical blending of in-person contacts and interactions via technology between students, facilitators, and resources. (Wu, et al., 2020). It has been discovered to encourage proactive learning practices rather than a result from instruction, which is meant by self-regulated learning. (Grønlén, et al., 2021) . Blended learning is fastly becoming as the advanced norm for providing learning material in nursing education. (Leidl, et al., 2020)

It is recommended that continued education, assessment/reassessment, feedback, as well as monitoring should be used to sustain the learned progress in knowledge, and abilities. As potential influences on learning, workplace structure and environmental changes should be

investigated (Hassanein, et al., 2021). Researches had also demonstrated that blended learning may significantly improve nurses' knowledge and practice during PIVCs insertion, administering adult intramuscular injections, and in administering drugs. (Valizadeh, et al., 2021) Blended learning programs for PIVCs insertion incorporate simulated practice in a thoughtful manner which possess the ability to enhance patient care and clinical practice which aiming to improve patients' outcomes, (Keleekai, et al., 2016)

#### Significance of the study:

PIVCs are inserted to approximately 70% of the hospitalized patients (Yasuda, et al., 2021). At least 80 percent of all patients in the hospital receive some kind of infusion treatment, and it is estimated that more than 300 million shorts (3 inches) of PIVCs are marketed annually in United States (Keleekai et al. 2016). Catheter failure is the phrase that used to describe the inadvertent removal of more than 25% of PIVCs (Takahashi et al., 2020) The best device and location to insert a cannula are chosen by nurses, they also prepare the site properly and remove the vascular access carefully, all of which reduce the risk of PIVC complications (El-seadi, et al. 2020).

Intravascular device complications and failure had a profound impact on nurses, patient outcomes, and ultimately on the system of health care. According to several research, one of the major obstacles to integrate evidence-based nursing practice is the lack of knowledge and practices (Bayoumi and Mahmoud 2017). There is a dearth of research comparing between the knowledge and abilities of staff nurses with little PIVC education to those with more in-depth training. There is proof that using skilled nurses to perform PIVC insertion reduces patient complications. knowledge and abilities of PIVC insertion are closely connected to the 1<sup>st</sup> success trial (Keleekai, et al., 2016). Professionals in the healthcare agency could learn online. Today, it is essential for healthcare professionals to take advantage of chances for ongoing learning to keep their knowledge and abilities updated. In blended learning, interactions between students, facilitators, and resources are systematically

combined with technology-mediated face-to-face contacts. (Wu, et al. 2020)

According to the researchers' observations in real-world settings like in the medical and surgical departments many patients who are not treated for their PIVC or who are not given the proper care and safety interventions in a timely manner usually suffer from serious squeal, because there weren't much studied done in this field and nursing personnel works at varied shifts and weren't able to attend face-to-face instruction sessions so the blended learning modules had become a popular alternative for offering continuing education to nurses, for that the researchers suggested that using the blended learning program to improve nurses' knowledge and performance when inserting PIVC for adult patients.

#### **Aim of the study:**

Was to evaluate the Effect of Blended Learning Program on nurses' knowledge and Practice regarding peripheral vascular catheter insertion for adult patient.

#### **Operational definitions**

1. **Blended learning:** it is defined as combining in-person instruction with computer-mediated training as well as the intentional blending of in-person and online learning experiences in the classroom (Sáiz-et al., 2020)
2. **Peripheral Intravenous catheter (PIVC):** is a tiny, flexible tube that is attached to the skin with an adhesive dressing after being placed into a peripheral vein, typically the metacarpal, cephalic, or basilica vein. To give intravenous fluids, transfusions of the blood, chemotherapy, as well as the other medications (Kleidon et al., 2020); (Australian Commission on Safety as well as Quality in Health Care (2021)

#### **Design:**

Quasi-experimental design (pre- & post-test) was used to achieve the purpose of the present study.

#### **Hypothesis:**

1. Nurses who are exposed to blended learning program their mean scores of knowledges and practice will improve comparing to their mean score pre-intervention.

#### **Setting:**

The current study was conducted in two hospitals Minia university hospital and Liver University Hospital at Minia City, Egypt.

#### **Sample**

Convenience sample of all present registered nurses (200) who worked in the above stated facilities and provided care to patients receiving peripheral vascular access during the time of the current study.

#### **Inclusion criteria:**

The nurses at Minia university and liver hospitals from both sexes who accepted to share in the present study also, could utilize the internet, and have an android mobile with what's App and internet access.

#### **Study tools**

Three tools were used to collect data based on extensive review of the related literature.

#### **Tool I: Demographic characteristics of the participated nurses:**

It assessed the study subject regarding age, gender, department, level of education, attending training courses regarding PIVC and years of experience.

#### **Tool II: Structured interview questionnaire about Knowledge towards Care and Maintenance of PIVC:**

It developed by the researchers after reviewing the updated related literatures (Perry, et al., 2015), (Lynn, et al., 2018), and (Nettina,etal., 2018). It was designed to assess nurses' knowledge regarding care and maintenance of PIVC, which was measured via fourteen questions with an answer including ("right" wrong" and "I don't know").

### The Scoring system for tool II:

Each correct answer scored one point, on the other hand an incorrect or "I do not know" answer scored zero. Scores were divided as satisfactory level of knowledge when equal sixty percent or more than sixty percent from the total scores and unsatisfactory level of knowledge when the total score less than sixty percent.

**Tool III: Nurses' practice Observational Checklists regarding care and maintenance of PIVC;** IT was evaluated through (12) questions, with a scale including (done or not done)

### Scoring system for tool III:

Each nurse's practice scored one mark if done and scored zero if not done. Nursing practice was calculated and then converted to a percentage. it considered satisfactory level of practice if the calculated value lower than seventy-five percent considered unsatisfactory level of practice according to (Bedier, et al., 2014; Ouda et al., 2019)

### Tools Validity:

The tools' content validity was assessed by a panel of 5 academic professors in the field of the research from medical and surgical specialty, from Minia , Beni-Suef as well as Benha Universities, to determine to which extent the study instruments measure what was intended to be measured, all the members of the jury agreed that the existing research tools were valid to assess the study's objectives.

### Tools Reliability

The reliability of the study tools was assessed by using Alpha Cronbach's test :tool II (the Structured interview questionnaire about Knowledge towards Care and Maintenance of PIVC) reliability level was (0.978) and the reliability of the 3<sup>rd</sup> tool( practice Observational Checklists of nursing care and maintenance of PIVC) was (0.911), the scale coefficient revealed that these measures were sufficiently reliable.

### Pilot study

Ten percent of the studied sample (20 nurses) were randomly chosen to check study tools applicability, practicability, and relevancy also to estimate time needed to fill in the tools. The finding of the pilot study's revealed that the study tools clear, concise and understood, but some minor modifications were done so the nurses sharing in the pilot study were excluded.

### Ethical Considerations

After formulating the study protocol, the Ethics Research Committee of the Faculty of Nursing, and the Director of the Minia University Hospitals at the Governorate of Minia both provided the formal official approval for conducting the study. During the in-person recruitment phase, each participant gave their verbal agreement after being informed about the study objectives. Nurses acquainted that they had the freedom to quit from this study at any time without facing consequences. Participants anonymity and confidentiality were preserved as the questionnaire was free from any inquiries that would reveal their true identities. All information was condensed and only the final aggregate was presented.

### Study fieldwork:

**The present study was performed through four phases.**

#### 1. The preparatory phase:

Before data were collected, the researchers visited the selected university hospitals to organize and formulate plans for recruitment, data collection, as well as for conducting the educational sessions. Data collection was performed along six months from the starting of December 2020 to the end of May 2021., Demographic characteristics of the participated nurses (tool one), Structured interview questionnaire about Knowledge towards Care and Maintenance of PIVC (tool two) were obtained by the researchers through printed pre-test during face-to-face interview to know nurses' strength and weak points regarding their level of knowledge that should be covered in the content of the study program. Regarding the observational checklists about nursing care and maintenance of PIVC (tool

three), it was assessed through researchers' direct observation.

## 2. The planning phase:

Through analyzing the pre-test, the researchers identifying nurses' real learning requirements, so the researchers prepared the content of the blended learning program module. An online link was established by the researchers and sent to the studied nurses through their websites for social media as (face book and on WhatsApp mobile phone).

## 3. The Implementation phase:

Learning program created based on nurses needs which identified via the preparatory phase. the blended learning model was segmented into eight sessions two of them was delivered face to face and six online by using a live broadcast Zoom application. The researchers created a blended learning program for front-line nurses who perform PIVC insertion, care, as well as maintenance in order to help them to update their knowledge about PIVC-related subjects and learn how to

The sessions were included the following:

Sessions	Time	Content
1 <sup>st</sup> session	20-30 Minutes	<ul style="list-style-type: none"> <li>• Introduction</li> </ul>
2 <sup>nd</sup> session	20-30 Minutes	<ul style="list-style-type: none"> <li>• Anatomy and physiology of vascular system (Face to face)</li> </ul>
3 <sup>rd</sup> session	20-30 Minutes	<ul style="list-style-type: none"> <li>• Assessment of peripheral veins</li> <li>• Catheter Selection</li> </ul>
4 <sup>th</sup> session	20-30 Minutes	
5 <sup>th</sup> session	20-30 Minutes	<ul style="list-style-type: none"> <li>• Sites of PIVC insertion,</li> <li>• Procedure of insertion</li> </ul>
6 <sup>th</sup> session	20-30 Minutes	
7 <sup>th</sup> session	20-30 Minutes	<ul style="list-style-type: none"> <li>• Complications of intravenous catheter</li> <li>• Complications Management</li> </ul>
8 <sup>th</sup> session	20-30 Minutes	

## Evaluation phase:

The post-test questionnaire was done to evaluate nurses' level of knowledge as well as practices. It was given for nurses by creating it through using Google form website for the two tools (second and third). The sample that was being investigated was asked to respond to it and finish the submission process online. Through the same online social media websites previously described, Post-test was performed twice: The first phase, was immediately after implementing the blended learning program, and the second was in the follow up phase,

implement best skills to improve patient care and safety. Through utilizing of medical notes, case studies, simulated skill exercises, and knowledge assessments with built-in feedback. Also, the sample subjects were given data on best skills while being continuously involved in the learning process. Each session took approximately twenty to thirty minutes to be complete, while at the end of every session there was 15 minutes for online discussion to answer questions and correct any misunderstanding points. The researchers started each session with a conclusion for the last one. After considering the working shifts of all nurses, they were distributed into groups (3 nurses in each) for 18 hours along threeweeks.

All Videos were recorded and were available to all participated nurses at any time to download them through using the same link. Method of teaching used during each lecture including power point presentation, brain storming, questioning, and answering, for attracting the attention of the studied nurses.

after three months post implementing blended learning program.

## Statistical analysis:

The statistical software for social sciences (SPSS) version 22 was utilized to arrange, classify, as well as analyze the collected information. For qualitative and quantitative variables, respectively, the mean and standard deviations of the data were reported using descriptive statistics. The paired t-test, chi-square test, were the statistical tests that were applied. If the p-value was less than 0.05, high significance was assumed, and the p-value was

greater than 0.05, no statistical significance difference was taken into account.

## Result

**Table (1):** Illustrated that (55%) of studied sample were in the aged between 20-30yrs. old with mean age ( $1.71 \pm 0.944$ ). Females were more prevalent than males in the studied sample that represented (67%). As well as (40.5%) of current studied sample were working at medical departments. related to level of education (58 %) of the current studied sample were graduated from technical institute while the minority were Diploma nurses, (67%) of studied sample didn't attain any training courses, Regarding years of experience (87%) of studied sample had from 1-3 years of experience with mean ( $1.765 \pm 0.7158$ ).

**Table (2):** demonstrated that studied sample had right answer about these items of the structured questionnaire regarding care and maintenance of PIVC pre implementing the blended learning program these items were (1,2,3,4,5,6,7,8,9,) which constituted (48%,50%, 50%, 75%, 75.5%, 45%, 61.5%,79.5% and 70%) respectively while they had wrong answer about questions (9, 10,11,12 and 14) which represented (50%,49%,50%,53%& 48.5%) respectively. On the other line the studied sample didn't have any idea about the answer of questions 13 which constitute (42.5%).

**Table (3):** demonstrated that studied sample performed only these steps for caring of

the patients with PIVC pre- implementing the blended learning program (1 and 2) which constituted (61%. and 80%,) respectively while they didn't perform any of the steps (3,4,5,6,7,8,9,10,11 and 12) which represented (100%,56%,55%,56%& 82%,57%,97%,94%,60% and 85%) respectively

**Table (4):** Showed that there were differences in nurses' practice throughout the program implementation. There was statistically significant difference between pre and immediately post blended learning program implementation. Also, there was statistically significant difference notices among pre & follow up program implementation except in the step of the use of transparent dressing when securing IV catheter. with P-value = 000\*\*.

**Figure (1):** showed that (96%) of nurses had a satisfactory level overall practice immediately after the implementation of the blended learning program, compared to (32%) of the nurses who had been studied before the program implementation and (11%) in the follow up phase post program implementation.

**Figure (2):** showed that (89%) of nurses had satisfactory total level of practice immediately after implementing the blended learning program compared to (10%) of studied nurses before blended learning program implementation as well as (75%) at the follow up phase post program implementation.

**Table (1): Demographic characteristics of the studied nurses (n=200)**

Item	No	Percentage (%)
<b>Age (years)</b>		
20 – <30	110	55
30 – <40	54	27
40 – <50	20	10
50 and more	16	8
Mean ± SD	1.71±0.944	
<b>Gender</b>		
Female	134	67
Male	66	33
<b>Department</b>		
• Medical units	81	40.5
• Surgical units	45	22.5
• Emergency	20	10
• Endoscopy	10	5
• Operation	12	6
• ICU	32	16
<b>Education level</b>		
• Diploma	42	21
• Technical institute	58	29.0
• B.SC.	52	26.0
• Postgraduate	48	24.0
<b>Attending Training courses</b>		
Yes	52	26
No	148	74
<b>Experience / years</b>		
• <1	80	40.
• 1 – <3	87	43.5
• >3	33	16.5
Mean ± SD	1.765 ± 0 .7158	

**Table (2): Nurses' Knowledge regarding care and maintenance of the PIVC pre-implementing the blended learning program (N = 200)**

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Knowledge Variables	Right N (%)	Wrong N (%)	I don't know N (%)
1. The catheter gauge 14G, 16G, 18G and 20G are suitable to use for peripheral intravenous Catheter	96 (48.0)	84 (42.0)	20 (10)
2. Veins use for intravenous catheter normally located at dorsal) and ventral surface of the upper extremities right and left hand/arm (metacarpal, cephalic and basilic)	100 (50)	82 (41)	18 (9)
3. Based on Universal Infection Control Guidelines, IV catheter can be used 48-72 hours if no signs and symptoms of Complication	100 (50)	80 (40)	20 (10)
4. Phlebitis is the most identifiable infection related to IV catheter	150 (75.0)	26 (13)	24 (12)
5. The environment situation (e.g. cleanliness) will influent the risk of infection related to PIV catheter	151 (75.5)	42 (21.0)	7 (3.5)
6. Hand hygiene before procedure IV insertion is important in order to prevent infection.	90 (45)	55 (27.5)	55 (27.5)
7. Maintaining aseptic technique during insertion of IV catheter can help to decrease occurrence of infection	123 (61.5)	73 (36.5)	4 (2.0)
8. Wearing sterile gloves during insertion of PIV catheter are advisable.	159 (79.5)	36 (18.0)	5 (2.5)
9. Skin preparations at insertion site are require before IV catheter inserted.	70 (35.0)	100 (50)	30 (15)
10. Increase attempts for catheter will increase the risk of infection.	86 (43.0)	98 (49)	16 (8)
11. Using transparent dressing will help to recognize early signs and symptoms of infection	90 (45.0)	100 (50)	10 (5)
12. Removing IV catheter immediately if not in use, will help to reduce risk of infection occur.	70 (35.0)	106 (53)	24 (12)
13. Giving intravenous therapy will increase risk of infection through peripheral PIV catheter.	55 (27.5)	60 (30.0)	85 (42.5)
14. Patient educations on how to care IV catheter is important as it do help to reduce risk of infection.	35 (17.5)	97 (48.5)	68 (34)

**Table (3):** Nurses' practice regarding the care and maintenance of the peripheral IV catheter pre- implementing the blended learning program (N = 200)

NO	Practice Variables	Done N (%)	Not done N (%)
1	The nurse always changes IV catheter after 72 hours inserted.	122 (61)	78 (39)
2	The nurse immediately changes the IV catheter to non-affected part when there is a sign of phlebitis	160 (80.0)	40 (20)
3	The nurse always uses transparent dressing when securing IV catheter.	—	200 (100.0)
4	The nurse always writes date, time, site, size and name of person on PIV catheter	88(44)	112 (56)
5	The nurse use administration set for IV catheter within 72 hours.	90 (45)	110 (55)
6	The nurse Observe patient for any complications of IV catheter as infiltration, phlebitis and extravasation	88(44)	112 (56)
7	The nurse always maintains aseptic technique during preparing, inserting and removing of IV catheter.	36 (18)	164 (82)
8	The nurse always changes the dressing when it wet or dislodge.	86 (43.0)	114 (57.0)
9	The nurse always educates patient how to care the IV catheter and how to recognize the signs and symptoms of IV catheter infection	6(3.0)	194 (97.0)
10	The nurse performs hand hygiene and put on PPE before IV catheter being carried out.	12 (6)	188 (94)
11	The nurse always prepare skin before the insertion of IV catheter.	20(10)	180 (60)
12	The nurse is confident enough to carry out this procedure (IV catheter) because of having enough knowledge and experience.	30(15)	170(85)

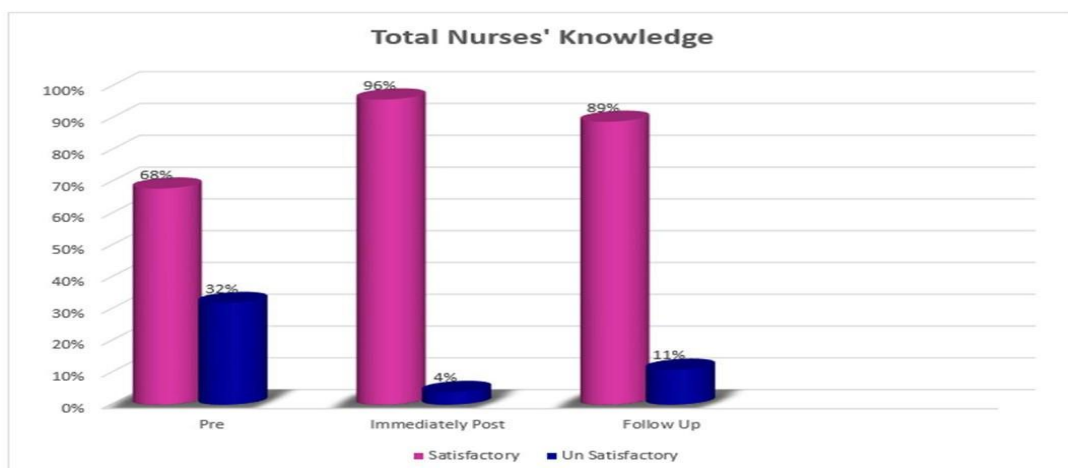
**Table (4):** Difference in nurses' practices throughout the three phases of blended learning program implementation (n=200):

Item	Before/ Immediate				Before / Follow up			
	Before Mean ±SD	Immediate Mean ±SD	t	Sig	Before Mean ±SD	Follow up Mean ±SD	t	Sig
1. The nurse always changes IV catheter after 72 hours inserted.	1.390±.4889	1.120±.3257	8.58	.000	1.390±.4889	1.240±.4281	5.93	.000
2. The nurse immediately changes the IV catheter to non-affected part when there is a sign of phlebitis	1.200±.4010	1.075±.2640	5.33	.000	1.200±.4010	1.190±.3932	1.42	.158
3. The nurse always uses transparent dressing when securing IV catheter.	2.000±0000	2.000±.0000	14.25	.000	2.000±0000	2.000±.0000	25.24	.000
4. The nurse always writes date, time, site, size and name of person on PIV catheter	1.560±.4976	1.055±.2285	14.54	.000	1.560±.4976	1.100±.3007	13.02	.000
5. The nurse use administration set for IV catheter within 72 hours.	1.550±.4987	1.035±.1842	15.13	.000	1.550±.4987	1.075±.2640	13.42	.000
6. The nurse Observe patient for any complications of IV catheter as infiltration, phlebitis and extravasation	1.560±.4976	1.025±.1565	22.34	.000	1.560±.4976	1.250±.4341	9.46	.000
7. The nurse always maintains aseptic technique during preparing, inserting and removing of IV catheter.	1.820±.3851	1.105±.3073	13.69	.000	1.820±.3851	1.460±.4996	10.58	.000
8. The nurse always changes the dressing when it wet or dislodge.	1.570±.4963	1.085±.2795	22.62	.000	1.570±.4963	1.450±.4987	5.21	.000
9. The nurse always educates patient how to care the IV catheter and how to recognize the signs and symptoms of IV catheter infection	1.970±.1710	1.250±.4341	27.36	.000	1.970±.1710	1.535±.5000	12.38	.000
10. The nurse performs hand hygiene and put on PPE before IV catheter being carried out.	1.940±.2380	1.150±.3579	22.91	.000	1.940±.2380	1.395±.4900	15.43	.000
11. The nurse always prepare skin before the insertion of IV catheter.	1.900±.3007	1.175±.3809	19.22	.000	1.900±.3007	1.450±.4987	12.76	.000
12. The nurse is confident enough to carry out this procedure (IV catheter) because of having enough knowledge and experience.	1.850±.3579	1.200±.4010	8.58	.000	1.850±.3579	1.250±.4341	17.28	.000

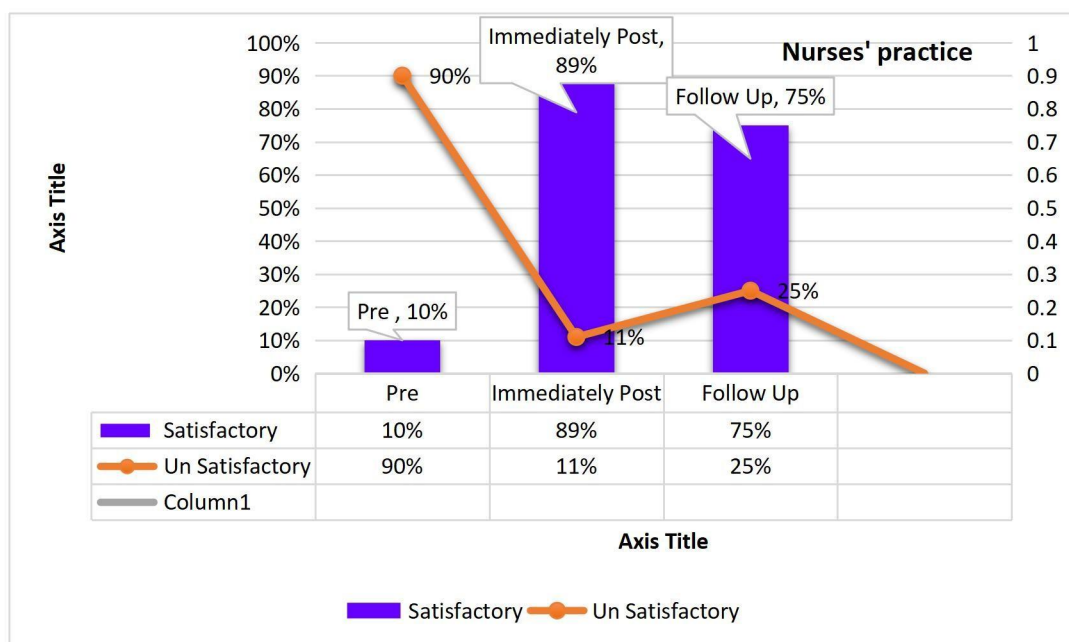
NS= not significant \* p = ≤.05 (statistical significance)

\*\* p = ≤.01 (highly statistical significance).





**Figure (1):** Total nurses’ Knowledge before, immediately post as well as in the follow up phase post blended learning program implementation (n=200):



**Figure (2):** Total nurses’ practices before, immediately post as well as at the follow up phase post blended learning program implementation (n=200)

**Discussion:**

Worldwide hospitals, PIVCs are the most frequently used invasive procedure. When inserting, and managing intravenous therapy during a patient admission, these devices might cause a variety of complications to the patients (Blanco-Mavillard et al., 2019).The quality of care, patient safety, as well as patient satisfaction could all be improved as a result of understanding

and early detection of risk factors by nurses that could also reduce hospital stays and overall healthcare costs. (Milutinović, et al. 2015)

**Concerning demographic characteristics of participants,** the findings of the current research illustrated that more than fifty percent of participated nurses (55%) were in the age group 20:30 yrs. old. with mean (1.71±0.944). The researcher's opinion explained that; older nurses

usually have more administrative duties, and this age is the working age of nurses in hospitals wards. These findings were agreement with (Hossain, Arif et al. 2016) who reported that average age of nurses participate in their research were in between (25-35 yrs. old), also these findings were in line with Mekonen et al., (2020) who found that more than fifty percent of participants were in the age group of 25-29 yrs. Old. Concerning gender: Females were more prevalent than males in the studied sample which represented (67%). This result may be due to that most of the nurse staff that employed in hospitals were females. Additionally, career of nursing in Egypt includes more females than males. It's also because females are naturally drawn to careers that require caring for others. Such findings were in line with Keleekai, et al. (2016) who documented that majority of respondents were female, which represented (87%). Moreover, these findings were agreed with Labrague & Los-Santos (2020) who founded that more than sixty-six of the studied sample were female.

According to working department; the majority of current participants were working at the medical departments; from the researchers' practical application standpoint this finding may be because the nurses who working in the medical wards which considered obstacles work than in another department so many nurses were transferred to it. This outcome disagreed with (Osti, et al. 2019) who mentioned that more than fifty percent of the respondents (53.5%) were in the critical units.

Related to the level of education, the majority (58 %) of the studied sample were graduated from technical institute while the minority were Diploma nurses, according to researchers' point of view this result may due to the differences in economic and educational level between the nurses. this result was agreed with (Mohamed, et al. 2020) who found that less than thirty-three of participant nurses had secondary nursing school. also, Milutinović,etal., (2015). who reported that three nurses (2.9%) had a master's level in nursing, higher than thirty-three graduated from faculty of nursing, and more than fifty percent of the nurses (61.8%) had presented in secondary school.

Regarding training courses nearly two third of the participants in the current study didn't

attain any training courses, this result was supported by (Hassanein and Sobh 2021) who reported that four fifth of their sample had no training programs.,

Regarding yrs. of experience the majority of studied sample had from one to three yrs. of experience with mean  $(1.765 \pm 0.7158)$ . According to the researchers' view this might be because they were still new without enough experiences. This result was supported by Osti, et al., (2019) who reported that the highest of respondents (57%) had employment histories less than a year; on the other hand, they were still inexperienced. as well as Ouda, et al. (2019), who reported that lower than fifty percent of the nurses in their study had experience less than three yrs., as well as lower than twenty –five percent had experience less than five yrs.

**Regarding nursing knowledge toward care and maintenance of PIVCs:** In the current study, it was discovered that post-implementing blended learning program, nurses' knowledge had increased. This result was supported by Simonetti et al., (2015) who interpreted that nurses who participated in education programs had more knowledge scores compare to those who had not ( $P < 0.001$ ).

**Regarding nurse practice toward care and maintenance of PIVCs:** According to the present results more than three quadrants of nurses had satisfactory total practice levels immediately after implementing the blended learning programs, as opposed to studied nurses (10%) prior to program implementation, increase to (75%) after program implementation. This outcome was consistent with Ravik et al., (2017) who reported that nurses' performance regarding care of PIVC its key competencies enhanced by ongoing education. Additionally, Salgueiro-Oliveira et al. (2019) revealed that there was a connection between unsatisfactory nursing practices and nurses' lack of knowledge. moreover, Keleekai et al. (2016) who reported that employed the simulation-depend blended learning to teach how to insert PVCs showed that nurses' knowledge, abilities, and confidence had greatly increased post- blended learning intervention implementation.

**Limitations of the study:**

- Possible nurses lack of desire and time to use technology.
- The increase in workload during the adjustment period.
- Lacking in phonemic awareness skills among nurses.

**Conclusion**

This study underlined the need of adopting nurse continuing education programs to enhance their knowledge as well as practice with regard to the management of PIVCs and the avoidance of related complications. The study's hypothesis was proved through theory-guided practice promotes nurse knowledge and care delivery. Also, the comparison between pre- and post-blended learning program was revealed statistically significant changes, demonstrated through improvement in nurses' knowledge as well as practice following the blended learning program implementation. Thus, the outcomes showed that the blended learning program which its content developed on the nurses identified needs was successful.

**Recommendations**

Based on the results of this study, the researchers make the followings suggestions:

- Further research should be conducted to confirm and extend the present findings.
- Specifically, future studies must involve multiple centers to increase the generalizability of the study findings, use a randomized controlled trial design, employ multiple outcome metrics to assess nurse's knowledge as well as practice that related to PIVC, evaluate the effect of blended learning on nurse's outcome.
- Nurses need continuous education about PIVC also require formal online education about the essential of PIVC and how to prevent or decrease its complications, the hospital nurses must support the blended educational approach as a line to overcome

the difficult in developing face to face education.

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