Effect of Training Program on Critical Care Nurses' Performance Regarding Infusion Pump Medications Administration

Jihad Mohammed Awad [1], Sabah Said Mohamed [2], Samah Elsayed Ghonaem [3,] Nora fares Mohamed [4]

[1] Demonstrator of Medical Surgical Nursing, Faculty of Nursing, Benha University, Egypt.

[2] Professor of Medical Surgical Nursing, Faculty of Nursing, Benha University, Egypt.

[3] Assistant Professor of Medical Surgical Nursing, Faculty of Nursing, Benha University, Egypt.

[4] Lecturer of Medical Surgical Nursing, Faculty of Nursing, Benha University, Egypt.

Abstract

Context: Infusion pump is an external medical device used to deliver fluids in controlled manner into the patient's body for variety of environments and variety of purposes. **Aim:** the study aim is to evaluate effect of training program on critical care nurses performance regarding infusion pump medications administration. **Methods:** The study used a quasi-experimental design, specifically employing a pre/post-test methodology on a convenience sample of (70) nurses who assigned to care of critical patient who receive medications via infusion pump. This study was conducted in ICU at Benda University Hospital. **The study utilized the following tools: I)** Self-administered questionnaire to evaluate nurses knowledge regarding infusion pump medications administration. **II)** Observational checklist to evaluate nurses' actual practices regarding preparing phase, setting up phase, administration phase and post administration phase of infusion pump medications administration. **Results:** 20.0 % of studied nurses had satisfactory level of total knowledge about infusion pump medications administration pre training program implementation to be significantly improved during immediate and post one month of training program implementation among 71.4% & 65.7%, respectively. While 21.4 % of studied nurses had a competent level of total practice pre program implementation to be significantly improved during immediate and post three months of program implementation among 80.0% &71.4%, respectively. There was highly significant difference in total nurses' knowledge and practice score within study periods observed as $p < 0.001$. **Conclusion:** Training program improved nurses' knowledge and practice regarding infusion pump medications administration. **Recommendation**: Continuing educational programs for all nurses in order to update their knowledge and practice level regarding infusion pumps is necessary.

Key words: *Training program, Nurses' knowledge and practice, Infusion pump. Medications administration*

Introduction

Infusion Pumps are electronic medical devices used to control the administration of intravenous fluids to deliver measured amounts at careful and regulated rates under positive pressure to the patients. They often incorporate a mechanism or structure that mediate active transport across a biological membrane, using needles, where it has the best, most immediate effect. Occasionally subcutaneous, epidural or enteral methods are used but the amount of fluid is restricted in these methods. Infusion pumps can administer fluids in cases where other methods would be impractical or unreliable **(Smith & Gray, 2022).**

Today's healthcare settings and their design and development have kept pace with

technology over the decades. Infusion pumps are common devices which have a plethora of functions and features and a range of alarms to alert the user that infusions are nearing completion, have ended or their range of sensors has detected that the patient requires attention. The role of the nurse in safely managing this ever-changing technology should not be underestimated. It highlights the importance of fully integrating infusion pumps into intravenous **(IV)** therapy training and assessment. Nurses have to identify the breadth of practices, education associated with administering of infusions in critical care unites and potential patient safety issues related to IV pump infusions **(Padhi, 2023).**

Infusion pump used by various hospital sectors and it has become indispensable in therapies requiring continuity and precision in the administration of medication and food. It mainly used to administer fluids such as nutrients or medications to patients. In comparison to manual administration of fluids, it provides controlled administration and has the ability to deliver fluids in small volumes or at precisely programed rates or intervals **(Raikar et al., 2023).**

Critically ill patients with life threatening conditions require constant care, monitoring and a number of life-sustaining medications. The administration of medication and fluids into a patient's veins is referred to as intravenous (IV) administration, and most of hospitalized patients receive medications this way **(Lissak et al., 2024).** Infusion pumps have shown a positive impact on medications' safety for critical patients, the reduction of IV medication errors, the creation of safer work environments for nurses, and the optimization of capital returns, quality control, and the continuous improvement of the processes. Furthermore, the use of pump technology has shown to be profitable in the intensive care unit (ICU) because it avoids costs from prevented medications errors and allows for savings on disposables and medications by establishing standardized concentrations and dosing units **(Beaudart et al., 2023).**

Nurses have an important role in insuring safety in the medication administration process; the role of the nurse in safely managing this ever changing technology should not be underestimated, the nurses have to keep up to speed with the technology as it develops **(Hanson & Haddad, 2022).**

Nurses focus their efforts on the administration of medications and fluids via an intravenous (IV) line, central line, or venous access port. Ensuring patients receive the appropriate IV for the treatment ordered, selecting and managing the appropriate equipment, maintaining arterial catheters, assessing the patient's response to intravenous therapy, and observing for potential drug complications are all central duties of the infusion nurse. In order to be effective at their job, these nurses must be skilled in performing venipuncture, possess extensive pharmacological knowledge, have meticulous documentation skills, be aware of proper infection control protocol, and have steady hands **(Nickel et al., 2024).**

Infusion pumps have shown a positive impact on medications' safety for critical patients, the reduction of IV medication errors, the creation of safer work environments for nurses, and the optimization of capital returns, quality control, and the continuous improvement of the processes. Furthermore, the use of pump

technology has shown to be profitable in the intensive care unit (ICU) because it avoids costs from prevented medications errors and allows for savings on disposables and medications by establishing standardized concentrations and dosing units **(Beaudart et al., 2023).**

Significance of the study

Intravenous infusion pump systems are among the most frequently used technologies in health care. An estimated 90% of hospital patients receive IV medications via infusion pumps, these devices are used in patient care, particularly in critical and acute care settings **(Giuliano et al., 2022).**

According to **Elsayed et al, (2019):** who studied the nurses' performance regarding infusion Pumps' medication administration among critically ill patients, found that **70%** of the studied nurses had unsatisfactory total knowledge regarding infusion pumps' medication administration among critically ill patients and **63.3%** of the studied nurses had an unsatisfactory level of total practice regarding the infusion pumps' medication administration among critically ill patients. According to annual report of Benha University Hospitals Statistical office **(2023)** the number of admitted patients to critical care settings was **1102** patients (**Benha University Hospitals Statistical office, 2023).**

Additionally **Musa and Mahmood, (2023)** who studied Evaluate the Impact of Short Training Program on Nurse's Knowledge Regarding Intravenous Lines Management recommended there is often need of training for nurses in regulating and managing this therapy. So, the current study was conducted to evaluate the effect of training program on critical care nurses' performance regarding infusion pump medications administration.

Aim of the study: the study aim is to evaluate effect of training program on critical care nurses performance regarding infusion pump medications administration..

Research hypotheses:

H1-Level of nurses' knowledge regarding infusion pump medications administration could be significantly improved after implementation of the training program than before.

H2-Level of nurses' practice regarding infusion pump medications administration could be significantly improved after implementation of the training program than before.

H3-There could be a significant correlation between nurses' knowledge and practice regarding infusion pumps medications administration after implementation of the training program.

Subjects and Method

Study design: Quasi-experimental study design (pre –post intervention) will be utilized to achieve the aim of the study.

Study setting:

The study was carried out in intensive care unit at Benha University Hospital, Benha city, Qalyubia Governorate, Egypt .It locates in second floor of the medical building, there is a nurse station at the center of the ICU, it contains three rooms and four counters; each room has two beds and each counter contains four beds and the total are 22 beds in the unit included critically ill patients. There are another four small rooms: nursing room, nursing supervisor's room, physicians' room and teaching room.

Subjects

A convenience sample of all available nurses who were already assigned to provide direct care for ICU patients were recruited in the study**,(n=70)** after exclusion of nurses who involved in pilot study.

Tools for data collection: the researcher used two tools which were:

Tool I: Nurses' Self-administered questionnaire :

This tool was designed by the researcher based on a thorough review of recent and related literature **such as Elsayed et al., (2019) and Musa and Mahmoud, (2023).** It aimed to assess nurses' knowledge regarding infusion pump medications administration **consisting of two parts which were:**

Part (I): Nurses' personal data and contained 7 questions as**:** Age, gender, marital status, educational level, years of experience in nursing field, years of experience in Critical Care Unit and attendance of training courses on infusion pump medications administration.

Part (II): Part two: Nurses' knowledge assessment:

This part contained 52 questions and concerned with assessment of nurses' knowledge regarding infusion pump medications administration:

- **Anatomy and physiology of circulatory system (4 questions).**
- **Definition of infusion pump and its types (6 questions).**
- **Disadvantages and problems of the infusion pump (8 questions).**
- **Methods of determining drug dose calculations and How to deal with multiple pumps for a patient (14 questions).**
- **Nursing care before administration of infusion pump medications (11 questions).**
- **Nursing care during administration of infusion pump medications (4 questions).**
- **Nursing care after administration of infusion pump medications (5 questions).**

Scoring system:

- One point was allotted for each correct answer and zero point was given for each incorrect answer. Total knowledge score was summed up "52 points'' that converted into a percentage and categorized into:
- < 80% was considered as an unsatisfactory level of knowledge. (≤42 score).
- ≥ 80% was considered as satisfactory level of knowledge. (≥42 score).

Tool II: - Nurses' observational checklist:

This tool adapted from **Wilkinson et al., (2019), Lister et al., (2021), Pedersen, (2021) & Robinson Wolf et al., (2022).** It is used to assess nurses' actual practices regarding infusion pump medications administration. **This tool included four parts:**

Part 1: Nursing practice during preparing phase (17 steps).

Part 2: Nursing practice during setting up phase (19 steps).

Part 3: Nursing practice during administration phase (17 steps).

Part 4: Nursing practice post administration phase (10 steps).

Scoring system

The total practice score was **63** score distributed as one mark for each step correctly done and zero for incorrectly done or not done, the total practice check list score graded as the following: -

- **< 85%** was graded as Incompetent level of practice **(<54 score).**
- **≥ 85%** was graded as competent level of practice equal to **(≥ 54 score).**

Nursing Training program booklet:

It designed by the researcher in simple Arabic language for the purpose of the study based on related recent literature such as **Atanda et al., (2023), Boullata, (2021) & Aaronson et al., (2020),** it included two parts:

The theoretical part: It consists of basic knowledge related to anatomy and physiology of circulatory system, definition, types of infusion pumps, infusion pump problems and how to manage it , methods for determining the dose of infusion medications, disadvantages of infusion pumps and their complications, location of the infusion pump relative to the patient as well as specific patient safety instructions when using an infusion pump.

The practical part: It included nurses' skills regarding infusion pump medication administration at (pre, during and post)administration phase. It was given to nurses at the first session of program to refine their knowledge and practice.

Validity and reliability of tools:

The tools were reviewed by a panel of five experts from medical surgical nursing field, faculty of nursing, Benha University. Jury involved one professor, two assistant professors and two lecturers to test the relevance, clarity of tools' content, comprehension, understanding, applicability and necessary modification was done accordingly. While reliability of tools was tested using Cronbach alpha test revealing that (0.869, 0.708) indicating good reliability.

Ethical consideration

Scientific Research Ethics Committee at Benha University's Faculty of Nursing approved the study with code **University (REC-MSN-M 3)** to conduct study**.** Also**,** official endorsement gained from the dean of the nursing faculty, Medical director of Benha university Hospital and ICU director at Benha University Hospital. After explanation of the purpose of the study. The study's aim was clarified to nurses along with freedom to discontinue their participation at any moment without any rationalization. Throughout study phases, researcher ensured the privacy, confidentiality and anonymity. Participated nurses provided verbal and written consent.

Pilot study

Ten percent (7 nurses) of the study sample shared in a pilot study to test the tools' applicability, clarity, and the amount of time needed to complete them. After analyzing the data from the pilot study, the required modifications done. Exclusion of subjects who shared this study from actual sample was done later.

Fieldwork:

From the beginning of March, 2024 to the end of August 2024, collection of data pertinent to study was completed through four phases:

1-Assessment phase: (pretest)

Data collected at morning and afternoon shifts three days/week. Nurses' knowledge was assessed through self-administered questionnaire **(Tool I)** which given to each nurse to fill it and time required for completion of the questionnaire was ranged from 30-45 minutes. While nurses' practical skills were evaluated by the researcher using direct observation by using observational Checklist **(Tool II)** during different phases of infusion pump medications administration. This assessment helps the researcher to define and detect nurses' deficits in knowledge and practice.

2-Planning phase:

The researcher put plan for carrying out the study after collecting data about the study setting. The training program sessions designed by the researcher according to nurses' needs and deficiencies in their performance. It was written in Arabic language and reviewed by the supervisors then the validity was done by a panel of five experts from medical surgical nursing field. Teaching materials were prepared as video, picture and colored booklet that helped in covering theoretical and practical information.

3-Implementation phase:

In this phase, the researchers distributed studied nurses into small groups (10 group) and each group was about (7 nurse) and start application of teaching sessions as each session was about (30-45 minute) including;

Session one: (Theoretical session)

It included anatomy and physiology of circulatory system, definition of infusion pump, types of infusion pumps, infusion pump problems and how to manage it, methods of determining the dose of infusion medications.

- Session two: (Practical session) :-

• **Phase (1):** It included how to apply nursing skills before administration of infusion pump medications.

• **Phase (2):** It included how to apply nursing skills during administration of infusion pump medications.

• **Phase (3):** It included how to apply nursing skills post administration of infusion pump medications. And Specific patient safety instructions when using an infusion pump.

٤- Evaluation phase:

Posttest was done immediately and after one month of data collection to evaluate the effect of training program on critical care nurses performance regarding infusion pump medications administration by using the same tools.

Statistical analysis

Data analysis was performed using the SPSS software (version 25). Qualitative data was presented as a number and percent. Furthermore, quantitative data was described as mean or standard deviation, as appropriate. Chi-square test was used to examine the difference and relation between qualitative variables during different periods. Fisher's exact test was applied on smaller sample sizes, alternative to the chi-square test, when the frequency count is < 5 for more than 20% of cells .For quantitative data. Pearson method was used to test correlation between numerical variables. A p-value ≤0.05 was considered significant, and ≤0.001 was considered highly significant.

Results:

Table (1): shows that the age of 72.9% was within (21- <30 years) with a mean age of 29.27 ± 0.44 years. Concerning gender,

60 % of the studied nurses were female. And 65.7% of them were married. As for the education level, 52.9 % of the studied nurses had bachelor of nursing, and 85.8 % had 1-< 5 years of experience in nursing field as well as working in ICU among 71.4% of them, with 21.4% attended previous training programs for infusion pumps since ≥ 6 months for one time among 66.7 % of them.

Table (2): reveals that 40.0 % of the studied nurses had satisfactory level of Knowledge regarding anatomy and physiology of circulatory system which improved to 91.4 % immediately post training program implementation while slightly decrease to 90.0% in post one month with a statistically significant difference regarding total nurses' knowledge about infusion pumps' medication administration between pre and post implementing the training program.

Figure (1): illustrates that 20.0 % of studied nurses had a satisfactory level of total knowledge about infusion pump's medication administration pre program implementation compared to 71.4% & 65.7%, respectively at immediate post and post one month of program implementation with (p value = 0.008* & 0.017*, respectively).

Table (3): reveals that 20.0 % of the studied nurses had competent level of nurses' practice during setting up phase which improved to 80.0 % immediately post training program implementation while slightly decrease to 75.7% in post one month with a statistically significant difference regarding total nurses' practice of infusion pumps' medication administration between pre and post implementing the training program.

Figure (2): illustrates that 21.4 % of studied nurses had a competent level of total practice during infusion pumps' medication administration pre program implementation compared to 80.0% &71.4%, respectively of them at immediate and post one month of program implementation with (p value =0.029* & 0.034*, respectively).

Table (4): clarifies that there was a positive and highly significant correlation between total nurses' knowledge with their total practice regarding infusion pumps' medication administration immediately and post one month of program implementation with p-value of (<0.001**), while there was no significant correlation (p=0.057 n.s) pre program implementation.

Table (1): Percentage distribution of studied nurses according to their personal data (n = 70):

Nurses' personal data	No.	%
Age / years		
21-<30	51	72.9
30 - 40	19	27.1
Mean ± SD	**29.27 ± 0.44**	
Gender		
Female	42	60.0
Male	28	40.0
Marital status		
Married	46	65.7
Single	24	34.3
Educational level		
Nursing diploma	9	12.9
Nursing Technical institute	24	34.2
Bachelor of Nursing	37	52.9
Years of Experience working in nursing field		
< 1 year	5	7.1
1-< 5 years	60	85.8
5 - <10 years	5	7.1
Mean ± SD	**4.00 ± 0.38**	
Years of Experience working in ICU		
< 1 year	20	28.6
1- <5 years	50	71.4
Mean ± SD	**1.71 ± 0.45**	
Attending previous training programs about infusion pumps		
Yes	15	21.4
No	55	78.6
If yes, since	**(n=15)**	
< 6 months	5	33.3
≥6 months	10	66.7
If yes, number of training programs		
One	10	66.7
Two	5	33.3

Table (2): Difference of total nurses' knowledge regarding infusion pumps' medication administration pre and post implementing the training program (n=70).

Total knowledge	Response	Knowledge (pre training program) n= 70		Knowledge (immediately post training program) n= 70		Knowledge (post 1 month of training program) n= 70		χ^2 test P value (1)	χ^2 test P value (2)
		(No.)	%	(No.)	%	(No.)	%		
Knowledge about anatomy and physiology of circulatory system	Satisfactory ≥ 80%	28	40.0	64	91.4	63	90.0	5.185 0.023*	4.375 0.036*
	Unsatisfactory < 80%	42	60.0	6	8.6	7	10.0		
Knowledge about infusion pump	Satisfactory ≥ 80%	10	14.3	52	74.3	48	68.6	5.347 0.021*	4.038 0.044*
	Unsatisfactory < 80%	60	85.7	18	25.7	22	31.4		
Knowledge about infusion calculations	Satisfactory ≥ 80%	12	17.1	51	72.9	46	65.7	7.556 0.006*	5.396 0.029*
	Unsatisfactory < 80%	58	82.9	19	27.1	24	34.3		
Knowledge about nursing care before administration of medications by intravenous infusion pump	Satisfactory ≥ 80%	17	24.3	59	84.3	58	82.9	4.645 0.031*	4.186 0.041*
	Unsatisfactory < 80%	53	75.7	11	15.7	12	17.1		
Knowledge about nursing care during administration of medications by intravenous infusion pump	Satisfactory ≥ 80%	14	20.0	56	80.0	54	77.1	5.185 0.023*	4.375 0.036*
	Unsatisfactory < 80%	56	80.0	14	20.0	16	22.9		
Knowledge about nursing care after administration of medications by intravenous infusion pump	Satisfactory ≥ 80%	8	11.4	48	68.6	45	64.3	5.018 0.025*	4.410 0.042*
	Unsatisfactory < 80%	62	88.6	22	31.4	25	35.7		

(*) Significant at p ≤0.05.
(1) Difference between total knowledge pre and immediately post training program
(2) Difference between total knowledge pre and 1 month post training program

Figure (1). Difference between nurses' total knowledge level about infusion pump's medication administration pre and post implementing the training program (n=70).

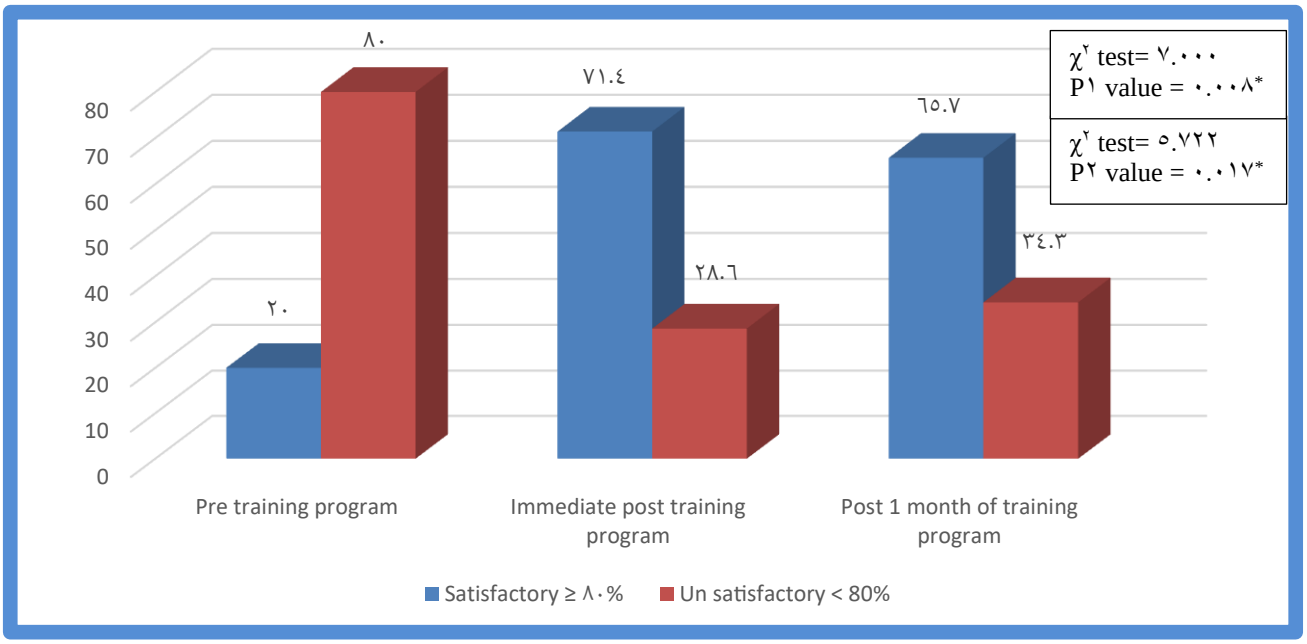

Table (3): Difference of total nurses' practice regarding infusion pumps' medication administration throughout phases of study (n=70).

Total practice	Response	Practice (Pre training program) n= 70		Practice (Immediately post training program) n= 70		Practice (Post 1 month of training program) n= 70		χ2 test P value (1)	χ2 test P value (2)
		(No.)	%	(No.)	%	(No.)	%		
Nurses' practice during preparing phase	Competent ≥ 85%	10	14.3	51	72.9	48	68.6	5.347 0.021*	4.346 0.037*
	Incompetent < 85%	60	85.7	19	27.1	22	31.4		
Nurses' practice during setting up phase	Competent ≥ 85%	14	20.0	56	80.0	53	75.7	5.613 0.018*	4.375 0.036*
	Incompetent < 85%	56	80.0	14	20.0	17	24.3		
Nurses' practice during administration phase	Competent ≥ 85%	12	17.1	55	78.6	54	77.1	4.291 0.038*	3.950 0.047*
	Incompetent < 85%	58	82.9	15	21.4	16	22.9		
Nurses' practice post administration phase	Competent ≥ 85%	13	18.6	55	78.6	51	72.9	5.948 0.015*	4.354 0.037*
	Incompetent < 85%	57	81.4	15	21.4	19	27.1		

(*) Significant at p ≤0.05.
(1) Difference between total practice pre and immediately post training program
(2) Difference between total practice pre and 1 month post training program

Figure (2). Difference between nurses' total practice level during infusion pumps' medication administration throughout phases of study (n=70).

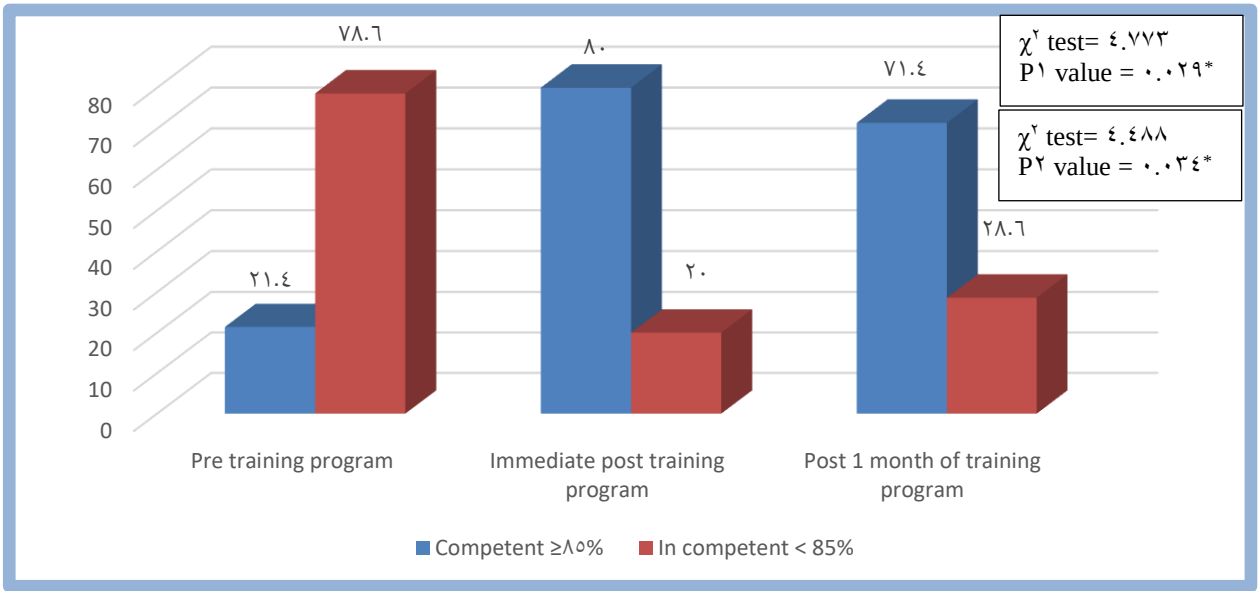

Table (4): Correlation between total knowledge and total practice regarding infusion pumps' medication administration among studied nurses throughout phases of study (n=70).

r-\ p values / *variable*	Periods	*Total knowledge*	
		r	**p- value**
Total practice	Pre	0.229	0.057 $^{n.s}$
	Immediately post	0.520	<0.001**
	Post one month	0.589	<0.001**

($^{n.s}$) Not statistically significant at p> 0.05 (**) Highly statistically significant at ≤0.001

Discussion:

The nurse has an important role in safely managing infusion pumps and this ever-changing technology .It highlights the importance of fully integrating infusion pumps into intravenous **(IV)** therapy training and assessment. Nurses have to identify the breadth of practices, education associated with administering of infusions in critical care unites and potential patient safety issues related to IV pump infusions **(Padhi, 2023).**

Infusion pumps have shown a positive impact on medications' safety for critical patients, the reduction of IV medication errors, the creation of safer work environments for nurses, and the optimization of capital returns, quality control, and the continuous improvement of the processes. Furthermore, the use of pump technology has shown to be profitable in the intensive care unit **(ICU)** because it avoids costs from prevented medications errors and allows for savings on disposables and medications by establishing standardized concentrations and dosing units **(Wolf & Hughes , 2019).**

Concerning studied nurses' personal data, the findings of the current study revealed that more than two thirds of studied nurses were at the age group from 21 to 30 years old with mean age 29.27 ± 0.44 years. From the researcher's point of view, this might be due to newly graduated personnel who assigned to intensive care unit. This result agreed with Fathy et al., (2020) who studied " Nurse's knowledge and practice regarding medication errors in critical care units: descriptive study " and reported the majority of the studied nurses from 20 to 30 years old. On the other hand, disagreed with **Damar & Baria, (2024),** who studied "Skill Training Programme on Knowledge and Skills Regarding Uses of Instruments and Devices in Intensive Care Unit" and reported that nearly three quarters of the studied nurses' age from 20 to 21 years old.

more than half of studied nurses were females. From the researcher's point of view, this result may be due to the fact that the profession of nursing in Egypt has a long history of association with females. Also this finding could be interpreted in the light of the fact that the majority of nurses in Egypt are females and their number is still greater than males in the nursing fields over the past ten years. This result agreed with **Elsayed et al., (2019)** who studied "the nurses' performance regarding infusion Pumps' medication administration among critically ill patients" as they reported that all most of the studied nurses were females. While this finding disagreed with **Gydan et al., (2023)** who studied "Safety Measures for Prevention of Falling in Intensive Care Units in Kirkuk " and reported that more than half of studied nurses were males.

The current study revealed that the majority of the studied nurses had years of experience from 1 to less than 5 years. This result supported by **Aziz et al., (2020)** who conducted a study entitled "Assessment of nurses' performance regarding the implementation of patient safety measures in intensive care units" and reported that more than two thirds of studied nurses having about from 1 to less than 5 years of experience in the field of nursing. While, **Ahmed et al., (2019)** found that, slightly less than half of the studied nurses had more than 10 years of experience in nursing.

Regarding their educational level :more than half of studied nurses had bachelor degree in nursing; from the researcher point of view, this result congruent with nature of intensive care unit where it requires nursing staff at a high level of education to provide patient with high quality care. This finding agreed with **Kassew et al., (2020)** who reported in their study that

more than two thirds of the studied nurses had nursing bachelor degree. But this finding disagreed with **Karikari et al., (2023)** who conducted a study and clarified that more than half of studied nurses had nursing diploma.

Regarding attending training programs about infusion pumps, the current study revealed that slightly less than one quarter of the studied nurses attended training programs about infusion pumps. And nearly more than three quarters didn`t attend any training programs. From the researcher view, this may be due to hospital policy as in most government hospitals in Egypt as a result of the lack of resources and the large number of nurses and patients.

This result supported with **Elsayed et al., (2022) and** reported that the minority of studied nurses participated in training programs about infusion pumps. But this result disagreed with **Almalki et al., (2023)** who studied "Assessment of knowledge, attitude, and adherence to national guidelines for preventing central line-associated bloodstream infections among ICU nurses of adult patients in Jeddah, Saudi Arabia" and reported that more than three quarters of studied nurses participated in training programs.

Concerning Nurses' knowledge toward anatomy and physiology of circulatory system, the present study revealed that less than half of studied nurses had satisfactory level pre training program, most of them immediately post- training program. From the researcher's point of view, this finding may be related to nurses' exhaustion from increased work load in the ICU which may hinder their ability to read and update their knowledge. This finding agreed with **Gad Allah & Ramadan, (2024)** who found knowledge gap among more than three quarter of the studied nurses' regarding anatomy and physiology of circulatory system. On contrast, **Rajput Vidyapeeth, (2024)** in study conducted to evaluate "Knowledge of Staff Nurses Regarding Identification and Management of Cardiac Arrhythmias" found that nearly half of the nurses had sufficient knowledge about regarding anatomy and physiology of circulatory system..

Concerning Nurses' knowledge about infusion pump, the study findings reported that the minority of studied nurses had satisfactory level of knowledge regarding infusion pump prior to the training program implementation, which improved nearly three quarter of them immediately post the training program implementation. This finding agreed with **Beaudart et al., (2023)** who revealed in their study that nurses' knowledge about infusion therapy was adequate among more than half of them.

This study discovered that the minority of studied nurses had satisfactory level of knowledge about infusion calculations prior to training program implementation, while improved to nearly three quarters of them post training program implementation. This result is in accordance with, **Damar & Baria, (2024),** who revealed that nearly two thirds of studied nurses reported inadequate knowledge.

As regard to nurses' total knowledge about infusion pumps' medication administration, this study reported a great improvement in knowledge score among almost two thirds of nurses post training sessions than before. This finding agreed with **Fathy et al., (2020)** who found most of

the studied nurses had unsatisfactory level of total knowledge.

Concerning nurses' practice during preparing phase of infusion pumps' medication administration, the present study reported that that less than fifth of studied nurses' practice were at satisfactory level regarding preparations prior to training program implementation, while improved to nearly three quarter of them immediately post training program implementation. This finding is consistent with **van der Sluijs., (2019)** who found that one quarter of studied nurses had competent practice regarding preparing phase prior to training program implementation. However, on contrast **Taylor & Jones, (2019)** found that three quarter of the studied nurses had satisfactory level of practice regarding preparations before infusion pumps' medication administration.

Concerning difference of nurses' total practice levels regarding infusion pumps' medication administration throughout phases of study: the present study revealed that less than one quarter of the studied nurses had competent level of total practices regarding infusion pumps' medication administration prior to training program implementation, while more than three quarter of their practice improved to be at competent level immediately post training program implementation.

These findings corresponded with the finding of studies conducted by **Lamsal & Shrestha, (2019)** who conducted study in "Nurses' knowledge and practice regarding intravenous therapy in a teaching hospital, Bharatpur" and reported that nearly two thirds of studied nurses had incompetent level of total practice. On the other hands, these results disagreed with **El-Feky, (2020)** who found that more than half of the studied nurses had competent level of total practices.

total knowledge and total practice scores among the studied nurses pre, immediate and post one month period of training program implementation: the current study showed that there was a positive and highly statistically significant correlation between total knowledge and total practice score of infusion pumps' medication administration therefore the two stated research hypothesis were supported**. From the researcher view of point,** when the knowledge increased, the level of nursing practice increased. Also, these result may be due to the knowledge acquired by studied nurses help them to perform practical skills after understanding the scientific knowledge background about them.

This finding was in agreement with **Ibrahim et al., (2024)** who revealed that there was a positive and highly statistically significant correlation between nurses' knowledge and their practice. On the other hand, this result disagreed with **Yilmaz et al., (2023)** who illustrated that there was no statistically significant correlation between nurses' knowledge and practice in their study.

Conclusion

The training program effectively improved nurses' knowledge and practice regarding infusion pump medications administration as there was highly statistically significant correlation between total knowledge and total practice scores of nurse's post training program implementation that confirmed research hypotheses.

Recommendations

- Continuing educational programs for all nurses in order to update their

knowledge and practice level regarding infusion pumps.

- Designing and distributing Arabic booklets for critical nurses illustrating how to use infusion pumps.
- Continuous evaluation from the head nurse and nurse supervisor to the staff nurses' knowledge and practice is essential to identify their educational needs.
- Further study should be conducted on a larger sample size from different geographical distribution for generalization of the results.

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