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Plan-Do-Check-Act Framework: Effects on Pediatric Students Nurses Compliance toward Using Intravenous Smart Pump

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Authors' contributions

This work was carried out in collaboration between both authors. Author NAA chose the research idea, state the significance of the problem, managed the literature review search and designed the study. Author NAAS managed the statistical analysis and helped in implementation of the study. Authors NAA and Author NAAS managed the intervention of the clinical practice and the analyses of the study. Both authors read and approved the final manuscript

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ABSTRACT

Background: Using Intravenous Smart Pump by pediatric nursing students has shaped the challenge of finding innovative ways to teach clinical skills. *The study aimed* to assess the effect of PDSA framework on pediatric nurses compliance in using smart pump technology for intravenous medication administration in the pediatric intensive care unit.
Design: A Quasi-Experimental quantitative, pre/post-test design was used to conduct the study. A purposive sample of 90 pediatric nursing students chosen based on the simple random sample for the academic year 2016– 2017, participated in the study.
Methods: Three tools were designed by the researchers to collect the necessary data to implement the Plan Do Study Act (PDSA) framework.
Statistical Analysis: The collected data were coded, analyzed and tabulated using frequencies and percentage, mean, standard deviation & chi-square tests.

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Results: There was a statistically significant difference and marked improvement in nurses students' total knowledge and skills levels of smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework) pre/post periods of assessment. It was observed that the majority of studied sample had good scores (100%, 97.8%, 97.8% & 93.3%) respectively post-intervention compared to (73.3%, 64.5%, 52.2%, 36.7%, 16.7%, 13.3%) pre-program and respectively ($p<0.01$).

Conclusion: Administration of intravenous therapy for neonates can be risky but when supported by the use of smart pump systems with proper programming, compliance nurses students and staff education by reporting, monitoring, it will be a valuable tool to avoid actually catastrophic damage related to medication and infusion errors.

Recommendation: Collaboration between health professionals is the key of successful implementation of smart infusion pump technology which can improve patient safety.

Keywords: Plan-Do-Check-Act; framework-effects; pediatric students Nurses; compliance; smart pump.

1. INTRODUCTION

In the neonatal intensive care unit (NICU), the neonates are considered one of the most susceptible group, to medication errors that can lead to overwhelming, life-threatening significance [1].

Smart infusion pumps can serve to maintain patient safety when administering intravenous drugs, where the flow rate needs to be closely monitored [2]. A smart pump is a computerized version of an integrated drug library. Each drug in the library has programmed concentrations, dosage units, and maximum and minimum infusion rates. It planned to double-check the programmed dose of a drug with the aim of preventing over- and under-dosage, respectively during medication or fluid infusion administration. In the Pediatric Intensive Care Unit, nurses' acceptance is growing experiences with these pumps but still facing challenges in implementation and dealing with technical performance issues [3].

In the health care setting compliance means the continuing development of consultation the authorized, ethical, and qualified standards applicable to a particular healthcare organization. Health care providers and administrations should change toward quality care practices, strategies, and measures to define attain professional standards, by training nurses staff and monitor their adherence to the standers' of care, and policies. Moreover compliance from governments, to assess the challenges facing staff and plan strategies to fill the gap based on best evidence practice [4].

Smart pumps and bar-code-assisted medication administration (BCMA) can support to decrease drug-dosing errors when it used correctly. Nurses using BCMA scan the child identification band and medication codes before handling medications. In one study, BCMA decreased wrong dosage errors by 90.4%, medication administration errors by 80.7%, and medications lacking prescriptions by 72.4% [5]. [6] studied the profits of using smart pumps in pediatric ICU setting. The results clarified that user safety software compliance was 78%. Using the smart pump device resulted in 92 cases of programming errors being interrupted; 84% of these medications were for pain, sedation, cardiac conditions, and infections. Smart pumps played an effective role in children safety.

Greatest medication error takes place in pediatric neonatal units. This challenges facing pediatric nurses because they can't control factors that increase the possibility of medication through 3 shifts on 24 hours per day. When planning how to prevent intravenous error, focusing on providing neonates-centered care is key because neonates are unique in their needs and venerable to adverse complication.

In the 1950s, W. Edwards Deming created a model known as the Plan Do Study Act (PDSA) cycle, is a four-step cycle that allows to implement change, solve problems, and continuously improve processes. Its cyclical nature allows it to be utilized in a continuous manner for ongoing improvement. He used this cycle as a model for change in an effort to promote continuous improvement and achieve top-quality results [7] and [8].

1.1 Significance of the Problem

Safeguarding the neonates in the pediatric intensive care unit during the intravenous medications administration process is a priority in the different pediatric settings. But achieving medication administration competence is a challenge facing to pediatric nursing students. Using Smart pumps will provide immediate benefit in helping to avert potentially serious and life-threatening medication errors. Because of this, the Plan Do Study Act (PDSA) framework is a great tool to use when assessing pediatric nurses students compliance in using smart pump technology for intravenous medication administration in pediatric intensive care and identify opportunities for best practice improvements.

1.2 Aim of the Study

The study aimed to assess the effect of PDSA framework on pediatric nurses compliance in using smart pump technology for intravenous medication administration in pediatric intensive care unit through:-

1. Assessing pediatric nurses students' knowledge, skills and adaptive behaviors in dealing with standard drug concentrations system with "smart-pump" technology on reducing reported medication-infusion errors
2. Developing and implementing a PDSA framework based on nurse students' needs.
3. Determine nurses students viewpoints about factors influencing intravenous and medication errors.
4. Evaluating the effect of PDSA framework on pediatric nurses' knowledge, skills, satisfaction and factors that promote compliance to safely administer intravenous medications using infusion smart pump2.

2. SUBJECTS AND METHODS

The study was carried out during the academic year within 10 months from September 2017 to June 2018.

2.1 Design

A Quasi-Experimental quantitative, pre/post-test design was used to conduct the study.

2.2 Setting

The study was conducted at the tertiary hospital, in Riyadh, Kingdom of Saudi Arabia.

2.3 Subjects

A purposive sample of 90 pediatric nursing students chosen based on the simple random sample for the academic year 2016– 2017, participated in the study during studying the pediatric course for two semesters. Faculty of Nursing, Princess Nourah bint Abdulrahman University. The students' nurses were in the age group ranged from 20 to less than 23 years.

2.4 The Inclusion Criteria were as Follows

Healthy students, attended regularly at faculty, studying same contents and posting to the same way of teaching and clinical training and willing to participate in the study according to their group rotation in pediatric intensive care units.

2.5 Tools of Data Collection

Three tools were designed by the researchers to collect the necessary data, which were:

I. A pre/post Plan Do Study Act (PDSA) Framework Interviewing Questionnaire:

This framework helped the students to improve skills and accomplish compliance using a plan for change. It was developed by the researchers in light of relevant references to determine the nurses' knowledge and practical problems. It was written in a simple Arabic language, its content validity was assessed and secured by 7 expert consultants from the pediatric nursing departments. The interviewing questionnaire includes 2 main parts:

Part 1: This part was used to gather demographic data such as age, grade, level of education, marital status.

Part 2: It is concerned with the four phases of framework which include:

Plan: Identify and analyze the problem or opportunity, develop hypotheses about what the issues may be, and decide which one to test.

Do: Test the potential solution, ideally on a small scale, and measure the results.
Check/Study: Study the result, measure effectiveness, and decide whether the hypothesis is supported or not.

Act: It concerned with implementation if the solution was successful.

A 22-item questionnaire, questions used to obtain information about the responsibilities and ethics, identification of hospital policy, child's identification bracelet. Verify patient's allergies with the chart, aseptic technique application, compliance with the 8 rights of medication administration (correct medication, route, time, patient ID, dosage, and documentation) operating smart pump….etc.

Part 3: Asked participants to identify factors that they had been perceived associated with their own medication errors, and measures to that motivate compliance with the protocol and ideas for strategies to reduce medication errors.

Questions were in the form of close- open-ended questions. Scoring system for nurse students' scores was as follows: > 75, Good; 50-70, Average; and < 50 Poor.

II. Observation Checklists (Pre/Post Format):

This was designed by the researchers to assess the actual nurses' performance related to:

Gather equipment. Following infection control measures, read the prescription chart and Check drug label (storage). Countercheck calculation of drugs, applying 8 right of medication administration, following the infection regulation when preparing the medication, confirming the prescribed infusion rate, scan the bar code on the package. Recheck the label with the MAR before taking them to the child, check child identification bracelet and chart for allergies. Hung IV fluids on the smart pump according to the manufacturer's directions. Program pump to the appropriate rate and begin infusion. Set alarm if recommended by the manufacturer. Place label on tubing appropriate date, assessing the IV site for the presence of inflammation or infiltration, check the rate of primary infusion and recorded the actual time of the administration and document the administration of the medication immediately. Evaluate the child response to medication and monitor IV site at periodic intervals, apply the label to tubing reflecting the day/date for next set change and Maintain interpersonal relationship, communication and responsibility.

The researchers allocated 10 marks for each procedures performance. They evaluated as follows:

- **Need practice** (scored 0) for a student who is unable to meet the full procedures steps probably.
- **Satisfactory** (scored 1) for a student who is addressing obstacles or constraints that are not immediately
- **Excellent** (scored 2) for a student who is able to perform all required steps correctly.

Tool 111: The Students Satisfaction about (PDSA) framework Post Application:

It was developed by the researchers to determine the students' satisfaction from implementation. It was analyzed using yes or no.

Content Validity: The validity of the framework tools was critically evaluated judgment by a experts panel of 7 pediatric nursing professors**.** Clarity of sentences, the simplicity of content, scope and purpose, accessibility and clinical significance were used to evaluate the framework. After rigorous revision by the experts, the tool and guidelines were finalized based on their recommendations.

Pilot Study: It was conducted on 10 nursing students to measure the clarity and practicability of the study tools. The pilot subjects were later excluded from the study sample. According to the pilot study results, the necessary modifications were done.

Administrative Design and Ethical Considerations:

Official permission was obtained from the Faculty Dean to conduct the study. Agreement to conduct the study was obtained from the Head of the Pediatric Care Units, also nursing students agreed to participate in the study was obtained. The aim of the study and procedures were explained to the students to attain their cooperation. They were informed about the threats and benefits, that their participation was entirely voluntary, their rights to drop out from the study at any time, or choose not to answer the

questions with no consequences on their academic achievements. Confidentiality of the information was ensured.

2.6 Procedures

2.6.1 Data collection: Plan-do-check-act framework was carried out on 3 phases namely

2.6.1.1 Assessment phase

The third-year nursing students of the BSc Nursing program who are studying pediatric course were approached while in ordinary lectures. They were randomly selected during studying the course. Students who were willing to participate through both semesters in the study completed the questionnaire of Plan-Do-Check-Act Framework in a private office through the interview. The students answered the questionnaire twice (before and after the implementation of the Framework). Researchers explained the objectives of the study and invited students to participate. Each student read and completed an informed consent form. They informed that their responses would be treated confidentially. Data were collected taking approximately 20 min for each student. All students voluntarily completed the questionnaires. During the assessment phase of Plan-Do-Check-Act Framework: The researchers specified two weeks at the beginning of each semester to collect data about the subjects by interviewing them from Sundays to Thursdays.

Plan: Means creating the objectives and processes necessary to deliver results in accordance with set requirements. Assessed the problems identified by students that affected their compliance with the existing hospital protocol for the checking and administration of medications operation using the smart pump. Analyzed the students needed to enhance the sense of responsibility, improve their knowledge and skills and development operating standards during administering intravenous infusion.

2.6.1.2 Implementation phase

The researchers allocated 12 weeks per each semester to cover both the theoretical and practical sessions of the pediatric course. The researchers allocated 10 students per each group. The researchers were keen to motivate the students 'performance and used reinforcement techniques as praise to enhance learning.

Do: Means implementing the planned frame-work: taking phases in controlling the students' settings of training.

At the faculty simulation laboratory, the researchers held PowerPoint lecture and video about the administration of intravenous infusion by using the smart pump for 1 hour to each group. Then start to collaborate with pump vendor to develop training material for students. The researchers informed them training schedule rollout for practical training. First orientation carried out for the student on the pump apparatus and provide knowledge of how to use the pumps. Assessed their perception of low risk for errors associated with IV medications, and the perception of extra time and work associated with pump programming. Determine approach of teaching methods which included multiple types such as class session which focusing on meaning of infusion pump, how to operate the device, the correct use of the safety software, aseptic technique and infusion and medication administration rights and calculation, and group discussions which emphasize on medication error ,the benefits of infusion pump in preventing medication errors were included in the plan , and online education for any interpretation . For practical training tools developed: Hands-on education on simulation device, demonstrations, and role play were used while the instruction media used were colored posters, tip sheets, frequently asked questions, PowerPoint presentations, and online modules. Each student was asked to complete the demonstration on smart infusion pumps and had access to a smart infusion pump device during the training session in the presence of researcher and constructive criticism was given for each student performance.

2.6.1.3 Evaluation of plan-do-check-act framework

Check: Means after implementing the planned processes, monitoring and evaluation of the processes and results against objectives and specific knowledge and skills are needed and a report of the obtained results. Evoked students attention using design challenge question is posed to promote a brainstorming session.

The researchers allocated 2 weeks to evaluate the effects of Plan-Do-Check-Act Framework on

pediatric nurses' compliance to safely administer intravenous medications using infusion smart pump using the same tools of assessment phase immediately after the model implementation.

Act: means concerned with the improvement regardless if the intervention was effective or not and modification needed. This step involves shaping the benefit of continuing training and change and enhance nurses compliance. [9] [7]. The researchers took the Students opinion and the satisfaction about the intervention and how to avoid medication errors.

2.7 Statistical Analysis

The collected data were coded, analyzed and tabulated using frequencies and percentage, mean, standard deviation & chi-square tests. Data entry and analysis were done by using statistical package for the social sciences (SPSS Version 20).

3. RESULTS

Data from (Fig. 1) Illustrates that mainly of students (42.2%) were working in pediatric Emergency Unit and 22.2% working in Pediatric Premature unit followed by 35.6%.of them were working in Pediatric intensive care Unit.

It was clear from Table 1 that there was a statistically significant difference and marked improvement in nurses students' total knowledge levels of smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework) during different periods of assessment. It was observed that the majority of the studied sample had good scores (100%, 97.8%, 97.8% & 93.3%) respectively post-intervention compared to (73.3%, 64.5%, 52.2%, 36.7%, 16.7%, & 13.3%) pre-program and respectively ($p<0.01$).

As displayed in (Table 2) there was a marked improvement in nurses students' total scores of skills level and statistical significant difference in compliance to smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework) .It is clear that the majority of students had excellent scores (100%, 92.2%, 97.8% & 88.9%) respectively post intervention compared to (37.8%, 30.0 %,25.5%, 23.3%, 20.0%, & 13.4%) pre-program and respectively ($p<0.01$).

Table 3 conveyed that majority pediatric nursing students' were satisfied and showed performance compliance after implementation of Plan Do Study Act (PDSA) framework where Students opinionative percentage ranged from (100.0% to 96%).

Concerning factors influencing intravenous and medication errors as accessible in (Table 4) that showed that majority of Students' (100.0%, 97.8%, 93.3% and 88.9%) respectively conveyed that poor doctor handwriting, shortage of nurses staff in relation to critically ill neonates, lack of training on medication calculation, lack of training on smart pump programming, congested environment in hospital, and work overload were the main factors that lead to infusion and medication error.

4. DISCUSSION

The study highlights the importance of preparing pediatric nurses' students for future responsibility and involvement in future performance and share in the reduction of drug and intravenous administration. Nurses students vigilance and continuous training of safety measures of using smart infusion pump are key factors for preventing medication and intravenous errors. As mentioned by [10] who stated that academic researchers should focus on nurses students during clinical training of medication rights to prevent medication errors and ensure patient safety.

The study aimed to assess the effect of PDSA framework on pediatric nurses students compliance in using smart pump technology for intravenous medication administration in pediatric intensive care units through assessing pediatric nurses students' knowledge, skills and compliance in dealing with the standard of drug concentrations system with "smart-pump" technology on reducing reported medication-infusion errors. On the other hand, investigate the barriers to successful implementation.

The first phase of the current study focused on the assessment of students' knowledge and practice in using the smart pump for intravenous and medication administration and compare the difference level before introducing them to the experience and after implementation of the framework. The assessment conveyed that students who lacked essential knowledge about using the smart pump of intravenous and medication administration before implementation

Table 1. Distribution of nurses knowledge level and compliance to smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework)

Items of smart pump intravenous administration	Pre N=90 knowledge level			Post N=90 knowledge level			Chi-square t & p-value
	Poor No %	Average No %	Good No %	Poor No %	Average No %	Good No %	
Responsibilities & Ethics	53 (58.9)	22(24.4)	15 (16.7)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Identification of hospital policy - Child's identification bracelet . Verify patient's allergies with chart	58 (64.5)	20 (22.2)	12(13.3)	0 (0.0)	6 (6.7)	84 (93.3)	<0.01
Aseptic technique application	15(16.7)	44(48.9)	31(34.4)	0 (0.0)	2(2.2)	88 (97.8)	<0.01
Medication 8 rights	10 (11.1)	33 (36.7)	47(52.2)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Calculating drug doses by using calculator and conversion of 1 gram to milligrams in the calculation of doses. Awareness of infusion equation	33 (36.7)	42(46.6)	15(16.7)	0 (0.0)	6 (6.7)	84 (93.3)	<0.01
Controlled Drugs Theory	14 (15.5)	18 (20.0)	58(64.5)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Checking by two nurses for high -risk drugs Drug incompatibilities Reporting. Wearing signs	22 (24.4)	66(73.3)	12(13.3)	8 (8.9)	0 (0.0)	90 (100)	<0.01
Shock- medication errors Infusion pump program	75(83.3)	15(16.7)	0 (0.0)	0 (0.0)	2(2.2)	88 (97.8)	<0.01
Switching on the infusion ,regulating values and starting infusion adjusting infusion rate while infusion is active 1and2 ,saving diagnostic information, administration of an infusion is active Stopping and switching off the infusion							
Child Assessment before giving medication	8 (8.9)	16 (17.8)	66(73.3)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Monitor child condition before, during and after medication	0 (0.0)	23 (25.6)	67 (74.4)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Disposal of sharps	5 (5.5)	70(77.8)	15(16.7)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Assess the effectiveness of medication in achieving outcomes	3 (3.3)	73 (81.1)	14 (15.6)	0 (0.0)	0 (0.0)	90 (100)	<0.01
Documentation and reporting	32(35.5)	25 (27.8)	33(36.7)	0 (0.0)	0 (0.0)	90 (100)	<0.01

Table 2. Distribution of nurses skills level and compliance to smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework)

Steps	Pre N=90			Post N=90			Chi-square & p-value
	Need practice	Satisfactory	Excellent	Need practice	Satisfactory	Excellent	
Gather equipment. Read the prescription chart. Check the drug label (storage).Countercheck calculation of drugs. Apply 8 right of medication administration. Follow the infection regulation when preparing the medication.	15(16.7)	63 (70.0)	12(13.3)	3(3.3)	7(7.8)	80(88.9)	*<0.01*
Confirm the prescribed infusion rate. Scan the bar code on the package. Recheck the label with the MAR before taking them to the child. Check child identification bracelet and chart for allergies.	22(24.4)	50(55.6)	18(20.0)	0 (0.0)	7(7.8)	83 (92.2)	*<0.01*
Hung IV fluids on the smart pump according to the manufacturer's directions. Program pump to the appropriate rate and begin infusion. Set alarm if recommended by the manufacturer. Place label on tubing appropriate date.	63(70.0)	27(30.0)	0(0.0)	3(3.3)	7(7.8)	80(88.9)	*<0.01*
Assess the IV site for the presence of inflammation or infiltration.	18(20.0)	45(50.0)	27(30.0)	0 (0.0)	7(7.8)	83 (92.2)	*<0.01*
Check the rate of primary infusion and recorded the actual time of the administration.	5(5.6)	62(68.9)	23(25.5)	0 (0.0)	0 (0.0)	90(100.0)	*<0.01*
Document the administration of the medication immediately	2(2.2)	54(60.0)	34(37.8)	0 (0.0)	0 (0.0)	90(100.0)	*<0.01*
Evaluate the child response to medication, and monitor IV site at periodic intervals	6(6.7)	63(70.0)	21(23.3)	0 (0.0)	0 (0.0)	90(100.0)	*<0.01*
Apply label to tubing reflecting the day/date for next set change.	3(3.3)	75(83.3)	12(13.4)	0 (0.0)	0 (0.0)	90(100.0)	*<0.01*
Maintain interpersonal relationship, communication and responsibility	22 (24.5)	48(53.3)	20(22.2)	0 (0.0)	0 (0.0)	90(100.0)	*<0.01*

Table 3. Pediatric nursing students' satisfaction and compliance after implementation of plan do study act (PDSA) framework (n=90)

Students opinionative	%
Usefulness for future nursing performance in my workplace	98.0
The objectives of the simulation session at faculty laboratory were Clear	100.0
Clearness of objectives of the simulation session	99.0
Task training at faculty laboratory before real situation practice was Usefulness	99.0
Getting essential knowledge before, during and after training	99.0
Accepting constructive feedback after the training session	99.0
Confident in nursing intervention for infusion administration	96.0
Identifying my weakness and strength during training	100.0
Oriented to methods for drugs and infusions calculations and became vigilant when preparing medications.	96.0
Identifying signs of shock	99.0
Knowing what to do for problem - solving	98.0
Receiving constructive feedback after simulation session	100.0
Identifying the process of operating the pump that will be valuable for future nursing performance in my workstation	99.0
Implementing nursing skills as hospital protocol	100.0
Time for simulation session was enough to be proficient in medication and intravenous administration	90.0
Usefulness of orientation before training	100.0
Providing nursing cares during infusion administration in a calm and confident manner	100.0
Monitor the child's condition before, during and after intravenous administration and react appropriately to cases of unsafe practice	100.0
proficient in recording and documentation	100.0
Confidence in applying pharmacology knowledge in practice	96.0
Ability to communicate effectively with individuals of the health care team	100.0
Ability to assess the effectiveness of medication in achieving outcomes	96.0
Overall satisfaction	99.0

was improved and became more aware of the operating process of the smart pump after implementation. This was clear from the Table 1 that highlighted a highly significant difference in nursing students knowledge before and after implementation of the framework concerning using of a smart pump, where majority (100%, 92.2%, 97.8%, & 88.9%) respectively of them got excellent level of knowledge and manifest upgrading compliance to smart pump intravenous administration (Pre and Post Plan Do Study Act (PDSA) framework). As declared by [11] who definite that nursing student s curriculum could play a vital role in preparing the student for practice and patient safety outcomes by increasing their awareness and considerate of the factors associated with medication errors . This in agreement with [12] who mentioned that supplying today's nursing students with technologically is crucial to saving patients' lives than old-style teaching of didactic lectures combined with skills training. As well as [13] who advise exchanging our learner-centered educational toward competency education.

In the beginning, lacked of students' knowledge and the experience was the main challenge facing the researchers but after providing them with knowledge and a comprehensive demonstration of the simulation practice helped in transferring knowledge to practice Additionally, the researchers used faculty simulation laboratory to explore student behaviors during training that could translate to the clinical setting. In fact, the researchers supported the student and maintain a conducive learning environment with measures of a new technology of smart pump the process as a method of administering intravenous infusion through simulation, group discussion and brainstorming, and encouraging the students to be familiarized with using an electronic application. After implementation, the students became satisfied with the new experience and mentioned on how real the simulations seemed and how they developed proficient skill and let them more confident and compliance for real clinical performance. Where students achievement for self-efficacy and knowledge related to quality and safety

Table 4. Pediatric nursing students' viewpoints about factors influencing intravenous and medication errors

Student viewpoints	No	Yes
	Number percentage	Number percentage
Poor communication between the health care team	10 (11.1)	80 (88.9)
Poor doctor handwriting	0 (0.00)	90 (100.0)
Shortage of nurses staff in relation to critically ill neonates	0 (0.00)	90 (100.0)
Lack of the source of pharmacological information in the ward	2 (2.2)	88 (97.8)
Lack of training on medication calculation	0 (0.00)	90 (100.0)
Continuous blaming by head nurse for reporting medication errors	10 (11.1)	80 (88.9)
Lack of training on smart pump programming	0 (0.00)	90 (100.0)
Working in an educational hospital let the environment congested with more students(Noise, heavy traffic)	0 (0.00)	90 (100.0)
Students mentioned that language and cultural variation was the main barriers	6 (66.7)	84 (93.3)
Lack of recording and reporting system for medication errors	0 (0.00)	90 (100.0)
The lack of monitoring of the care during the intravenous administration process	6 (66.7)	84 (93.3)
The use of doctors abbreviations instead of the full name of drugs	0 (0.00)	90 (100.0)
Lack of attention to double check for the dose of a drug on the medicine card	6 (66.7)	84 (93.3)
The similarity in the name of drugs , shape ,and lack of attention to the label of drugs	0 (0.00)	90 (100.0)
Nurses continuously busy with different routine in the neonatal unit plus the concentration of infusion pump	0 (0.00)	90 (100.0)
Lack of familiarity with the process of operating the infusion pump	0 (0.00)	90 (100.0)
Many new admission at the same time	0 (0.00)	90 (100.0)

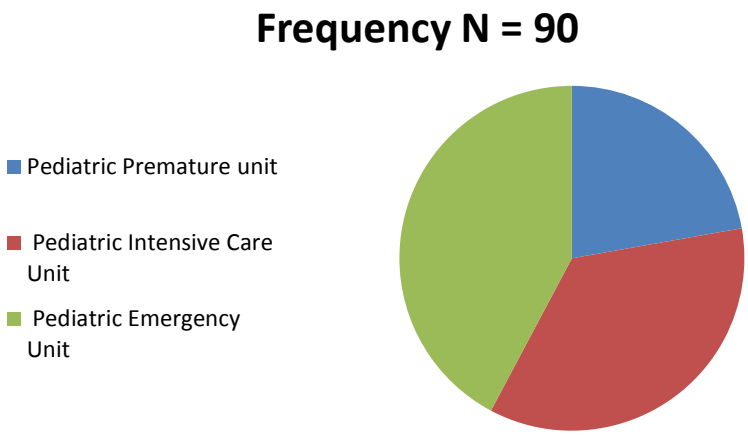

Fig. 1. Pediatric nursing students rotation distribution

competencies skill is often accomplished at different rates students. This was evident from the Table 2 that illustrated a high percentage of use of safety software in our study (92%) of success and compliance .This is corresponding with [14] and [15] who mentioned that infusions administration by using smart pumps with the drug library program is the key of success in preventing programming errors from reaching patients and compliance with the technology implementation was 92% and user acceptance was high. This also was in agreements was [16] who stated that student training achievements using role-play simulation play an important role in developing critical thinking skills and experience.

The present study sheds light on the importance of integration a compulsory medication safety course in our undergraduate nursing program to raising students' awareness of the factors associated with medication errors and their prevention and the importance of their vital roles as a future healthcare professional involved in the medication cycle. In the same stream with [17] who conveyed that analysis of 47 studies recommended a vital role of educational interventions program in improving students and clinician behavior with improved adherence to guidelines of medication administration rights.

Alongside the development of using the smart pump during training in clinical the three settings in (The Pediatric Emergency Unit, Pediatric Premature Unit and Pediatric Intensive Care), the researchers asked nursing students to maintain proper communication with the health care team and seek clarification when mistakes arise. Moreover encouraging them to monitor registered nurse role in the medication cycle practice, to increase their awareness of their compliance for future responsibilities in the medication cycle. This is the same line of [18] [11] who emphasized that targeted teaching strategies by using case studies and a series of short videos that helping in representing the system factors associated with medication errors and their prevention besides, aiding the nurses students in consolidating learning concepts on medication calculation competency and under-standing the roles of the health care professionals involved in the medication cycle.

Moreover, the current study proved the statistically significant differences regarding nurses students perception of the increased level of neonates safety provided after implementation. Students satisfaction was already high after implementation as displayed in the Table 3 where the majority (100%, 98, and 96%) respectively of students were agreed that the implementation of (PDSA) framework was beneficial. This viewpoint in agreement with [19] who revealed that clinicians and nurses proper technology innovations clinical training helping them to operate the IV smart pumps in a more time-efficient manner and make fewer use errors and maintain patients safety. In the present study, the students stated that training heightened their self-esteem consequently increase their self- confidence and decrease apprehension about making medication err ors, and day by day they became smarter in providing safe neonatal care. Moreover, [20,21,22] who informed that endorsing undergraduate students realistic teaching strategies could play a vital role in transferring handy quality and efficiency skills experiences to the clinical environment and meet the burdens of professional practice that overcome challenges facing all healthcare.

The present study sheds light on the main causes of the factors associated with intravenous and medication errors as displayed in the Table 4. The majority (100.0%) of students reported that the situation appears complex and they agreed that poor doctor handwriting, shortage of nurses staff in relation to critically ill neonates, lack of training on medication calculation, lack of training on smart pump programming, lack of recording and reporting system for medication errors, the use of doctors abbreviations instead of full name of drugs, nurses continuously busy with different routine in neonatal unit plus the concentration of infusion pump and nurses continuously busy with different routine in the neonatal unit plus the concentration of infusion pump are main causes of errors. It is imperative that nurses students should receive effective training in keeping children safe and preventing medication errors. From the all mentioned factors, it was clear that to manage the intravenous and medication errors, and to maximizing the benefits of smart pumps this are in need of collaborative approach and cooperation between all health team members and continuous training of users on smart pump technology to enhance children safety and reduce potential adverse drug events. This reported by [23] and [19] who stated that the main causes of IV smart pump errors include

overriding dose error alerts and, the complexity of the device user interface, the time required to program, lack of proficiency in using the infusion pumps. To overcome the problem of medication and intravenous errors and maintain brilliance nursing care for children safety .In the same stream [24] and [25] who advised that the hospital supportive practice environment including health team proper relation between hospital staff and students play a vital role in enhancing students ongoing training chances to contribute in decision making and children care. Besides the maintenance of nurse administrators who are evident and available, who listen to nurses' concerns to decrease their worries about new tasks achievements.

Finally, the use of smart pump technology has the potential to minimize the risk of error by providing safety measures before medication is administered. Nurses students are in needs for continuous monitoring to increase participation while enhancing retention of the knowledge and skills obtained during the training sessions. In addition to crucial environmental conditions that encouraging safe medication practices via a smart pump, and to be vigilant when administering medications to reduce the high error rate.

5. CONCLUSION

Administration of intravenous therapy for neonates can be risky but when supported by the use of smart pump systems with proper programming, compliance nurses students and staff education by reporting, monitoring, it will be a valuable tool to avoid actually catastrophic damage related to medication and infusion errors. Moreover, the key to compliance of neonates safety and success in administering smart infusion systems journey requires attention from academic educators to ongoing training for nurses students and commitment to continuous safety risk assessments.

6. RECOMMENDATION

Based on the results of this study, it recommended the following:

- Collaboration between health professionals is the key to successful implementation of smart infusion pump technology which can improve patient safety
- Raising the awareness of pediatric nurses students in pediatric intensive care units and about the efficient lines of communication that allow them to report compliance concerns without retaliation, including the ability to anonymously report concerns and complaints
- Academics educators should be a commitment to provide ongoing education and monitoring nurses students compliance and behavioral factors associated with the effective use of technology.
- Further research is needed to explore the transferability of knowledge and clinical skill competency across different practice settings including simulated clinical learning environments.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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