Effect of Simulation-Based Training on Nurses' Performance about Procedural Pain Management of Neonates' Heel-Sampling

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Abstract

Background: The heel stick is now the most common way to draw a neonate's blood for neonate screening tests and is usually done within 3 to 7 days after birth. Simulation-based training serves as a link between classroom learning and clinical practice. It aids nursing competency before working with neonates in a real-life environment, hence improving the quality of care and ensuring neonates' safety. **This study aimed to** evaluate the effect of simulation-based training on nurses' performance in procedural pain management of neonates' heel sampling. **Method**: To achieve the aim of this study, a quasi-experimental design (one group pre/ post-test design) was used. **Setting**: The study was conducted in the Neonatal Intensive Care Unit affiliated with Mansoura University Hospital. **Subjects**: A convenience sample composed of 50 neonatal nurses regardless of their age, gender, qualifications, and experiences, who were working at the previously mentioned settings. Also, all available neonates comprised 50 undergoing heel stick puncture regardless of their gestational age, gender, and birth weight during the research period. Tools for data collection: Tool I: A Structured Interviewing Questionnaire, Tool II: Observational Checklists, Tool III. Neonatal Infant Pain Scale was used to collect data. **Results**: There was a highly statistically significant difference between the studied nurses' knowledge and practice. The study result revealed that more than two-thirds of the studied nurses had a poor level of knowledge, and more than half of the nurses had an incompetent level of practice about neonates' heel sampling before implementing the simulation-based training. The vast majority of the studied nurses had a good level of knowledge and most of them had a competent level of practice after implementing simulation-based training. There was a highly statistically significant difference and improvement in nurses' performance after simulation-based training than pre-training. **Conclusion:** The present study concluded that simulation-based training had a positive effect on improving nurses' performance regarding procedural pain management of neonates' heel sampling. **Recommendations:** The study recommended that simulation-based training should be integrated as an effective method in nurses' training about neonates' heel sampling.

Introduction

These days, within three to seven days of birth, the heel stick is the most popular method for taking a newborn's blood for neonatal screening tests. According to **Goto et al. (2020),** the heel stick is used to detect specific diseases such as sickle cell disease, galactosemia, hypothyroidism, and phenylketonuria. Heel stick procedures hurt and may affect the newborns negatively. Serious consequences may arise from newborn pain, especially if the discomfort is prolonged and can alter behavior, cognition, and physiology. Further evidence of lower heart rate and oxygen consumption, irregular breathing, hormonal and metabolic issues, and altered facial expressions in neonates in pain has been demonstrated (**Ayede, 2020**).

With specialized training, expertise, and understanding of the care of newborns and their families, neonatal nurses are professionals. Neonatals are living longer in Neonatal Intensive Care Units (NICUs) thanks to advances in science and technology (**Franck et al., 2020**). But a lot of negative things have happened as a result of things like the necessity for more invasive procedures and technology, the constant demand for light, background noise, and the need for excessive manipulation when providing treatment. These impacts therefore cause modifications in newborns' development, particularly in preterm neonates (**Alebel et al., 2020**).

Heel stick procedures hurt and may affect the newborns negatively. Serious consequences may arise from newborn pain, especially if the discomfort is prolonged and can alter behavior, cognition, and physiology. Further evidence of lower heart rate and oxygen consumption, irregular breathing, hormonal and metabolic issues, and altered facial expressions in neonates in pain has been demonstrated (**Ayede, 2020).**

Heel sampling is a painful procedure often performed for various purposes, and causes the baby's foot may have persistent adverse effects on infants' pain processing and stress response. Using vibration within a safe level with a vibrator is used to relieve pain in adults and pediatric populations, but its use has been less studied in infants. Melzack and Wall first proposed the

gate control theory in 1965, expressing the analgesic effect of vibration on perceived pain. According to this theory, vibration stimuli compete with the transmission of pain impulses in the spinal cord-thalamic pathway, hypothesizing that infants are less likely to perceive pain (**Nimbalkar et al., 2020).**

Neuro-developmental outcomes are harmed by inadequate pain treatment in neonates. Beyond early infancy, it modifies physiological reactions, pain thresholds, and behavior associated with stress or pain. Pain management in newborns should therefore be considered an integral element of standard medical and nursing treatment rather than being motivated by ethics or empathy. Development and validation of novel treatment methods, encompassing both pharmaceutical and nonpharmacological approaches, will be crucial (**Forest & Harris-Haman, 2022**). Numerous non-pharmacological methods of managing pain are effective; these include oral sucrose/glucose, breastfeeding, non-nutritive sucking (NNS), kangaroo mother care/skin-to-skin care, nesting, heel worming, touch, massage, music therapy, and swaddling during heel sticks. These methods help manage pain without the use of pharmaceuticals for neonates (**Nimbalkar et al., 2020**).

The calcaneus bone and other foot components may be harmed by an incorrect heel-stick method. Some newspapers have noted that walking becomes more difficult as people age. Heel stick exercises are safe as long as they are limited to the medial and lateral planter aspects of each heel pad, i.e., medial to a visual line drawn from the middle of the big toe and extending posteriorly to the heel, or lateral to a line drawn from between the fourth and fifth toes and extending posteriorly to the heel. Bruising, erythema, or recurrent punctures restrict the area that can be penetrated. This is especially true for babies born prematurely, whose tiny heels may need many blood draws (**Shayani & Marães 2022).**

Role-playing, lifelike virtual environments, competent individuals, pediatric patient simulators, and other resources are all used in nursing simulation-based clinical training, which goes beyond the simple handling of mannequins. According to the National Council of State Boards of Nursing (NCSBN), clinical simulation is now considered essential to nursing education. It is described as "an activity or event replicating clinical practice using scenarios, high-fidelity manikins, medium-fidelity manikins, standardized patients, role-playing, skills stations, and computer-based critical thinking simulations" (**AbdElbaky, 2018**).

Numerous advantages come with simulation-based training, such as the capacity to personalize instruction, modify the degree of difficulty, provide prompt feedback, and enable repeated practice. However, the study discovers that opportunities to practice nursing skills on real patients are typically limited for undergraduate degrees (**Alexander et al., 2015**).

Significance of the study

Reducing pain is crucial not only as a matter of ethics but also because experiencing pain repeatedly might have negative effects. When a newborn is having a heel stick puncture, nurses are crucial to the care team. Using techniques including swaddling, sucrose administration, nesting, nonnutritive sucking, and foot massage, nurses should assess, care for, and control the pain of newborns after heel stick punctures. Therefore, it is essential to improve the knowledge, skills, and attitudes of nurses. Clinical education using the simulation of this reality could potentially affect the competency of freshly trained healthcare staff particularly nurses, decreasing the risk of errors and enhancing patient safety (Goto et al., 2020).

The aim of the study

This study aimed to evaluate the effect of simulation-based training on nurses' performance in procedural pain management of neonates' heel-sampling

Operational definition

Nurses' Performance: included nurses' knowledge and practices

Research hypothesis

Simulation-based training is expected to have a positive effect on improving nurses' performance in procedural pain management of neonates' heel-sampling

Subjects and Methods

To achieve the aim of this study, a quasi-experimental design (one group pre/ post-test design) was used.

Setting

The current study was carried out at the Neonatal Intensive Care Unit in Mansoura University Hospital. The neonatal intensive care unit (NICU) contains six rooms divided as follows: three rooms for critical care cases, one for ordinary care cases, and one for preparing medications and nutrition. The last room is under the maintenance and repairs. Each room that receives critical care cases accommodates six incubators, and each nurse takes care of two neonates,

while the room for ordinary care cases accommodates four cases who are cared for by one nurse.

Subjects

A convenience sample composed of 50 neonatal nurses regardless of their age, gender, qualifications, and experiences, who were working at the previously mentioned settings, and agreed to participate in the study. Also, all available neonates comprised 50 undergoing heel sticks regardless of their gestational age, gender, and birth weight during the research period.

Tools of Data Collection

Three tools were used to collect data

Tool I: A Structured Interviewing Questionnaire: It was designed by the researchers after reviewing related literature **Alburaey et al., (2020); Adam et al., (2020); Mohamed et al., (2018**). It had the following three parts:

Part 1- Personal Characteristics of the studied nurses: It included five questions (age, gender, qualifications, years of experience, training courses).

Part 2- Personal Characteristics and medical history of the neonates, that was included six questions (gestational age, gender, birth weight, mode of delivery, medical diagnosis, and duration of hospital stay).

Part 3- Nurses' knowledge regarding pain related to heel sampling. It was composed of yes-or-no and multiple-choice questions that were closed-ended. The examination consisted of thirty-one questions covering the items of; the definition of heel sampling, heel stick puncture causes, heel sampling times per week, heel sampling sites, heel sampling complications, nurse's role during heel sampling, pharmaceutical, and non-pharmacological pain management techniques, advantages of using non-pharmacological techniques such as kangaroo position, warm compresses, swaddling, nesting, neonatal massage, and sucrose administration. The answers provided by the nurses were classified as satisfactory knowledge if scores exceed 75%, and Unsatisfactory knowledge when the scores fall below 75%.

Tool II. Observational Checklists: The observational checklists were adopted from Anand et al., (2017) and Yilmaz & Inal (2020). It served as an evaluation tool for nurses' procedural pain control methods when it came to heel-sampling newborns. The observational checklists comprised six procedures: the eight-step kangaroo care method, the eight-step swaddling procedure, the eight-step nesting procedure, the 12-step neonatal massage procedure, and the seven-step sucrose administration procedure. Throughout their real work shifts, nurses were observed and their practices were assessed; a practice was deemed competent if it received a score of 85% and above, and incompetent if it received a score of less than 85%.

Tool III. Neonatal Infant Pain Scale (NIPS): It was adopted from Chen et al., (2020), It employed non-pharmacological pain treatment to measure the level of pain experienced by newborns during heel stick punctures. Both full-term and preterm infants can be treated with the behavioral neonatal infant pain scale. The instrument was utilized to evaluate the actions that nurses have identified as suggestive of pain in infants. It is made up of eight indicators: oxygen saturation, heart rate, state of alertness, breathing patterns, arm and leg movements, facial expression, and crying. The NIPS pain scale is as follows: (0–2) for no to mild pain, (>4) for mild to moderate pain, and for severe pain (>4).

Field Work

The actual fieldwork for data collection took place over six months, starting in May 2023 and ending in October 2023. The researchers began by introducing themselves, outlining the purpose and design of the study, and getting a sense of the nurses' expectations. Two days a week, the researchers were on duty in the study setting alternating between them during the morning and afternoon shifts, when they observed the newborns that required heel stick punctures. About 25 to 30 minutes were needed to complete the questionnaire, and 30 minutes were needed to complete the observational checklists.

Data was collected through the following faces

I-Preparatory phase

-Before beginning the study, the Mansoura University Faculty of Nursing's ethics committee gave its approval.

-Official permission for data collection was obtained from the responsible authorities of the study setting after an explanation of the study objective.

-A group of five academics with extensive experience in the field of pediatric nursing examined the tools for content validity, and no revisions were made.

-The Cronbach's alpha test was used to assess the reliability of tools two and three which was 0.89.

Ethical Considerations

The research approval was obtained from the Scientific Researcher Ethical Committee, Faculty of Nursing at Mansoura University before starting the study. Before beginning the research, formal approval was sought

from the directors of the previously listed settings as well as the dean of the nursing faculty. The study was conducted with strict confidentiality maintained. Everyone who works with nurses was given the assurance that their information would only be used for research, and they were all made aware of their freedom to leave the study at any time, for any reason.

Pilot study

A pilot study was conducted on 10% of the total sample size (5 nurses) and (5 neonates) based on sample criteria to test the feasibility and applicability of the tools to assess the time required to fulfill the tools and find out the possible obstacles and problems that might face the researcher and interfere with data collection. No modifications were made according to the results of the pilot study. Subjects included in the pilot study were included in the study sample.

II-Implementation phase

- The study was submitted for the approval of the ethical committee of the research

- Formal administrative approval from the setting was obtained before the commencement of this project.

- "After the assessment phase was over, the researchers used the information gathered from the assessment phase to construct the educational program based on the needs of the previously evaluated nurses. It was created to update and enhance nurses' understanding of procedural pain management for newborns undergoing needle heel-prick blood sampling.

- "Two theoretical sessions were used to deliver the theoretical content, which included information on newborn heel samples, kangaroo care, swaddling, nesting, infant massage, and sucrose administration. Each 45-minute session was held.

- Through three simulations related to six procedures; neonatal heel sampling, kangaroo care method, swaddling, nesting procedure, neonatal massage, and sucrose administration the implementation of simulation-based training was intended to improve nurses' performance regarding procedural Pain Management of Neonates' Heel Sampling. Every simulation lasted between thirty and forty-five minutes.

-The researchers solicited input regarding the preceding session at the start of each new session, and they concluded each one with a summary.

- Depending on their scheduled attendance, the examined nurses were divided into subgroups of variable numbers (6–8).

- After analyzing the relevant literature and determining the true needs of the nurses under study, a simplified booklet covering all topics related to procedural pain management of newborns through heel sampling was provided to nurses in Arabic as support material.

- A variety of instructional techniques, including lectures, discussions in small groups, brainstorming, drawings, demonstrations, and re-demonstration using the required tools and a simulation manikin that was supplied by a hospital teaching class faculty clinical lab to apply for a simulated education program.

- Handouts, PowerPoint, figures, flipcharts, and illustrated videos were used as teaching tools to teach neonates undergoing heel sampling about procedural pain management. The practical procedures included researchers demonstrating the heel stick puncture procedure (10 steps), kangaroo care (8 steps), swaddling (8 steps), nesting (8 steps), neonatal massage (12 steps), and administering sucrose. The clinical demonstration and re-demonstration of the study nurses on the procedural pain management of infants during heel sampling was part of these sessions.

Evaluation phase

The researchers reassessed the effect of simulation-based training on nurses' performance in procedural pain management of neonates during heel-sampling post one month using the same pretest tools.

Statistical analysis

Data were translated, coded, and tabulated into a form that was specifically created to be input into a computer. SPSS version 22 was utilized for data entry and analysis. The Excel program was used to help make the graphics. The same group's pretest and posttest results were compared using t-tests, which were used to analyze quantitative data presented as mean and SD. Quantitative data was expressed as numbers and percentages. Pearson correlation was used to explain the link between quantitative variables that were normally distributed. Using a P-value of 0.05, the significance was ascertained as follows:

- A P-value less than 0.05 was considered to be statistically significant.

- A P-value less than or equal to 0.001 was considered to be highly statistically significant.

Results

Table (1) demonstrates that, with a mean age of 24.8 ± 4.9 years, (62%) of the nurses under study were over 25, and that, by far, the majority of them were female. Sixty-six percent of the nurses in the study had training from the Technical Institute of Nursing. Of those with years of experience, 48% had between five and fewer than ten years.

Figure (1) illustrates that 90% of the nurses under study did not participate in a simulation-based training program for procedural pain management during heel sampling in neonates.

According to **Table (2),** 76% of the neonates were boys, 68.0% had gestational ages less than 37 weeks, and 56% weighed between 2 and more kg when they were admitted. In addition, 66% of the newborns had RDS, 50% required a hospital stay of one week, and 86% of them were delivered via cesarean section.

Figure (2) presents an improvement in nurses' knowledge regarding heel sampling in neonates, with a highly statistically significant difference observed between pre- and post-training one month of simulation-based training ($P<0.001$). It proves that, before receiving the simulation-based training, 85% of nurses' expertise on the newborns' heel-sampling was unsatisfactory. However, after a month of implementing simulation-based training, their level of knowledge increased to a satisfactory level (90%) because of the training.

Table (3) indicates an improvement in nurses' practice regarding heel sampling of neonates when compared before and after a month of implementation of simulation-based training ($P<0.001$).

Figure (3) shows that before receiving simulation-based training, 76% of nurses had an incompetent practice level for heel-sampling of neonates. However, after a month of implementing simulation-based training, their level of practice increased to a competent level (88%) as a result of the training.

Figure (4) portrays the improvement in the pain level of newborns before and after a month of simulation-based instruction regarding heel sampling. Additionally, shows that after the newborns' heel sampling and before getting the simulation-based training, 36% of them experienced severe pain. However, after a month of implementing simulation-based training, everyone's degree of suffering decreased to the point that nobody was experiencing severe pain.

Table (4) illustrates that, following simulation-based training on the heel-sampling process for neonates, nurses' knowledge, practice, and neonatal discomfort were positively correlated, with a p-value of less than 0.001. Knowledge and practice had substantial positive relationships ($r = 0.447$, $p < 0.001$), as did knowledge and neonatal pain ($r = 0.223$, $p < 0.001$) and practice and neonatal pain ($r = 0.222$, $p < 0.001$), according to correlation analysis. This finding supports the notion that pain, practice, and knowledge are positively correlated.

Table (1): The studied nurse's distribution regarding their characteristics (n. =50)

Demographic characteristics	No.	%
Age (Years)		
<25 years	31	62.0
25 - ≥ 36 years	19	38.0
Mean ± SD	**24.8 ± 4.9**	
Gender		
Male	10	20.0
Female	40	80.0
Qualifications		
Technical Institute of Nursing	33	66.0
Baccalaureate degree in nursing	17	34.0
Years of experience		
<5 years	15	30.0
5 – <10 years	23	48.0
10 - ≥15 years	12	22.0

Figure (1): The studied nurses' distribution regarding their attendance training course about simulation-based training about procedural pain management of neonates' heel-sampling (n. =50)
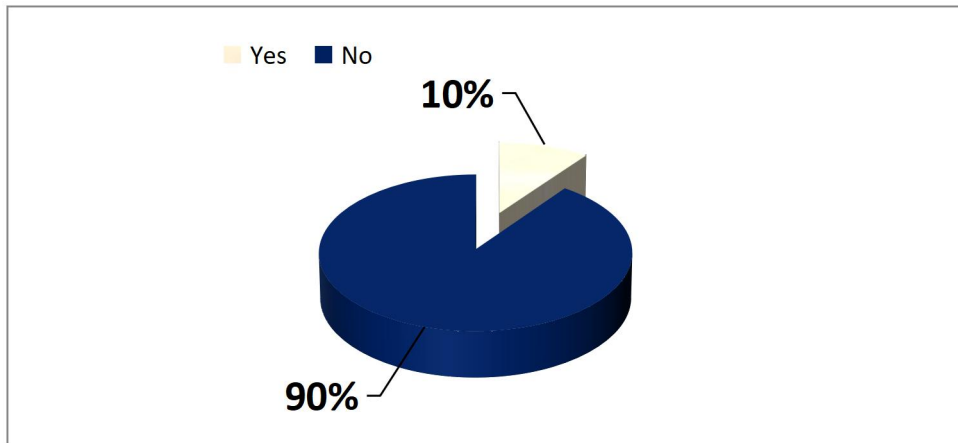

Table (2): The studied Neonates Distribution regarding their Characteristics and Medical History (n=50).

Neonates' Characteristics	No	%
Gestational age (weeks)		
< 37	**34**	**68.0**
37: < 38	16	32.0
Gender		
Boys	**38**	**76.0**
Girls	12	24.0
Weight (Kg)		
1: < 2	22	44.0
2: > 3	**28**	**56.0**
Mode of delivery		
Cesarean section	43	**86.0**
Normal vaginal delivery	7	14.0
Diagnosis		
RDS	33	**66.0**
Hyperbilirubinemia	6	12.0
Preterm	5	10.0
Congenital anomalies	4	8.0
Neonatal sepsis	2	**4.0**
Hospital stay/week		
< One week	5	10.0
One	25	**50.0**
Two	11	22.0
Three	4	8.0
Four	5	10.0

Figure (2): Percentage distribution of the studied nurses' level of knowledge regarding procedural pain management of neonates' heel-sampling pre and post-one-month post-simulation-based training implementation (n=50)
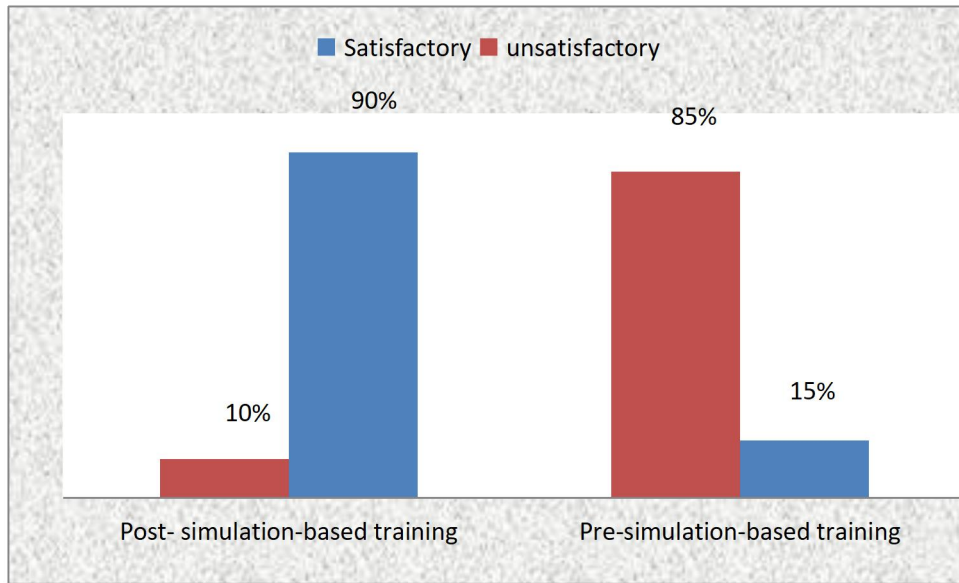

Table (3): Percentage distribution of the studied nurses' level of practice regarding procedural pain management of neonates' heel- sampling pre and post-one-month post-simulation-based training implementation (n=50)

Nurses' practice	Pre-simulation-based training implementation				One-month Post- simulation-based training implementation				F	P
	Incompetent		Competent		Incompetent		Competent			
	No	%	No	%	No	%	No	%		
Heel Stick Puncture	24	48.0	26	52.0	3	6.0	47	94.0	17.56	<0.001**
Kangaroo Care	27	54.0	23	46.0	4	8.0	46	92.0	18.33	<0.001**
Swaddling	33	66.0	17	34.0	6	12.0	44	88.0	13.44	<0.001**
Nesting	34	68.0	16	32.0	7	14.0	43	86.0	83.25	<0.001**
Massage	43	86.0	7	14.0	2	4.0	48	96.0	12.67	<0.001**
Sucrose administration	44	88.0	6	12.0	5	10.0	45	90.0	43.42	<0.001**

(**) Highly significant at P<0.001

Figure (3): Percentage distribution of the studied nurses' level of practice regarding procedural pain management of neonates' heel-sampling pre and post-one-month post-simulation-based training implementation (n=50)
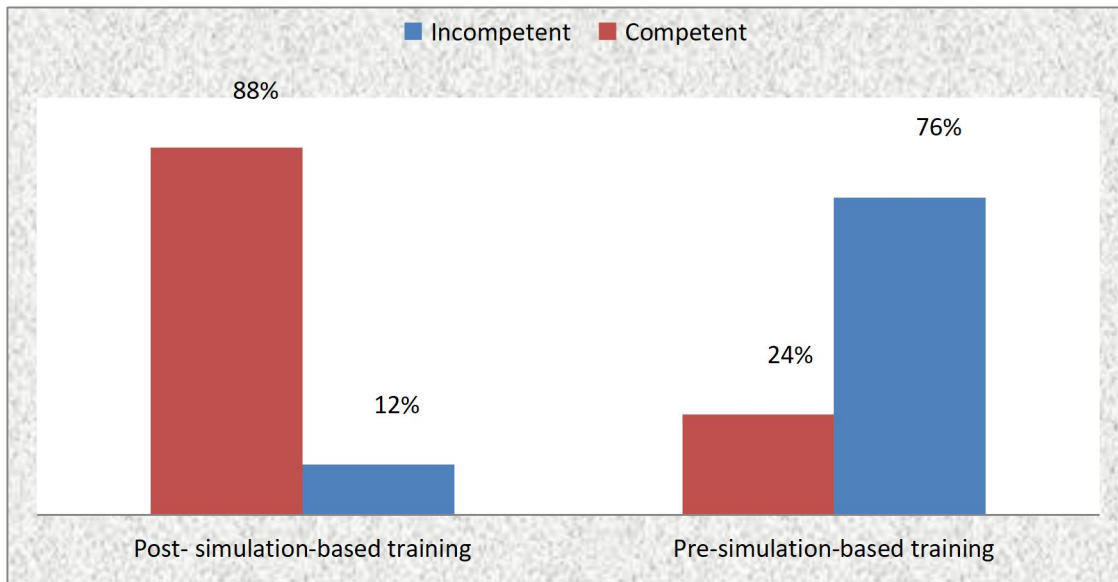

Figure (4): Percentage distribution of the studied neonates' pain level following procedural pain management of neonates' heel- sampling pre and post-one-month post-simulation-based training implementation (n=50)
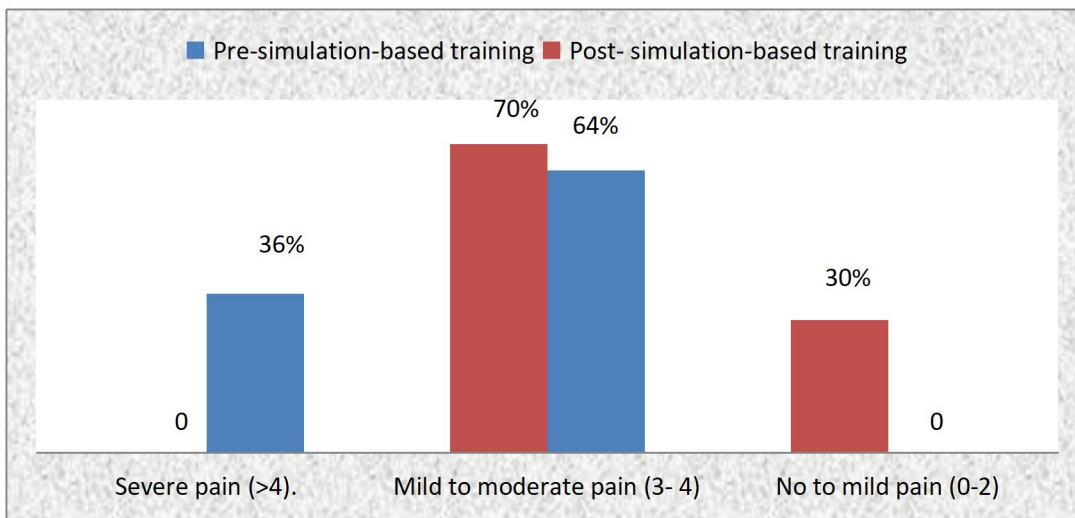

Table (4): Correlation coefficient between total knowledge, practice, and pain level pre and post-one month of simulation-based training implementation (No= 50)

Variable	Correlation coefficient	P-value*
Knowledge- neonatal pain	0.445	<0.001
Knowledge- practice	0.229	<0.001
Neonatal Pain – practice	0.227	<0.001

(**) Correlation is highly significant at the <0.001

Discussion

Nursing educators can assist aspiring nurses get ready for practice by using strategies like simulation. Performance is the completion of a given task to established benchmarks for accuracy, completeness, cost, and timeliness. Poor outcomes, especially for severely ill neonates, are associated with inadequate nursing knowledge preparation and abilities, according to a growing body of studies **(McGaghie et al., 2019).** Hence, this study aimed to evaluate the effect of simulation-based training on nurses' performance in procedural pain management of neonates' heel-sampling.

Results of the current study revealed that more than three-fifths of the studied nurses were aged < 25 years with a mean of **24.8 ± 4.9** years, and the majority of them were females. Regarding years of experience, nearly half of them had experience from 5 – <10 years. This finding was in disagreement with *Adam et al., (2020),* in Egypt who carried out a study entitled "Nurses' Perception about Pain Assessment and Management in Neonatal Intensive Care Units / Department of Pediatric Nursing" and found that 65% of the nurses their aged ranged between 20 to 29 years.

About two-thirds of the nurses had a technical nursing education, according to the most recent data regarding the educational background of nurses. The results of this study may be explained by the fact that, up until a few years ago, only girls at Egyptian institutions were able to pursue nursing education; this may also account for the high proportion of female students.

In terms of years of experience, it was shown that fewer than half of the nurses under study had worked in NICUs for more than five and less than ten years. According to Deshmukh and Shinde (2014), the majority of participants (71.67%) had less than five years of clinical experience, which contradicted the results. **Issa et al. (2018)** made similar findings in their study "Evaluation of Nurse's Knowledge in the Management of Premature Baby in Neonatal Units," which showed that close to one-third of the nurses under investigation had one to five years of experience. **Mohammed and Abdel Fattah (2018)** also discovered that over half of the participants had one to five years of experience. These findings agree with **Mohamed, et al., (2018)** in Egypt who carried out a study titled "Effect of Educational Program on Pediatric Nurses' Knowledge and Practice regarding selected non-pharmacological techniques to relieve pain in neonates and found that 87.8% of the study sample were less than 5 years of experience.

The present study revealed that most of the studied nurses do not attend training courses about simulation-based training about procedural pain management of neonates' heel sampling. From the researcher's point of view, it reflected the need of the studied nurses to receive simulation-based training about procedural pain management of neonates' heel sampling to improve their knowledge and practices about neonates' heel sampling.

Regarding neonatal gestational age, results of the present study found that less than three-quarters of neonates had gestational age <37 weeks. This finding was in agreement with **Aydin & Inal, (2019)**, in Turkey, who carried out a study entitled "Effects of Breastfeeding and Heel Warming on Pain Levels during Heel Stick in Neonates", and found that neonates' gestational age, 37 to 41 weeks.

According to neonatal birth weight, results of the present study found that more than half of neonates weighed between 2: and> 3 kg at admission. This finding was in agreement with **Zhang et al., (2018),** in China who carried out a study entitled **"Neonatal Intensive Care Nurses' Knowledge and Beliefs regarding Kangaroo Care in China"** and found that 65.7% of neonates weighed> 2,500. Regarding neonatal hospital stay, findings of the present study revealed that more than half of them had a week stay in hospital. This finding was in agreement with **Zhang et al., (2018)**, who found that 33.3% of neonates had a hospital stay from 6 to 10 days in hospital.

According to the total score level of nurses' knowledge regarding neonatal heel sampling, it was observed that an improvement with a highly statistically significant difference was found between nurses' knowledge pre and post-one-month simulation-based training implementation about neonates' heel sampling. From the researcher's point of view, it verified that using simulation-based training has positive impacts. This proves, in the opinion of the researchers, how successfully the simulation-based learning approach was implemented. This illustrated the critical requirement to comprehend the goal of the deployment of simulated-based education in order to increase knowledge. **Cerra et al., (2018**) study, "Effects of high-fidelity simulation-based on life-threatening clinical condition scenarios on learning outcomes of undergraduate and postgraduate nursing students," supports this finding by indicating that simulation training improved the performance and knowledge of nursing students.

The current study's findings demonstrated a considerable improvement in nurses' practice before to and following the adoption of simulation-based training, with a highly statistically significant difference about neonates' heel sampling. From the researcher's point of view, it confirmed the success of simulation-based training implementation that improves the nurses' knowledge and reflects on their good practices. According to earlier research, simulation-based education enhanced nursing students' performance. **Gomes et al. (2020**) studied "Clinical simulation for the teaching of wound evaluation and treatment," and **Nuraini et al. (2015**) examined the effect of simulation-based education on nursing students' practical achievements. Furthermore, clinical simulation was found by **Beal et al. (2017**) to be an effective strategy for improving the performance of studied students when compared to other teaching modalities.

Results of the present study found that more than three-quarters of nurses had an incompetent practice level about the neonates' heel sampling before receiving the simulation-based training. However, after receiving simulation-based training, their level of practice improved to a competent level (88%) post one month of simulation-based training implementation. These findings were in agreement with the results of **Alburaey, (2020),** in Saudi Arabia who carried out a study entitled "Pain Assessment and Management by Nurses in Neonatal Intensive Care Unit" and reported that more than half of the study sample had competent practices about non-pharmacological pain intervention for neonates during procedures.

These findings were in contrast with the results of **Di Clifford Faugere et al., (2022),** in Philadelphia who carried out a study entitled "Nurses' Perception of Preterm Infants' Pain and the Factors of their Pain Assessment and Management" and found that the majority of nurses had competent practices regarding heel stick puncture. From the researcher's point of view, this difference may be related to neonatal heel stick puncture becoming a routine procedure and may be previously studied in their course specification.

Regarding neonates' level of pain, the results of the present study found an improvement between neonates' pain levels pre and post-one-month simulation-based training implementation about neonates' heel sampling. These findings were in disagreement with the results of **Napiorkowska-Orkisz, (2022),** in Olsztyn, who carried out a study entitled "Evaluation of Methods to Minimize Pain in Newborns during Capillary Blood Sampling for

Screening" and found that 'no pain in 62.2%, moderate pain in 12.2% and strong pain in 25.6%. From the point of view of the researcher when pain goes unrelieved, it can result in cognitive impairment, mental confusion, and a lowered ability to concentrate on the task at hand of nurses during shift.

The findings of the current study revealed that there was a positive correlation between nurses' knowledge, practice, and neonatal pain post receiving the simulation-based training regarding neonates' heel-sampling procedure. Correlation revealed significant positive correlations between knowledge-practice, knowledge-neonatal pain, and practice–neonatal pain. This result confirms the positive relationship between knowledge, practice, and neonatal pain. This result may be due to that the studied nurses had poor knowledge about pain assessment and intervention methods to minimize neonatal pain, so there weren't had competent skills in pain management. These findings were in agreement with **De Clifford Faugere et al., (2022),** who found that nurses' perceptions and practices influenced their pain assessment practices, which predicted their implementation of interventions.

The findings of this investigation align with those of **Abd Elbaky (2018**), who reported in his research on the "Impact of a simulated education program on nurses' performance of invasive procedure at intensive care units" that knowledge, procedural intervention, and overall performance all showed improvements following the simulation education program.

Conclusion

Based on the findings of the current study, it can be concluded that simulation-based training had a positive effect on improving nurses' performance regarding procedural pain management of neonates' heel sampling.

Recommendations

   Based on the findings of the current study the following recommendations are suggested:

- Simulation-based training should be integrated as an effective method in nurses' training about neonates' heel sampling.

- Periodic assessment of nurse's performances regarding pain management of neonates undergoing heel sampling.

- Encourage neonatal nurses to update their knowledge and practices by attending training sessions, and workshops about non-pharmacological pain methods of the neonates undergoing heel sampling.

- Raising awareness of neonatal nurses about strategies of

non-pharmacological pain intervention as; swaddling, nesting, massage, kangaroo care, and sucrose administration, that minimize the pain of neonates undergoing heel sampling

- More attention must be paid to assessing, controlling, and managing neonatal pain through nonpharmacological intervention for nurses in the NICU during heel sampling.

- Integrate nonpharmacological pain intervention for neonatal pain during heel sampling in the nursing curriculum.

- Designing an illustrated booklet containing nonpharmacological pain management methods for neonates and NICU during heel sampling.

- To generalize the findings, the current study must be replicated with a wider sample of nurses and neonates in various contexts.

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