

Nurses' Performance Regarding Smart Infusion Pump In Relation To Medication Administration among Pediatric Patients

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Abstract

Background: An infusion pump is a medical device that delivers fluids, such as nutrients and medications, into a patient's body in controlled amounts. Nurses have an important role in ensuring safety in the infusion pumps' medication administration process. **Aim of the study** was to assess nurses' performance regarding smart infusion pump in relation to medication administration among pediatric patients. **Design:** A descriptive exploratory design was utilized in carrying out this study. **Settings:** The study was carried at three places in Mansoura New General Hospital Dakahlia Governate NICU, PICU and inpatients ward. **Study subjects:** A purposive sample of 120 nurses working at previously mentioned settings (45) nurses from NICU, (56) nurses from PICU and (19) nurses from inpatients' pediatric wards. **Data collection tools: Tool I.** Structured Questionnaire Sheet. **Tool II.** An Infusion Pumps' Medication Administration Observational Checklist. **Results:** Regarding nurses' total knowledge, more than three quarters of studied nurses had unsatisfactory total knowledge regarding smart infusion pump whenever, about one quarter of them had a satisfactory total knowledge. In relation to total nurses' practice, the study revealed that the majority of studied nurses had incompetent total practice regarding smart infusion pump whenever, the minority of them had a competent total practice. There was statistically significant relation between nurses' total knowledge and their total practices related to SIP **Conclusion:** regarding nurses' total knowledge, more than three quarters of studied nurses had unsatisfactory total knowledge regarding smart infusion pump. In addition, the majority of studied nurses had incompetent total practice regarding smart infusion pump. **Recommendations:** Provide in-service educational programs and upgrading courses based on pediatric nurses' needs and evidence-based guidelines to improve their knowledge and practice related to administration intravenous medications using infusion pump.

Keywords: Nurses' performance, Smart infusion pump, Pediatric Patients.

INTRODUCTION

Smart pumps are a promising technology to prevent medication administration errors. Smart pumps are infusion pumps manufactured with software that checks the nurse-programmed medication administration against pre-established institutional limits in customized medication libraries before beginning infusion. Because administration is the last step in the medication use pathway after ordering and dispensing, there are few opportunities to intercept errors in administration. Smart pumps provide alerts around many types of potentially unsafe infusion conditions, providing both 'soft alerts' and 'hard stops' when programmed dosing limits are violated. The goal of soft alerts is to raise awareness by notifying the user that the programmed medication infusion parameters are outside of the usual dosing range. These alerts can be overridden, however, and the infusion continued (Mahdy et al., 2018).

Several infusion devices are now available from different manufacturers to improve the accuracy of intravenous fluid administration for patient safety. Pediatrics' patients or fluid restricted patients may require a higher degree of infusion devices accuracy than other patients. A number of commonly used infusion pumps are designed for specialized purposes and in a variety of environments. An intravenous devices problem can be caused by software problems, alarm errors, human factors, mechanical or electrical failures and broken components. These problems can lead to over or under infusion and/or delay in therapy. There are some

complications from the infusion and vascular access devices are expensive to organizations in terms of wasted human resources, wasted supplies, impaired customer satisfaction and delays in patient care. These complications include phlebitis, infiltration and extravasations (Afify et al., 2022).

Causes of MEs were mostly environmental factors, lack of knowledge, lack of drug information sources, and incomplete prescribing. Poor nurses' performance and infusion pump errors may be related to lack on nurses' training and education about smart infusion pump; high nurses' workload, lack of supervision, defects in learning and practice, disturbances and interruptions during preparation or administration, lack of communication and skills, poor intravenous line in some patients and deficiencies in the design of related equipment (Giuliano et al., 2021).

Finally, nurses' do an important function in preventing errors because nurses are responsible for doing the last security checks that medications need before medications are administered to the pediatric patients. It is important to use an infusion pump in medication administration to decrease the incidence of MEs and adverse drug reactions (ADRs). Before starting or changing an infusion setting, nurses should confirm that the infusion pump is programmed correctly, perform an independent double check, when neonates receive multiple intravenous fluid or medications by infusion pump, every fluid or medication should be labeled with its name (Leopoldino et al., 2019).

SIGNIFICANCE OF STUDY

In Egypt, a study at NICU in Benha University Hospital; detected 3819 errors that affected 97% of neonates (Mahmoud et al., 2022). Another study at Abu El-Rish El-Monira and Sayed Galal NICUs revealed that, 74.5% prescription errors and 69.7% administration errors were detected in the two NICUs (Naser et al., 2021). Medication errors risks increase in infusion pump medications because it's more complex in calculation, preparation, administration, and follow up after administration. The Egyptian Medication Errors Reporting System disclosed that the most frequent administration errors were extra dose, dose omission, and medication omission. Therefore, applying nursing guidelines technique for effective use of smart infusion pump consequently decrease medication error, safe handling of HAMs, and enhancing their performance (Eslami et al., 2019).

AIM OF THE STUDY

The aim of this study is to assess nurses' performance regarding smart infusion pump in relation to medication administration among pediatric patients.

RESEARCH QUESTIONS:

1. What is the level of nurses' knowledge regarding smart infusion pump (SIP) in relation to medication administration among pediatric patients?
2. What is the level of nurses' practice regarding smart infusion pump (SIP) in relation to medication administration among pediatric patients?

3. Is there a relationship between nurses' performance and nurses' characteristics regarding smart infusion pump technology?

SUBJECTS AND METHODS

I - Technical Item:

Research design:

A descriptive research design was used to carry out this study.

Setting:

The current study was carried out at pediatric intensive care unit and neonatal intensive care unit of Mansoura New General Hospital.

Subjects:

➤ Type of the subject:

The subjects of this study will be consisted of all available nurses working at previously mentioned settings

Tools of data connection:

Data collection will be obtained by using two tools developed by researcher based on the relevant and most recent literatures (Pinkney et al., 2014 and Mukoreka & Sisay, 2015), consists of the following :

I. A Structured Questionnaire Sheet :

It is closed ended questions and filled by the studied nurses themselves. It included two parts :

Part 1 :

It was concerned with the assessment of the social characteristics of the nurses such as age, educational level, years of experience ...etc.

Part 2 :

It was concerned with the assessment of nurses' knowledge regarding intravenous medication administration using a selected type of infusion pumps among pediatric patients. The questionnaire consisted of questions in the form of multiple choice questions (MCQ)

and true/false questions. It covered eight main items about the syringe pumps' medication administration, which were: 1. Definition of the syringe pumps. 2. Preparing and setting up an intravenous infusion. 3. Infusion calculations. 4. Managing the dead volume in intravenous lines. 5. Identifying an infusion from multiple intravenous infusions. 6. Disadvantage of the syringe pump. 7. Labelling. 8. Infusion observation & patient monitoring.... etc.

Scoring system for nurses' knowledge will be as the following :

One mark for correct answer & zero for incorrect answer. The results of scoring system will be classified as followed :

- Satisfactory knowledge level: 80% or more.
- Unsatisfactory knowledge level: less than 80%.

II. An Infusion Pumps' Medication Administration Observational Checklist :

It is developed by the researcher by using the most recent and relevant literatures (**Pinkney et al., 2014 and Mukoreka & Sisay, 2015**) It is used to assess the nurses' level of practice regarding infusion pumps' medication administration among paediatric patients.

Scoring system for nurse's practice will be as the following :

One mark for correct done & zero for not done.

The results of scoring system will be classified as followed :

- %85 and more will be considered competent practice.
- Less than 85% will be considered incompetent practice

II – Operational item:

It involved three phases namely, preparatory phase, validity and reliability, pilot study and field work.

A- Preparatory phase:

It will include reviewing of related literature and theoretical knowledge of the study using books, articles, papers, periodicals and magazines to develop tools and to get acquainted with the various study aspects of the research problem.

A) Validity & B) Reliability:

It will be ascertained by panel of three experts in the field of pediatric nursing who will review the content of the tools for comprehensiveness, accuracy, clarity and relevance and necessary modifications will be done accordingly.

C) Pilot study:

A pilot study will be conducted to evaluate the validity and applicability of the tools, which will be used in the data collection. It will be conducted on 10% of the total number of nurses in order to evaluate the research plan, clarity and applicability of the study tools. Necessary corrections and modification will be done to reconstruct the changes in data collection tools..

Ethical considerations:

The ethical research considerations in the study include the following; the research approval will be obtained from the Ethical Committee of Scientific Research in Faculty of Nursing in Helwan University before starting the study. The researcher will obtain approval from Mansoura new general hospital, the researcher will clarify the objective and aim of the study to nurses included in the study and will get their consent before conducting the study. The researcher will assure maintaining anonymity and confidentiality of subjects' data. Nurses will be informed that they are allowed to

choose to participate or withdraw from the study at any time without penalty.

Field Work:

Data will be collected after obtaining an official agreement from the director of the nursing manager in the study setting. The Researcher will be available three days a week in the previously mentioned study setting over a period of 6 months to gather data for the study purpose using previously mentioned tools. Each nurse will be interviewed individually where the researcher will introduce herself and explain aim and expected outcomes of the study

.III- Administrative Item:

An official permission study will be obtained from dean of Faculty of Nursing Helwan University to the hospital administrators to conduct the proposed study.

IV -Statistical Item:

The collected data will be statistically analyzed, organized and presented in tables and graphs as required using statistical package of social science (SPSS) and suitable statistical tests will be used to test the significance of obtained results.

RESULTS:

The results of the current study were presented in three parts:

Part (I): Socio-demographic characteristics of the studied nurses: table (1) & figures (1&2).

Part (II): Distribution of studied nurses according to their knowledge regarding smart infusion pump (table 2) & figure (3).

Part (III): Distribution of the studied nurses according to their practice regarding smart infusion pump (table 3-6) & figure (4).

Part (IV): Relation and correlation between variables of the study (table 7-9)

Part (I): Socio-demographic characteristics of the studied nurses

Table (1): Frequency distribution of studied nurses according to their demographic characteristics (n=120).

	N o	%
Age		
22<30 years old	58	48.3
30<40 years old	44	36.7
40<50 years old	15	12.5
≥50 years old	3	2.5
Mean± SD =28.49 ± 8.685		
Gender		
Male	42	35.0
Female	78	65.0
Educational level		
Faculty of nursing	72	60.0
Technical nursing institute	37	30.8
Nursing school	11	9.2
Years of experience		
<1 year	45	37.5
1-5 years	51	42.5
>5 years	24	20.0

Table (1) illustrates that nearly half of studied nurses (48.3%) aged between 22 and 30 years old with mean age ±SD (28.49 ± 8.685) also, nearly two thirds of them (65.0%) were female. Regarding

educational level, this table illustrated that three fifth of studied nurses (60.0%) had a faculty of nursing whenever more than two fifth of them (42.5%) had from 1 to 5 years old and most of them (95.8%) didn't attend training courses related to smart infusion pump.

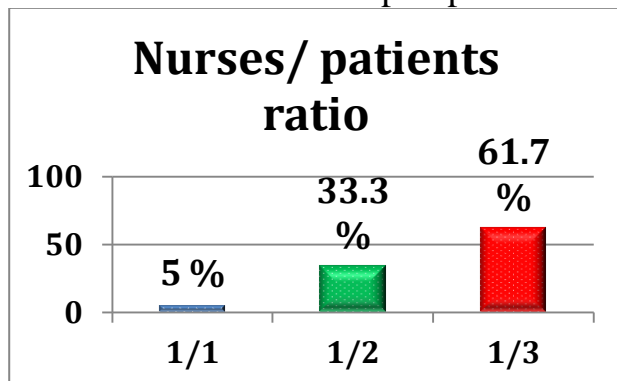


Figure (1): Frequency distribution of studied nurses according to nurses/ patients' ratio (n=120).

Figure (1) illustrates that nearly two thirds of studied nurses (61.7%) had nurse/ patient ratio about 1 nurse to every 3 patients and one third of them (33.3%) had nurse/ patient ratio about 1 nurse to every 2 patients.

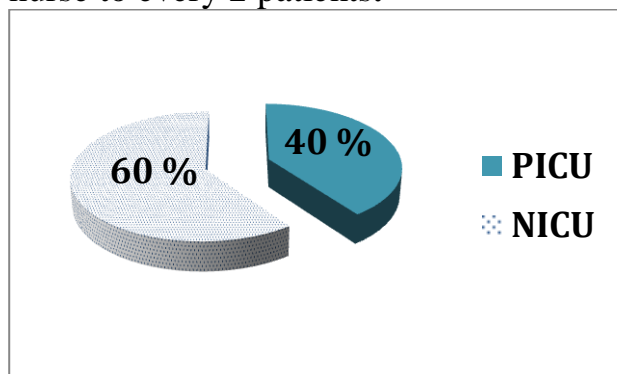


Figure (2): Frequency distribution of studied nurses according to their place of work (n=120).

Figure (2) shows that three fifth of studied nurses (60.0%) were working at neonatal intensive care unit (NICU) whenever, two fifth of them (40.0%) were working in pediatric intensive care unit (PICU).

Part (II): Distribution of studied nurses according to their knowledge

Table (2): Distribution of studied nurses according to their knowledge regarding smart infusion pump (n=120).

Items	Correct		Incorrect	
	Count	Percentage	Count	Percentage
Definition of smart infusion pump	21	17.5	99	82.5
Difference between smart infusion pump and traditional infusion pump	14	11.7	86	88.3
Precaution during medication administration	29	24.1	89	75.9
Uses of smart infusion pump	32	26.6	68	73.4
Advantages of smart infusion pump	56	46.7	64	53.3
Disadvantages of smart infusion pump	13	10.8	107	89.2
Most common error during use of smart infusion pump	14	11.7	106	88.3
The first action that nurse should take in case of a problem during infusion of fluid in a child sensitive to hyperhydration	25	20.8	95	89.2

Meaning of independent double check	12	10.0	98	90.0
Emergent situation in which the nurse should stop using the pump	44	36.7	76	63.3
Nursing role in case of defect in smart infusion pump	34	28.3	86	71.7
Information that should be present in the label of smart infusion pump	53	44.2	67	55.8
Possible cause of alarm from smart infusion pump	33	27.5	87	72.5
How to deal with the alarm of smart infusion pump	45	37.5	75	62.5
Methods of Calculating the fluid that given by smart infusion pump	29	24.1	91	75.9
Calculation of infusion rate and duration of infusion	21	17.5	99	82.5

Table (2) illustrates that nearly half of them (46.7% & 44.2%) had a correct knowledge regarding advantages of smart infusion pump and information that should be present in the label of smart infusion pump respectively whenever, the majority of studied nurses (82.5%, 88.3%, 89.2%, 88.3% & 82.5%) had incorrect knowledge regarding

definition of smart infusion pump, difference between smart infusion pump and traditional infusion pump also, disadvantages of smart infusion pump, most common error during use of smart infusion pump and calculation of infusion rate and duration of infusion respectively whenever most of them 90.0% had incorrect knowledge regarding meaning of independent double check. This table also shows that more than three quarters of nurses (75.9%) had incorrect knowledge regarding precaution during medication administration and methods of calculating the fluid that given by smart infusion pump.

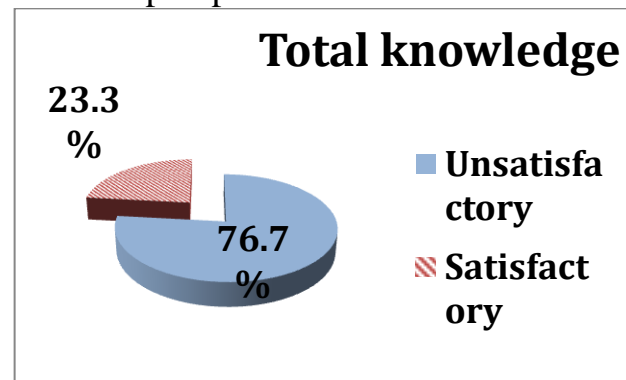


Figure (3): Frequency distribution of studied nurses according their total knowledge level regarding smart infusion pump (n=120).

Figure (3) illustrates that more than three quarters of studied nurses (76.7%) had unsatisfactory total knowledge regarding smart infusion pump whenever, about one quarter of them (23.3%) had a satisfactory total knowledge.

Part (II): Distribution of studied nurses according to their practice

Table (3): Distribution of studied nurses about their practice regarding smart infusion pump (preparatory phase) (n=120)

Items	Correctly Done		Incorrectly Done / Not Done	
Checking the patient chart for doctor order including drug type, dose, route, rate & amount	23	19.2	97	80.8
Checking the patient's chart for allergies.	13	10.8	107	89.2
Hand washing and wearing sterile gloves	103	85.8	17	14.2
Preparing all needed equipment including smart pump, gloves, medication, syringe and line.	71	59.2	49	40.8
Checking expiration dates of the medication and diluents.	50	41.7	70	58.3
Explaining the	12	10.0	98	90.0

procedure, purpose and action of the medication to the caregiver.				
Complete necessary assessment before administering infusion including patient identification	14	11.7	106	88.3
Ensuring five patient rights (right drug, right patient, right dose, right rate and right volume.	34	28.3	86	71.7

Pertaining to nurses' practice regarding smart infusion pump during (preparatory phase), this table illustrated that the majority of studied nurses (80.8%, 89.2% & 88.3%) didn't the steps correctly or not done regarding checking the patient chart for doctor order including drug type, dose, route, rate& amount, checking the patient's chart for allergies and completing necessary assessment before administering infusion including patient identification respectively. This table also revealed that most of nurses (90.0%) did the steps incorrectly or not done regarding explaining the procedure, purpose and action of the medication to the caregiver.

Table (4): Distribution of studied nurses about their practice regarding smart infusion pump (Priming and setting up-phase) (n=120).

Items	Correctly Done		Incorrectly Done / Not Done	
Using aseptic technique throughout the procedure.	25	20.8	95	79.2
Placing label on tubing with appropriate information about Patient's name, time and date the infusion started, volume & rate of infusion and name and signature of the person starting the infusion.	57	47.5	63	52.5
Using antiseptic swab to clean the access port or stopcock to minimize the spread of infection.	27	22.5	93	77.5

Concerning nurses' practice regarding smart infusion pump during (Priming and setting up-phase), this table illustrated that about half of studied nurses (47.5.0%) didn't the practice correctly or not done regarding placing label on tubing with appropriate information about patient's name, time

and date the infusion started, volume & rate of infusion and name and signature of the person starting the infusion whenever, more than three quarters of them (79.2 & 77.5%) did the steps incorrectly or not done regarding using aseptic technique throughout the procedure and use of antiseptic swab to clean the access port or stopcock to minimize the spread of infection respectively.

Table (5): Distribution of studied nurses about their practice regarding smart infusion pump (administration-phase) (n=120).

Items	Correctly Done		Incorrectly Done / Not Done	
Setting the infusion according to instructions and comparing with library limits	14	11.7	106	88.3
Performing an independent double-check of high alert drugs infusion by making another health care provider to check infusion setting independently and compare the infusion setting.	21	17.5	99	82.5
Starting the infusion and expel all air from the Iv line to prevent air embolism by using aseptic	71	59.2	49	40.8

technique				
Observing the patient for allergy lead to observed hemodynamic changes.	2	19.	9	80.
	3	2	7	8
Applying adhesive label to the IV tubing.	5	49.	6	50.
	9	2	1	8
Standardizing infusion system communication by using adhesive labels with different colors to distinguish high alert medication lines from other infusions	5	47.	6	52.
	7	5	3	5
Clearly communicating the architecture of infusion setups during transitions of care (handover) between providers to avoid dose errors	3	31.	8	68.
	8	7	2	3
Maintaining the tube free from kinking or obstructions.	8	68.	3	31.
	2	3	8	7
Never ignoring the alarm and respond immediately to correct the problem	7	61.	4	38.
	4	7	6	3
Assessing the patient for any adverse reaction.	5	43.	6	56.
	2	3	8	7

studied nurses (68.3%) didn't the steps correctly or not done regarding maintaining the tube free from kinking or obstructions. However, the majority of them (88.3%, 82.5% & 80.8%) did the practice incorrectly or not done regarding setting the infusion according to instructions, performing an independent double-check of high alert drugs infusion by making another health care provider to check infusion setting independently and compare the infusion setting and observing the patient for allergy lead to observed hemodynamic changes respectively. This table also illustrated that more than half of studied nurses (50.8%, 52.5% & 56.7%) did the steps incorrectly or not done regarding applying adhesive label to the IV tubing, standardizing infusion system communication by using adhesive labels with different colors to distinguish high alert medication lines from other infusions and assessing the patient for any adverse reaction respectively. This table also revealed that more than two thirds of studied nurse (68.3%) didn't the practice correctly or not done regarding clearly communicating the architecture of infusion setups during transitions of care (handover) between providers to avoid dose errors.

Table (6): Distribution of studied nurses about their practice regarding smart infusion pump (Post administration phase) (n=120).

Concerning nurses' practice regarding smart infusion pump during (Administration phase), this table showed that more than two thirds of

Items	Correctly Done		Incorrectly Done / Not Done	
	Discontinuing the infusion	95	79.2	25

aseptically				
Notifying the physician of completing the infusion	32	26.7	88	73.3
Continuous assessment of patients' condition for further adverse reaction	14	11.6	106	88.4
Documentation of drug administered, dose, route and volume of drug administered, any problem appeared during infusion and any adverse reaction from medication administration.	29	24.2	81	75.8

practice correctly or not done regarding notifying the physician of completing the infusion also the majority of them (88.4%) did the practice incorrectly or not done regarding continuous assessment of patients' condition for further adverse reaction and more than three quarters of studied nurses (75.8%) didn't the steps correctly or not done regarding documentation of drug administered, dose, route and volume of drug administered, any problem appeared during infusion and any adverse reaction from medication administration.

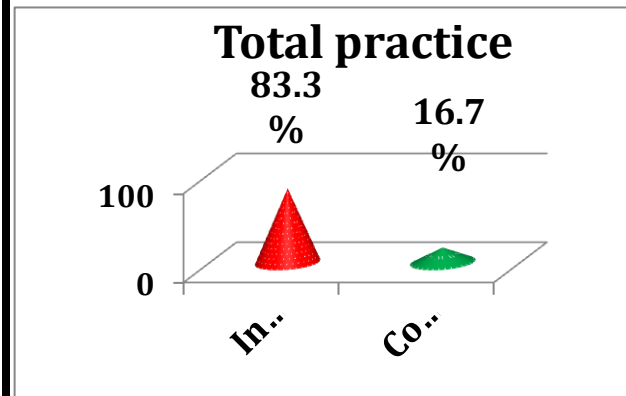


Figure (4): Frequency distribution of studied nurses according their total practice level regarding smart infusion pump (n=120).

In relation to nurses' practice regarding smart infusion pump during (**post infusion phase**), this table illustrated that more than three quarters of studied nurses (79.2%) didn't the practice correctly or not done regarding discontinuing the infusion aseptically whenever, nearly three quarters of studied nurses (73.3%) didn't

Figure (4) illustrates that the majority of studied nurses (83.3%) had incompetent total practice regarding smart infusion pump whenever, the minority of them (16.7%) had a competent total practice.

Part (IV): Relation and correlation between study variables.

Table (7): Relation between nurses' total knowledge and their demographic characteristics (n=120)

	Satisfactor	Un	Chi	P-
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	y		satisfactory		No	value
	No	%	No	%		
Age						
22<30 years old	5	17.9	53	57.6	24.804	0.000**
30<40 years old	12	42.9	32	34.8		
40<50 years old	8	28.6	7	7.6		
≥50 years old	3	10.7	0	0.0		
Gender						
Male	9	32.1	33	35.9	0.131	
Female	19	67.9	59	64.1		
Educational level						
Faculty of nursing	11	39.3	61	66.3	7.333	
Technical nursing institute	12	42.9	25	27.2		
Nursing school	5	17.9	6	6.5		
Years of experience						
<1 year	6	21.4	39	42.4	9.396	
1-5 years	11	39.3	40	43.5		
>5 years	11	39.3	13	14.1		

statistically significant differences ($p > 0.05$).

Table (8): Relation between nurses' total practice and their demographic characteristics (n=120).

	Com peten t		Incom petent		C hi	P- val ue
	N o	%	N o	%		
Age						
22<30 years old	4	20.0	54	54.0	21.306	0.000**
30<40 years old	11	55.0	33	33.0		
40<50 years old	2	10.0	13	13.0		
≥50 years old	3	15.0	0	0.0		
Gender						
Male	8	40.0	34	34.0	0.268	0.608
Female	12	60.0	66	66.0		
Educational level						
Faculty of nursing	5	25.0	67	67.0	17.826	0.000**
Technical nursing institute	9	45.0	28	28.0		
Nursing school	6	30.0	5	5.0		
Years of experience						

(Statistical significant difference) Non sig. >0.05 & Sig. <0.05* & High sig. <0.001**

This table illustrated that there was statistically significant difference between nurses' total knowledge and their demographic characteristic in all items except for age there was a highly statistically significant difference ($p < 0.001^{**}$) and for gender, there was

<1 year	4	20	41	41.	6.7	0.03
		.0		0		
1-5 years	8	40	43	43.		
		.0		0	95	3*
>5 years	8	40	16	16.		
		.0		0		

(Statistical significant difference) Non sig. >0.05 & Sig. <0.05* & High sig. <0.001**

This table illustrated that there was a highly statistically significant difference between nurses' total practice and their demographic characteristic regarding age and educational level ($p < 0.001^{**}$) and there was statistically significant difference between nurses' total practice and their demographic characteristic regarding years of experience and attendance of training courses ($p < 0.05^*$) whenever, there was no statistically significant differences regarding nurses' gender ($p > 0.05$).

Table (9): Correlation between total nurses' practice and their total knowledge (n=120)

Total nurses' knowledge	Total nurses' practice	
	r	p-value
	0.229*	0.012*

Table (9) illustrates that there was statistically significant correlation between nurses' total knowledge and their total practice ($p < 0.05^*$).

DISCUSSION

Smart infusion pumps are sophisticated computer systems that communicate within a network, using software and hardware designed to send the exact amount of medication at a precise rate to each patient. At the interface between the infusion pump and the nurse, critical decisions are made, presumptive actions are performed, and successful or deleterious outcomes are initiated. Although smart infusion pumps have reduced I.V. infusion errors, continuing lapses (programming, pump setup, channel/line mix-ups) coupled with known smart pump technology limitations require ongoing efforts to protect patients from harm (*Oliveir et al., 2021*).

According to the Infusion, the nurse is responsible for ensuring patient safety through competent infusion equipment use, including knowledge of appropriate indications, contraindications, and manufacturer's directions. When managing smart infusion pumps, clinicians must maintain clinical competency, adhere to organizational compliance goals,

confidently manage the I.V. medication administration process, vigilantly prevent error, assess the child and monitor the pump throughout each infusion, and ensure appropriate medication administration and patient handoffs and transfers are performed. Standardized clinical workflows will help ensure routine performance of all safety measures and reduced risks to patient harm (*Kuitunen et al., 2022*).

In many clinical settings, there remains gap between nurses' knowledge and practice regarding drug administration through using of SIP. To address this gap, this study aimed to explore nurses' performance regarding smart infusion pump in relation to medication administration among pediatric patients which is very important to understand the challenges faced by nurses and intervene appropriate strategies to reduce those challenges.

Part (I): Socio-demographic characteristics of the studied nurse

Regarding the demographic characteristics of studied nurses, the results of the current study revealed that

illustrates that nearly half of studied nurses aged between 22 and 30 years old with mean age \pm SD (28.49 ± 8.685), from the researcher point of view this could be interpreted that the newly graduated and young age nurses had updated and refreshed practical skills also have more power and energy so that they were recruited to work at the critical units such as emergency department and intensive care units, pediatric intensive care units (PICU) and neonatal intensive care units (NICU) moreover, old age nurses were working in administrative position such as nurses supervisors.

The study was supported by *Al-Otaibi et al., (2018)* who studied "Nurses' Medication Errors in the Pediatric Emergency Department in Saudi Arabia" and revealed that nearly one third of nurses aged from 20 to 29 years old. The study was also congruent with *Elsayed et al., (2020)* who studied "Nurses' Practical Knowledge about Neonatal Safety Using Intravenous Devices for Prevention of Medication Errors" and revealed that more than half of nurses aged less than 30 years old.

Concerning the gender of studied nurses, the results of the present study revealed that nearly two thirds of them were females, from the researcher point of view this could be due to the old perception that nursing profession is more suitable job for females more than males as females are more proficient in jobs that require caring skills. The study was agreed with *Quattromani et al., (2018)* who studied “Smart pump app for infusion pump training” and illustrated that the majority of nurses were female.

Regarding educational level of studied nurses, the current study illustrated that three fifth of studied nurses had a faculty of nursing from the researcher point of view, this could be due to their high grades in secondary school and the hospital administration recruit highly educated nurses in critical areas such as PICU and NICU. The study also revealed that more than two fifth of nurses had from 1 to 5 years of experience, this could be due to their young age, the study was supported by *Alrabadi et al., (2020)* who studied “Medication errors among registered nurses in Jordan” and illustrated that,

most of the enrolled participants had a bachelor (BSc) level of education, while the remaining had a master (MSc) degree as a higher education and regarding the years of experience, most of the participants had <5 years.

According to nurses/ patients’ ratio, the results of the present study showed that nearly two thirds of studied nurses had nurse/ patient ratio about 1 nurse to every 3 patients and one third of them had nurse/ patient ratio about 1 nurse to every 2 patients. From the researcher point of view, this could be due to hospital policy or the intensive care that needed in critical setting such as NICU and PICU so that each nurse is assigned care for little number of children. The study was supported by “*Tubbs-Cooley et al., (2019)* who studied “ Association of Nurse Workload With Missed Nursing Care in the Neonatal Intensive Care Unit” and revealed that most of nurses had neonate to nurse ratio 2 patients: 1 nurse.

Part (II): Distribution of studied nurses according to their knowledge

Concerning the advantages of smart infusion pump, the results of the

present study revealed that nearly half of nurses had a correct answer, also nearly half of them had correct knowledge about information that should present in the label of smart infusion pump. From the researcher point of view this could be due to their previous exposure to such information and they exclude the benefit of SIP and the data that should be documented on the pump to maintain patients' safety from their practical experience. The study was supported by *Zaborowski, (2018)* who studied "Efficacy of Smart Infusion Pumps from a Nursing Perspective" and revealed that the majority of nurses had adequate knowledge regarding the benefits of SIP such as easy use, safe administration and accuracy calculating dose in high vitality medication also nearly three quarters had adequate knowledge about safety information that should be documented on smart infusion pump.

The study also illustrated that, most of nurses had inadequate knowledge regarding most common errors and meaning of independent double check, from the researcher point of view this could be due to absence of

written policy regarding safe medication administration in pediatric units. The study was agreed with *Klarich et al., (2021)* who illustrated that most of their studied participants had inadequate knowledge regarding medication administration errors and independent double check.

The study revealed that the majority of nurses had inadequate knowledge about the difference between smart infusion pump and traditional infusion pump from the researcher point of view this could be due to lack of training courses, lack of exposure to such information or limited number of used smart infusion pump in hospital that results in poor knowledge regarding the difference. The study was supported by *Giuliano et al., (2021)* who studied "Intravenous Smart Pumps during Actual Clinical Use: A Descriptive Comparison of Primary and Secondary Infusion Practices" and revealed that majority of their studied participants had inadequate knowledge regarding the difference between SIP and TIP.

The results of the present study also illustrated that more than three quarters of nurses had inadequate

knowledge regarding methods of calculating the fluid that given by smart infusion pump and the majority of them also had incorrect answer regarding calculation of infusion rate and duration of infusion, from the researcher point of view this could be due to lack of training and the sophisticated practice that commonly done by the doctor and the nurse only assigned to perform doctor order regarding the dose, rate and duration. The study was in the same manner with *Elsayed et al., (2019)* who studied “Nurses' Performance Regarding Infusion Pumps' Medication Administration among Ill Patients” and revealed that most of nurses had unsatisfactory practice about intravenous infusion calculations and managing the dead volume in intravenous lines.

As regarding nurses' total knowledge about use of smart infusion pump, the results of the present study revealed that more than three quarters of studied nurses had unsatisfactory total knowledge regarding smart infusion pump whenever, about one quarter of them had a satisfactory total knowledge. From the researcher point of view this

could be related to the sophisticated procedure that require continuous reading of newly published updates and lack of attending of courses and educational program about use of SIP. The study was supported by *Giuliano & Blake, (2021)* whose study entitled “Nurse and pharmacist knowledge of intravenous smart pump system setup requirements” and illustrated that nearly three quarters of the studied nurses had unsatisfactory total knowledge regarding set up of infusion pumps' in medication administration. Conversely, the study was disagreed with *Elsayed et al., (2020)* who revealed that, less than two thirds of the studied nurses had average total knowledge regarding SIP including (knowledge about patient safety, medication administration process, medication errors and methods of prevention of medication errors). While, more than one third of them had good total knowledge.

Part (II): Distribution of studied nurses according to their practice

Concerning nursing practice regarding preparatory phase in smart infusion pump, the result of the present study revealed that the majority of

studied nurses had unsatisfactory practice regarding checking the patients' chart for doctor order including drug type, dose, route, rate& amount, checking the patient's chart for allergies and completing necessary assessment before administering infusion including patient identification, from the researcher point of view, this could be due to lack of training and clear instructions regarding maintenance of child safety. The study was agreed with *Mahdy et al., (2019)* who studied “Effect of an Instruction Guidelines on Intern- Nurses' Performance Regarding Medication Errors & Management” and revealed that about three quarters of studied nurses had unsatisfactory base line practice about checking the patients' chart for doctor order including drug type, dose, route, rate& amount, checking the patient's chart for allergies and completing necessary assessment before administering infusion including patient identification.

Concerning nursing practice about **Priming and setting up-phase** in smart infusion pump, the result of the present study illustrated that nearly three

quarters of studied nurses had unsatisfactory practice regarding using aseptic technique throughout the procedure and use of antiseptic swab to clean the access port or stopcock to minimize the spread of infection. From the researcher point of view, this could be due to lack of training and absence of supervision on nurses' application for aseptic technique. The study was supported by *Mendes et al., (2018)* who studied “Types and frequency of errors in the preparation and administration of drugs” and revealed that the majority of studied nurses had unsatisfactory practice about using aseptic technique during preparation of medication and also didn't use antiseptic swab to clean the access port. Conversely the study was disagreed with *Afify et al., (2022)* who studied “Nurses' Knowledge and Practices regarding Care of Children Undergoing Vascular Access and its Related Complications” and revealed that the majority of their studied participants had satisfactory practice regarding using aseptic technique during intravenous medication administration in pediatric patients.

Concerning nurses' practice regarding **Administration phase** in smart infusion pump during, the results of the present study revealed that the majority of studied nurses had unsatisfactory practice regarding setting the infusion according to instructions and comparing with library limits. From the researcher point of view, this could be due that, using smart infusion pump is sophisticated and complicated procedure that require comprehensive training, the study was supported by *DeLaurentis et al., (2019)* who studied "Stakeholder perceptions of smart infusion pumps and drug library updates: A multisite, interdisciplinary study" and revealed that most of their studied participants had incompetent practice regarding comparing between infusion instructions and library limits.

The results of the current study showed that more than two thirds of studied nurses had a correct practice regarding maintaining the tube free from kinking or obstructions, from the researcher point of view, this could be to nurses' desire to meet doctor order in order to complete medication administration at the prescribed rate in

the pre-determined time the study was agreed with *Oliveira et al., (2021)* who studied " Usability of volumetric infusion pumps in pediatric intensive care" and revealed that the majority of nurses had satisfactory practice regarding maintenance of patent intravenous line free from any obstruction during intravenous medication administration.

The results of the current study also revealed that the majority of nurses had incorrect practice regarding setting the infusion according to instructions and performing an independent double-check of high alert drugs infusion by making another health care provider to check infusion setting independently. From the researcher point of view this could be due to lack of training on the sophisticated procedure and setting up of infusion pump, also may be due to lack of written policy about using of smart infusion pump and maintenance of patient safety by double checking of infusion set-up. The study was in the same line with *Douglass et al., (2018)* who studied "randomized controlled trial on the effect of a double check on the detection of medication errors" and

revealed that more than half of nurses had unsatisfactory practice regarding independent double check of high alert medication.

The study was also agreed with *Schutijse et al., (2018)* who studied “Nurse compliance with a protocol for safe injectable medication administration” and revealed that nearly half of their participants had inadequate practice regarding second check by another nurse. Conversely the study was disagreed with *Labib et al., (2018)* who studied “High alert medications administration errors in neonatal intensive care unit: A pediatric tertiary hospital experience” who revealed that nearly three quarters of studied nurses had satisfactory practice regarding setting the infusion rate according to instruction and also the study was disagreed with *Koyama et al., (2020)* who studied “Effectiveness of double checking to reduce medication administration errors” and revealed that majority of studied nurses had satisfactory practice regarding setting the infusion rate and performance of independent double checking.

The results of the present study also revealed that more than half of studied nurses had unsatisfactory practice regarding applying adhesive label to the IV tubing, standardizing infusion system communication by using adhesive labels with different colors to distinguish high alert medication lines from other infusions, the study was agreed with *van der Sluijs et al., (2019)* who studied “Reducing errors in the administration of medication with infusion pumps in the intensive care department” and revealed that about half of studied participants had inadequate practice regarding distinguishing the IV line of different medication types with different colors and labels.

The present study revealed that more than two thirds of studied nurses had unsatisfactory practice regarding clearly communicating the architecture of infusion setups during transitions of care (handover) between providers to avoid dose errors, from the researcher point of view, this could be due to work overload and shortage of nursing staff that results in lack of training on the importance of appropriate

communication of important patients' care practice. The study was supported by *Kirkendall et al., (2020)* who studied "Human-Based errors involving smart infusion pumps: a catalog of error types and prevention strategies" and revealed that nearly two thirds of their participants had unsatisfactory practice regarding adequate communicating of infusion setting between nurses in different shifts.

Concerning nurses' practice regarding post **administration phase** in smart infusion pump during, the results of the current study showed that nearly three quarters of studied nurses had unsatisfactory practice regarding notifying the physician of completing the infusion also the majority of them had unsatisfactory practice regarding continuous assessment of patients' condition for further adverse reaction. The study was supported by *Elsayed et al., (2020)* who studied "Nurses' Practical Knowledge about Neonatal Safety Using Intravenous Devices for Prevention of Medication Errors" and revealed that more than half of studied nurses had unsatisfactory practice

regarding post infusion notification or assessing post transfusion reaction.

Concerning documentation, the result of the present study revealed that more than half of nurses had inadequate practice regarding documentation of drug administered, dose, route and volume of drug administered, any problem appeared during infusion and any adverse reaction from medication administration. From the researcher point of view, this could be due to absence of written policy about appropriate documentation and the importance of communication in protection of both the nurse and child, also this could be due to work overload that results in omission of documentation of certain notes. The study was supported by *Melton et al., (2019)* who studied "Smart pumps improve medication safety but increase alert burden in neonatal care" and revealed that about half of nurses had unsatisfactory practice regarding documentation of medication administration. The study was also supported by *Blandford et al., (2020)* who studied "Intravenous infusion practices across England and their

impact on patient safety: a mixed-methods observational study” and revealed that nearly half of nurses had unsatisfactory practice and errors during documentation process.

Regarding total nurses' practice about smart infusion pump, the result of the present study revealed that, that the majority of studied nurses had incompetent total practice whenever, the minority of them had a competent total practice, From the researcher point of view, this could be related to poor theoretical knowledge, lack of experience, absence of clear written instructions about smart infusion pump and inadequate training and supervision. The study was supported by *El-sayed et al., (2019)* who revealed that more than half of their studied participants had unsatisfactory total practice regarding smart infusion pump. Also the study was congruent with *Schnock et al., (2017)* who studied “The frequency of intravenous medication administration errors related to smart infusion pumps: a multihospital observational study” and revealed that nearly two thirds of participants had unsatisfactory practice regarding SIP.

Regarding the relation between nurses' total knowledge and there demographic characteristics, the result of the present study revealed that there was statistically significant difference between nurses' total knowledge and their demographic characteristic in all items except for age there was a highly statistically significant difference, Pertaining to the relation between age and nurses' knowledge, the study showed that there was a highly statistically significant relation this could be related to nurses with younger age had more knowledge than those with older age as they are newly graduated and have fresh knowledge and more information also, they might read or have training on medication administration by using smart infusion pump for job catching also, there was statistically significant relation between nurses' educational level and nurses' knowledge which could be related to BSC nurses have a good knowledge level rather than diploma and technical nurses which could be related to that BSC nurses have years of studying more than diploma nurses' this make them able to acquire more knowledge

and the curriculum of the faculty of nursing students include more details and information than the curriculum of technical institute or diploma of nursing. The study was supported by **Giuliano & Blake, (2021)** who illustrated that there was statistically significant relation between participants total knowledge and their age and educational level.

Regarding the relation between years of experience and nurses' total knowledge, the current study illustrated that there was statistically significant relation, as nurses' knowledge increased with increasing years of experience and this could be attributed to that the majority of them acquired their knowledge from the practical field and from trial and error. The study was congruent with **Reeves et al., (2021)** who studied "Increasing Adherence of Pump Integration with Electronic Medical Record through Simulation" and illustrated that there were significant relation between studied participance total knowledge level and their educational level and years of experience.

Regarding the relation between nurses' total practice and their demographic characteristics, the results of the current study revealed that there were a highly statistically significant difference between nurses' total practice and age, from the researcher point of view, this might be due to older age nurses had more years of experience and possible acquire more training courses so that they had more competent practice also, there was significant relation between nurses' total practice and their educational level, from the researcher point of view, this could be interpreted that highly educated and faculty graduated nurses had more years of studying that allow them to acquire more knowledge from their curriculum and skills through their studying and training periods. The current study was similar to **Kim et al., (2020)** who studied "A new injection rate estimation technique for on-site screening test of medication infusion pump by nurses" and illustrated that there was significant relation between studied participants total practice and certain characteristics as age and educational qualifications as high

qualifications were associated with more competency skills during application of medication administration using SIP.

In addition, the results of the current study illustrated that there was statistically significant difference between nurses' total practice and years of experience, from the researcher point of view, this could be related to those long years of experience results in acquiring more skills and become more competent due to frequent exposure to medication administration using SIP in different situations. The study was supported by *Alrabadi et al., (2020)* who revealed that there was significant relation between nurses' total practice and their years of experience. Conversely the study was disagreed with *Elsayed et al., (2020)* who revealed that there was no statistically relation between nurses' demographic characteristics and their total practice level.

Regarding the correlation between total nurses' practice and their total knowledge, the results of the current study revealed that there was statistically significant correlation

between nurses' total knowledge and their total practice, from the researcher point of view, this might be related to that higher level of knowledge results in more competent practice based on the present knowledge also more knowledge results in increasing the nurses' perception regarding the importance of competent practice so that results on satisfactory practice on dealing with different situation and how to deal with medication error and alarms. The study was supported by *Blandford et al., (2020)* who studied "Intravenous infusion practices across England and their impact on patient safety: a mixed-methods observational study" and found that there was significant correlation between participants knowledge and practice. Moreover, the study was similar to *Elsayed et al., (2020)* who revealed that there was highly significant association between nurses' knowledge and their total practice regarding SIP.

Conclusion:

Based on the results of the present study, it can be concluded that, regarding nurses' total knowledge about smart infusion pump, more than three

quarters of studied nurses had unsatisfactory total knowledge regarding smart infusion pump whenever, about one quarter of them had a satisfactory total knowledge. In addition, the majority of studied nurses had incompetent total practice regarding smart infusion pump whenever, the minority of them had a competent total practice. Regarding the correlation between total nurses' knowledge and practice, the present study concluded that that there was statistically significant correlation between nurses' total knowledge and their total practice.

References :

- Brown, T.H., Michael, M. & Grady, D. (2018):** Implementation of Smart Pump Technology with Home Infusion Providers, an Assessment of Clinician Workflow and Patient Satisfaction, *Journal of Infusion Nursing*, Vol 41 No. (6), Pp: 344–349.
- Caroline Fonzo-Christe, C., Bochaton, N., Kiener, A., Rimensberger, P. & Bonnabry, P. (2020):** Incidence and Causes of Infusion Alarms in a Neonatal and Pediatric Intensive Care Unit: A Prospective Pilot Study, *The Journal of Pediatric Pharmacology and Therapeutics*, Vol 25 No (6), Pp: 500–506.
- DeLaurentis, P., Walroth, T. A., Fritschle, A. C., Yu, D., Hong, J. E., Yih, Y. & Fuller, J. (2019):** Stakeholder perceptions of smart infusion pumps and drug library updates: A multisite, interdisciplinary study. *American Journal of Health-System Pharmacy*, 76(17), 1281-1287. <https://doi.org/10.1093/ajhp/zxz135>.
- Douglass, A.M., Elder, J., Watson, R., Kallay, T., Kirsh, D., Robb, W.G., ... & Coil, C.J. (2018):** A randomized controlled trial on the effect of a double check on the detection of medication errors. *Annals of emergency medicine*, 71(1), 74-82.
- Elsayed, S., Abusaad, F. & Hashem, S., (2020):** Nurses' practical knowledge about neonatal safety using intravenous devices for prevention of medication errors. *International Journal of Novel Research in Healthcare and Nursing*, Vol. 7No (1), Pp: (375-384), Month: January www.noveltyjournals.com.

Ibarra-Pérez, R., Puértolas-Balint, F. & Lozano, A. (2020): The Third WHO Global Patient Safety Challenge: *Medication without Harm*. Available online: <http://www.who.int/patientsafety/medication-safety/en>. Group. NHS Injectable Medicines Guide, www.medusa.wales.nhs.uk.

Ibarra-Pérez, R., Puértolas-Balint, F., Lozano-Cruz, E., ZamoraGómez, S.E. & Castro-Pastrana, L.I. (2017): Intravenous administration errors intercepted by smart infusion technology in an adult intensive care unit, *Patient Safe Journal*; 17(6): 430-436. doi: 10.1097/PTS.0000000000000374.

Jani, H., Chumbley, M., Furniss, D., Blandford, A. & Franklin, B. (2020): The Potential Role of Smart Infusion Devices in Preventing or Contributing to Medication Administration Errors: A Descriptive Study of 2 Data Sets, *Journal of Patient Safe*. 1;17(8):e1894-e1900. doi: 10.1097/PTS.0000000000000751.

Jones, M., McGrogan, A., Raynor, D., Watson, M. & Franklin, M. (2020): NHS Injectable Medicines Guide