The Impact of Simulation-Based Training regarding Neuroprotective Strategies on Nurses' Performance and Preterm Infants' Outcomes for Preventing Intraventricular Hemorrhage

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Abstract

Background: Intraventricular hemorrhage continues to pose a significant and potentially life-threatening risk in preterm or extremely low birth weight infants. Training through simulation serves as a bridge between theoretical understanding and practical application, enhancing nursing skills before encountering premature infants in real-life scenarios. This ultimately raises the level of care and protects the welfare of premature infants. **Aim**: To determine the impact of simulation-based training regarding neuroprotective strategies on nurses' performance and preterm infants' outcomes for preventing intraventricular hemorrhage. **Design**: A quasi-experimental research approach was utilized. **Subject**: A convenience sampling of 50 nurses working in the NICUs and a purposive sample of 50 preterm infants were chosen. **Setting**: Neonatal Intensive Care Units at Sohag University Hospitals, Egypt. **Tools**: three tools were employed; tool 1: Nurses' self-adminsitered Questionnaire sheet regarding neuroprotective strategiesfor preventing intraventricular hemorrhage; tool 2: Observational Neuroprotective Strategies Checklist (Pre/Post- assessment); and tool 3: Intraventricular Hemorrhage (IVH) Severity Rating Scale (Post-assessment). **Results**: The application of simulation-based training on neuroprotective strategies led to a marked decrease in the incidence of intraventricular hemorrhage (p-value < 0.001). A notable reduction was observed in the composite outcome, which included severe IVH, cystic periventricular leukomalacia, and mortality (p < 0.001). There were considerable enhancements in nurses' knowledge and practice following simulation-based training on neuroprotective strategies. **Conclusion**: Training through simulation on Neuroprotective strategies greatly improves nurses' performance and is linked to a reduced risk of intraventricular hemorrhage, cystic periventricular leukomalacia, and mortality in extremely preterm infants. **Recommendations**: It is advised that simulation-centered training be included as a successful training approach for nurses concerning neuroprotective strategies. It is advised to incorporate Neuroprotective strategies into the standard practices of the Neonatal Intensive Care Unit to enhance neonatal outcomes.

Keywords: Intraventricular hemorrhage, Neuroprotective strategies, Preterm infant, Simulation-based training

Introduction

Preterm delivery continues to be a major medical concern, frequently associated with high mortality rates and lasting complications **.** A significant condition impacting preterm infants is intraventricular hemorrhage (IVH). It occurs in about 21–23% of infants who are born prior to 32 weeks of gestation or have a birth weight under 1,500 grams **(Siffel et al., 2021). Lai et al. (2022)** found that the total occurrence of IVH in infants delivered before 28 weeks of gestation was 34.3%, with severe instances representing 15.0%.

In less developed nations, the prevalence rate is around 25%, primarily due to restricted resources and inadequate measures for brain protection **(Yeo et al., 2020).** The rate of IVH in Uganda is 34% **(MacLeod et al., 2021).**In Ethiopia, the prevalence was observed to be 36% among preterm infants. It results from various

factors: the primary contributing factor related to the low gestational age is the underdevelopment of the cerebral vascular system, which is connected to the inherent fragility of the germinal matrix vasculature and swift fluctuations in cerebral perfusion**.** A second contributing factor is the vessel pattern of the venous system of U-shaped alignment; consequently, the veins are prone to venous congestion and damage **(Papile et al., 2022).**

A Periventricular-intraventricular hemorrhage (PIVH) is identified through transcranial ultrasound Doppler screening in all infants born before 30 weeks' gestation, usually conducted at 7 and 14 days after birth **(Novak et al., 2022).** The primary treatment strategy consists of prenatal preventive measures, such as avoiding preterm labor and the regular administration of antenatal corticosteroids **(Amer et al., 2021).**

Nursing simulation offers a secure space for continuous practice until mastery is achieved, along with feedback that enhances skill development, critical thinking, and reflective analysis **(Sangita et al., 2020**). Simulation-based learning can be succinctly described as an educational method that integrates various activities, including patient simulators, virtual settings, and role-playing, to substitute or improve actual experiences with structured ones. It replicates clinical practice using scenarios, manikins, and computer simulations, providing instant feedback, repeated practice, and customized learning experiences. Nonetheless, restricted chances for practical experience with real patients in undergraduate programs can impede skill development, potentially resulting in mistakes and jeopardizing patient safety **(Malarvizhi et al., 2019).**

Effective education is essential for cultivating skilled healthcare practitioners. Nonetheless, information indicates that nurses might not be sufficiently prepared to address societal demands, especially in developing nations. Education based on simulation presents a possible solution, offering various activities such as patient simulators, virtual settings, and role-playing. Simulation serves as an important resource for nursing educators, allowing aspiring nurses to cultivate vital skills necessary for practical application in the field. Efficient performance is assessed by precision, thoroughness, expense, and pace. Insufficient preparation may result in adverse consequences, particularly in critical care **(Manashi et al., 2021).**

Learning through simulation includes various activities such as patient simulators, virtual settings, and role-playing." This method substitutes or improves genuine experiences with directed ones, replicating clinical practice via scenarios, manikins, and computer simulations (NCSBN). Simulation is vital in nursing education, offering practical training and fostering critical thinking skills **(Malarvizhi et al., 2019).**

Nursing education must emphasize cognitive, psychomotor, and emotional domains. Reliable assessment tools are crucial for measuring proficiency in procedures such as vein puncture **(Lapkin & Levett-Jones, 2021).** Experiences based on simulation necessitate careful planning and design to reach intended goals **(Standards Committee, 2023).**

Neonatal nurses play a vital role in preventing and treating IVH in preterm babies. Their duties involve multiple practices designed to protect the fragile health of at-risk populations: Precise observation of preterm infants is crucial for detecting early indicators of distress or complications **(Hussein & Elbahnasawy, 2023)**. Neonatal nurses are skilled in observing vital signs, neurological conditions, and reactions to nursing interventions to identify irregularities and manage IVH **(Garfinkle & Miller, 2020).**

The care for premature babies with intraventricular hemorrhage(IVH) in nursing emphasizes reducing additional brain damage and promoting the best neurodevelopmental results **(Smith & Thomas, 2023).** Essential elements involve diligent observation of vital signs and intracranial pressure, along with precise administration of respiratory assistance to prevent variations in cerebral perfusion. Nurses need to employ methods to lessen stress and ensure a calm, stable atmosphere to alleviate possible increases in IVH **(Kemp & Doran, 2023).**

Significance of the study:

The use of innovative learning tools, like simulation, has increased in nursing education with the progress of modern technology. Simulations develop a learning atmosphere that guarantees patients obtain safer care in healthcare services while reducing environmental hazards **(Ananda Kudari,2023).** Moreover, simulation offers researchers the chance to enhance the quality of nursing education by improving nursing students' abilities in infection control, minimizing infection risks, applying effective infection control techniques in healthcare environments, cultivating practical skills, utilizing simulation-based training to boost nurses' skills, increasing patient safety, elevating healthcare quality, and lowering patient health risks.

Enhancing neurodevelopmental results in preterm infants involves multiple strategies such as minimizing pain and stress, preventing head rotation and tilting of the incubator, steering clear of physical therapy movements, avoiding suctioning of the orotracheal tube, and avoiding cerebrospinal fluid collection that causes changes in heart rate and oxygen saturation (**Romantsik et al., 2020**). Moreover, nurses must work together with multidisciplinary teams to provide holistic care, which encompasses neurodevelopmental evaluations and proactive intervention methods (**Apile et al., 2022).**

Nurses play an active role in executing care bundles for preterm infants, including a series of interventions designed to prevent IVH. These bundles typically consist of infant positioning, nursing care packages, and medical management to reduce the occurrence of IVH in preterm infants **(Al-Haddad, 2022).** Consequently, the present research investigated the impact of the neonatal nursing care package on the occurrence of intraventricular hemorrhage in preterm infants.

Aim of the study:

This study aims to determine the impact of simulation-based training regarding neuroprotective strategies on nurses' performance and preterm infants' outcomes for preventing intraventricular hemorrhage **through:**

1. Assessing nurses' knowledge and practice about neuroprotective strategies pre- implementation.

2. Implement a neuroprotective strategies in the first 72 hours of preterm infants' life.

3. Assessing neonatal nurses' knowledge and Practice after the implementation of the neuroprotective strategies.

4. Evaluating the intraventricular hemorrhage incidence and severity post-implementation of the neuroprotective strategies.

Research Hypotheses

Hypothesis 1: Implementation of neuro-protective strategies for intraventricular hemorrhage is expected to significantly improve neonatal nurses' knowledge and practice.

Hypothesis 2: Implementation of neuroprotective strategies is expected to significantly reduce the incidence and severity of IVH in the first 72 hours of preterm infants' lives.

Materials and Methods:

Research Design: The current study used a quasi-experimental design to achieve the aim of this study (pre-post and follow-up test).

Sampling: A convenience sampling of 50 nurses working in the NICUs and a purposive sampling of 50 newly admitted preterm infants who are at risk for IVH were chosen..

Settings: The study was conducted in the Neonatal Intensive Care Units at Sohag University Hospitals, Egypt.

Tools of data collection:

Three tools were used to collect data**:**

Tool 1: Nurses' self-adminsitered Questionnaire sheet regarding neuroprotective strategies for preventing intraventricular hemorrhage: Created to evaluate nurses' understanding of all elements concerning the IVH Neuro- Protective approaches. This instrument was established by the researcher following an examination of the pertinent literature **(Gross et al., 2021; El Amouri, 2021 & Kolnik et al., 2023**). The questions were presented as

multiple- choice queries. This instrument was utilized before, after, and during a follow-up four months later simulation-based training regarding the implementation of neuroprotective strategies. It included three parts as follows:

Part I: Nurses' characteristics, including age, educational level, residence, and duration of experience at the neonatal intensive care unit.

Part II: Preterm infants' characteristics encompassing gender, gestational age, and weight.

Part III: Nurses' knowledge about the Intraventricular Hemorrhage Neuro-Protective strategies, including their knowledge of the etiology and description of IVH, the detrimental effects associated with IVH, the key components of neuro-protective treatments, and the identification of babies at risk for developing IVH (pre-/post-test).

The system of scoring:

An 11-item questionnaire is used to assess nurses' knowledge; correctly answered questions are worth one point, while missing or incorrect answers are worth zero. The aggregate score, which ranges from 0 to 11, represents the nurses' level of thorough comprehension.

- Unsatisfactory < 75%
- Satisfactory ≥ 75%

Tool 2: Observational Neuroprotective strategies Checklist (Pre/Post-test). It was adapted from **Chiriboga (2019)** to evaluate nurses' performance and adherence to strategy implementation. It is composed of the following items:

a. **Delivery Room practices** include delayed cord clamping for 30 to 60 seconds. Midline positioning, minimal handling, avoid prone positioning, and no bath given.

b. Keep natural **thermal regulation** at 36.5°- 37.5° Celsius.

NICU practices include: The incubator's head was raised to a temperature of 15 to 30 degrees. The baby was placed using conventional placement methods, with the head and body in the midline. To promote and sustain flexion and midline alignment, the baby was surrounded by supportive limits, like rolled bed linens. Swaddling, physical boundaries, and protecting the baby's eyes from light were among the non-pharmacological techniques used to lessen discomfort and anxiety.

Scoring system:

For three days in a row, practice was assessed every day. A score of one was awarded for each action that was carried out correctly, while a score of zero was awarded for actions that were not. There was a 27-point maximum potential score (9 items × 3 days). Practice levels were divided into the following categories:

- **Incompetent:** Less than 80%
- **Competent:** 80% or more.

Tool 3 – Intraventricular Hemorrhage (IVH) Rate of Severity Scale (Post-test):

The Severity of the IVH rate was evaluated through cranial ultrasonography, a standard practice in the NICU conducted by doctors for every admitted preterm infant on the third and seventh days post-birth. This assessment was performed based on the classification outlined by **Volpe et al. (2017).** The grading system relies on ultrasound results and classifies IVH severity in this manner:

• Grade 1: Blood occupies under 10% of the ventricle.

• Grade 2: Between 10% and 50% of the ventricle is occupied by blood.

• Grade 3: Over 50% of the ventricle is filled with blood.

• Grade 4: Existence of periventricular infarction.

This grading system enables the assessment of IVH severity both before and after implementing the neuroprotective strategies, thereby supporting the evaluation of its effectiveness.

Data Collection Procedure:

The research took place over a period of 6 months, from July 2023 to December 2023.

The researcher visited the NICU three days a week, switching between morning and afternoon shifts based on availability. Upon reaching, the researcher presented herself to the nursing team and parents, clarified the study aims, and secured the required consent.

Validity and Reliability: The validity assessment was conducted by three faculty members from the Pediatric Nursing Department at Sohag University. The nurse's knowledge questionnaire's reliability was validated by Cronbach's alpha coefficient (alpha=0.899 for the Knowledge Questionnaire , alpha=0.931 for the nurse's practice, and alpha=0.912 for Intraventricular Hemorrhage (IVH) Rate of Severity Scale)

Pilot study

It was carried out on 10% of the sample (5), and interviews were held to evaluate the tool's feasibility, usability, reliability, clarity, and practicality for estimating the time needed to finish them. No modifications were done. The pilot study sample was included in the main sample study.

Ethical considerations:

Approval for ethical considerations was secured from the Ethics Committee of the Faculty of Nursing at Sohag University (No/ 139- 19-7-2023). The researcher secured informed consent from the nurses and the parents of the infants after clarifying the study's purpose and guaranteeing the confidentiality of the gathered information. The nurses could exit the study at any moment without any obligations.

The process of data collection was structured into four separate stages:

1-Assessment Phase:

The researcher asked the nurses to fill in tool 1, and it took 10 minutes (pre-test). The nurses 'practices were assessed by the researcher through observation. The average time required to complete all checklists ranged between 30 and 35 minutes. Assess the prevalence of IVH by using tool three. The assessment phase took four months to collect all the necessary data. The program objectives were created after identifying areas of weakness in nurses' knowledge and practices where each nurse was interviewed before the training to gather their characteristics using tool (I) part (1), and their knowledge, practice, and **Intraventricular Hemorrhage (IVH) Rate of Seriousness** were evaluated using tool (I) part (2), tool II, and tool III.

II - Planning Phase:

The objectives, priorities, and expected outcomes were defined based on the previous phase's findings to address the practical needs, knowledge gaps, and satisfaction of nurses concerning intraventricular hemorrhage. The researchers organized five sessions, comprising two theoretical and three practical, for the participating nurses.

The simulation-based training:

A simulation-based training was developed and updated, encompassing both theoretical and practical sessions focused on the intraventricular hemorrhage. The primary aim of the simulation-based training sessions was to ensure that, by the conclusion of the sessions, nurses would gain knowledge and skills that enhance their performance in intraventricular hemorrhage in the Neonatal Intensive Care Unit (NICU).

3-**Implementation Phase:**

During the implementation phase, the simulation-based training was structured to enhance nurses' performance concerning the intraventricular hemorrhage in NICUs through five sessions, comprising two theoretical and three practical sessions, each lasting approximately 30-45 minutes. Each session commenced with feedback from the previous session, followed by a summary at the end. Researchers were present in the study settings three days a week from 9 a.m. to 12 p.m., conducting individual interviews with each nurse using the previously mentioned study tools. The participating nurses were organized into subgroups of varying sizes (4-6 nurses per group). A simplified booklet, provided in Arabic, served as supportive material, addressing all relevant knowledge and practices related to the intraventricular hemorrhage, developed after reviewing the pertinent literature and assessing the actual needs of the nurses

involved in the study. Various teaching methods were employed, including lectures, small group discussions, visual aids, brainstorming sessions, demonstrations, re-demonstrations with necessary equipment, and the use of a simulation manikin available in the hospital's teaching clinical lab to facilitate the simulation-based training. A variety of teaching media were utilized, including handouts, PowerPoint presentations, diagrams, flipcharts, and illustrated videos concerning intraventricular hemorrhage.

The first session, Theoretical knowledge was included (definition, causes, risk factors, clinical manifestations, diagnosis, treatment, and preventive measures).

- The second session included preventive measures such as Midline Positioning, Minimal Handling, Swaddling, maintaining boundaries, shielding eyes from light, and thermoregulation.
- The third to the fifth sessions (practical) included a demonstration of positioning and reinforcing learning with hands-on practice to prevent IVH, and emphasizing practice with hands-on training. The researchers concluded each session by summarizing the main points and providing positive verbal feedback. At the end of this session, each nurse received an Arabic informational booklet with theoretical and practical sections to increase their memory and knowledge.

Applying the Neuroprotective strategies consistently during the first 72 hours after birth for each eligible infant, and nurses' compliance with the strategies components was monitored using the observational checklist. The researcher then distributed a post-test and expressed appreciation to all participating nurses for their involvement in the study. In the evaluation phase, the nurses' performance was reassessed immediately after the simulation-based training (post-test).

4-**Evaluation Phase:** include the evaluation phase after Neuroprotective strategies to assess nurses' knowledge and practices, regarding prevention of IVH immediately and after four months. Assess the seriousness of IVH.

Statistical Analysis:

Data analysis was conducted using IBM's Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were employed to summarize the data. Inferential statistics comprising the Chi-square test and the independent t-test. The significance threshold was determined at p 0.05, while the threshold for highly significant was defined at p 0.001. All tests for statistical significance relied on a two-sided hypothesis test, with $p < 0.05$ deemed significant.

Results

Table 1 presents the socio-demographic characteristics of the nurses studied, with the highest percentage (32%) falling within the age range of 30 to <35 years. Concerning educational qualifications, 42% completed their studies at technical nursing schools. Regarding experience, 42% possessed between 5 and less than 10 years of work experience. Merely 10% of nurses indicated that they had prior training concerning neuroprotective strategies.

Table 2) shows that 70% of preterm infants were boys, with nearly two-thirds of the sample studied (68%) having a birth weight ranging from 1000 to less than 2000 grams. Over half of the infants (66%) were delivered at gestational ages between 28 and 30 weeks, with an average gestational age of 28.8± 1.38 weeks.

Table 3: - Shows a significant enhancement in nurses' understanding of intraventricular hemorrhage after the simulation-based training on neuroprotective strategies. The statistical evaluation validated the importance of these enhancements (0.000) before, right after, and during the follow-up of simulation-based training, emphasizing the efficacy of simulation-based training in improving and maintaining nurses' knowledge.

Figure 1 depicts the distribution of knowledge levels among the studied nurses regarding neuroprotective strategies at three points: before the simulation-based training, right after, and four months post the simulation-based training. Ninety-four percent of the nurses displayed an inadequate knowledge level before the simulation-based training, which dropped to 10% right after the training, and afterward, 96%

attained a satisfactory knowledge level one month later.

Table 4 shows that there were markedly significant enhancements in nurses' practices concerning neuroprotective strategies before, immediately after, and during follow-up of simulation-based training.

Figure 2 depicts the allocation of practice levels among the nurses examined regarding neuroprotective strategies at three points: before the simulation-based training, right after, and four months post-training. Ninety-two percent of the nurses displayed an inadequate practice level before the simulation-based training, which dropped to 12% right after the training, and later, 90% reached a competent practice level four months following the simulation-based training.

Table 5 demonstrates that there was reduction in the severity of Intraventricular Hemorrhage with a highly statistically significant difference found between pre and post- simulation-based training regarding neuroprotective strategies ($P<0.001$).

Table 6 illustrates the clinical results before and after simulation-based training related to neuroprotective strategies. It demonstrates that after simulation-based training, a significant decrease was noted in all negative outcomes. Intraventricular hemorrhage is decreased to 6%, with an adjusted odds ratio of 0.45 and a p-value that is highly significant (< 0.001). Likewise, the result of serious IVH, cystic periventricular leukomalacia, or death ($p < 0.001$). Significant statistical differences were observed in neuroprotective strategies before and after the simulation.

Table 7 shows a favorable relationship between the nurses' knowledge, practice, and the occurrence of intraventricular hemorrhage following their participation in the simulation-based training on neuroprotective strategies, with a statistically significant p-value of $p<0.001$. The correlation analysis indicated strong positive associations between knowledge and practice ($p < 0.001$), knowledge and the occurrence of intraventricular hemorrhage ($p < 0.001$), as well as a negative correlation between practice and the incidence of intraventricular hemorrhage ($p < 0.001$). These results confirm the favorable correlation between knowledge, practice, and the occurrence of intraventricular hemorrhage among the nurses examined concerning neuroprotective strategies.

Table (1): Nurses' distribution according to their characteristics (n=50).

Nurses' characteristics	No	%
1. Age per year		
<25	9	18
25-<30	14	28
30-<35	16	32
35- <40	5	10
More than 40	6	12
Mean ±SD: 33.4 ± 7.79 years		
2. Educational Level		
Diploma Nursing	10	20
Technical Nursing Institute	21	42
Bachelor's degree	19	38
3. Years of experience		
< 5	7	14
5-<10	21	42
10-<15	10	20
>15	12	24
4. Previous training regarding neuroprotective strategies for preventing intraventricular hemorrhage		
Yes	5	10
No	45	90

SD= standard deviation

Table (2): Preterm infants distribution according to their personal and clinical data (No=50).

Preterm infant's Characteristics	No	%
1. Gender		
Male	35	70
Female	15	30
2. Gestational age /weeks.		
< 28	3	6
28 -<30	33	66
30 -< 33	14	28
Mean ±SD: 28.8± 1.38		
3. Weight /grams.		
< 1000	7	14
1000 -< 2000	34	68
> 2500	14	28

SD= standard deviation

Table (3): Nurses' knowledge regarding neuroprotective strategies, Pre, immediate post, and follow-up of simulation-based training (n=50)

Knowledge regarding neuroprotective strategies	Phase						P value
	Pre		Post		Follow-up		
	No	%	No	%	No	%	
Intraventricular Hemorrhage							
Definition of IVH	5	10	49	98	48	96	0.001**
Pathophysiology of IVH	3	6	47	94	46	92	
Negative outcomes of IVH on preterm infants	8	16	49	98	47	94	
Main component of neuroprotective strategies							
Importance of neuro-protective strategies	11	22	48	96	44	88	0.001**
Midline Positioning	4	8	47	94	43	86	
Minimal Handling	5	10	48	96	45	90	
Swaddling	9	18	45	90	42	84	
Maintaining boundaries	7	14	47	94	44	88	
Shielding eyes from light	6	12	43	86	40	80	
Thermoregulation	2	4	48	96	44	88	

**Highly significant-Chi-square test

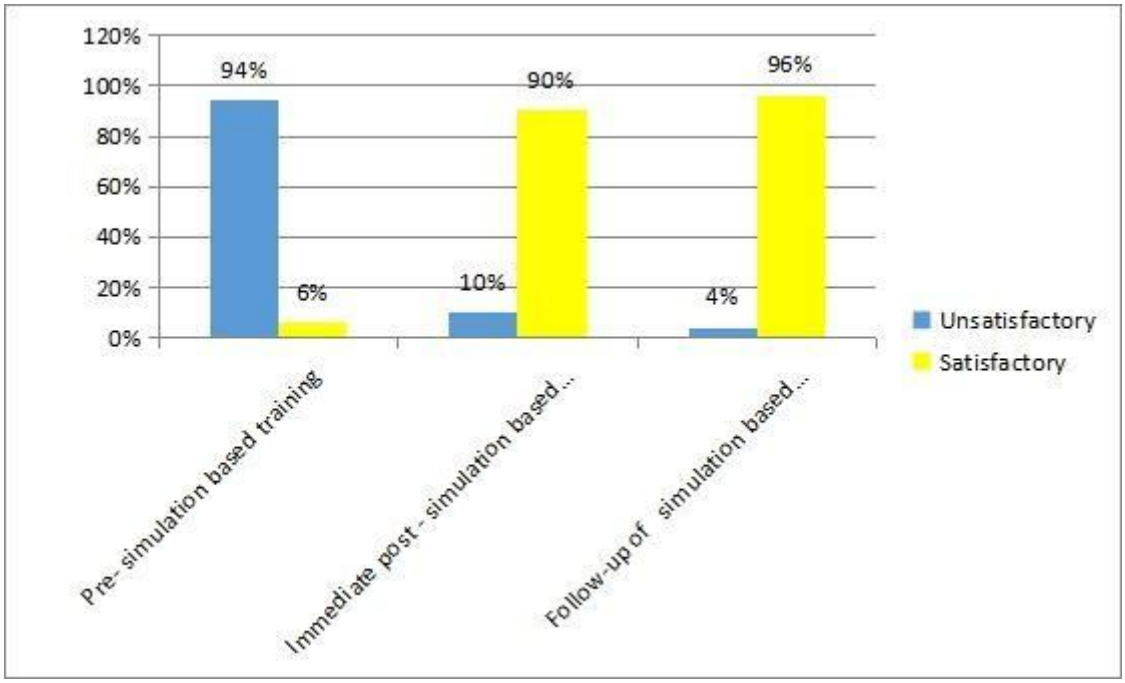

Figure (1): Total knowledge level of the studied nurses regarding neuroprotective strategies pre, immediate post, and follow-up of simulation-based training (n=50)

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able (4): Nurses' practice regarding neuroprotective strategies pre, immediate post, and follow-up of simulation-based training (n=50)

Practices regarding neuroprotective strategies	Phase						P Value
	Pre		Post		Follow-up		
	N	%	N	%	N	%	
Midline head positioning	25	50	47	94	46	92	0.001**
No prone positioning	24	48	46	92	45	90	0.001**
Elevating the head of the bed 15-30 degrees	23	46	45	90	44	88	0.001**
Minimal handling	22	44	44	88	43	86	0.001**
No bath given	28	56	45	90	45	90	0.001**
Natural thermal regulations between 36.5-37.5	26	52	43	86	42	84	0.001**
Swaddling	24	48	43	86	42	84	0.001**
Maintaining boundaries	21	42	46	92	45	90	0.001**
Shielding eyes from light	23	46	47	94	46	92	0.001**

**Highly significant -Chi-square test

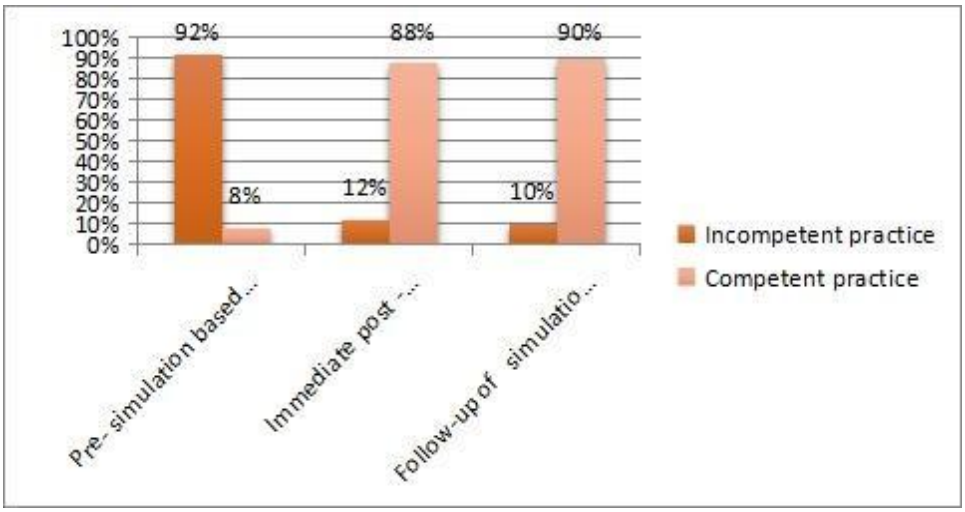

Figure (2): Total practice level of the studied nurses regarding neuroprotective strategies pre, immediate post, and follow-up of simulation-based training (n=50)

Table (5): Severity of Intraventricular Hemorrhage (IVH) pre- and post-simulation-based training regarding neuroprotective strategies

Outcomes	Pretest		Posttest		P value
	N	%	N	%	
Grade 1: Blood occupies under 10% of the ventricle.	1	2	0	0	< 0.001**
Grade 2: Between 10% and 50% of the ventricle is occupied by blood.	2	4	3	6	< 0.001**
Grade 3: Over 50% of the ventricle is filled with blood.	3	6	0	0	<0.001**
Grade 4: Existence of periventricular infarction.	2	4	0	0	< 0.001**

Table (6): Clinical Outcomes pre- and post-simulation-based training regarding neuroprotective strategies

Outcomes	Pretest		Posttest		Adjusted OR	95% CI	P value
	N	%	N	%			
Intraventricular Hemorrhage (IVH)	8	16	3	6	0.45	0.27 – 0.646	< 0.001**
Severe IVH / cPVL / Death (composite)	7	14	3	6	0.53	0.35 – 0.92	< 0.001**
Cystic Periventricular Leukomalacia	2	4	1	2	-	-	< 0.001**
Mortality	3	6	2	4	-	-	> 0.05ns

* ns (p> 0.05) **Highly significance
CI- (Confidence Interval

Table (7): Correlation coefficient between total knowledge, practice, and intraventricular hemorrhage incidence among the studied nursespre, immediate post, and follow-up of simulation-based training (No 50)

Variable	Correlation coefficient	P-value*
Knowledge- intraventricular hemorrhage incidence	0.437	<0.001**
Knowledge- practice	0.225	<0.001**
Intraventricular hemorrhage incidence - practice	-0.67	<0.001**

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

Discussion

A replicative teaching technique, simulation-based education uses a setting that is similar to real-world clinical situations. When necessary, this method makes repeated learning safe and efficient. Additionally, using standardized patients who have been carefully taught to portray their sickness and emotional states in a simulation that mimics real-life circumstances enables students to comprehend the thoughts and feelings of patients through interaction, thereby providing more realistic and tangible experiences **(Cant&Cooper, 2020).**

Simulation serves as a valuable tool for nursing educators to prepare future nurses for practical scenarios. Performance is defined as the accomplishment of a task evaluated against established standards of accuracy, completeness, cost, and efficiency. A growing body of research indicates that inadequate preparation and lack of skills among nurses are associated with negative outcomes, particularly in critically ill newborns **(McGaghie et al., 2019)**. So, the researchers did this study to determine the impact of simulation- based training regarding neuroprotective strategies on nurses' performance and preterm infants' outcomes for preventing intraventricular hemorrhage.

This study revealed that implementing interventions about neuroprotective strategies significantly improved nurses' knowledge and practices regarding neuroprotective strategies for the prevention of intraventricular hemorrhage (IVH) in preterm infants and observed a reduction in the severity and incidence of IVH in preterm infants.

Regarding attending previous training courses, the current study illustrated that ten percent of nurses attended training courses regarding neuroprotective strategies. From the researcher's point of view, this may be explained by the fact that training within the unit is not sufficient, and the nurses need periodical follow- up for intervention.

The study's results revealed that more than three-fifths of the participating nurses were between 30 <35 years of age, more than three- fifths of the nurses had completed a Technical Institute of Nursing, with a predominance of female nurses. The results of the current study may be explained by the historical context in which nursing education in Egyptian institutions was predominantly available to females until recent years, which could account for the high female representation.

Findings of the current study revealed a significant enhancement in nurses' understanding of intraventricular hemorrhage after the simulation-based training on neuroprotective strategies. The statistical evaluation validated the importance of these enhancements before, after, and during the follow-up of simulation-based training. From the researchers' point of view, it confirmed the benefits of simulation-based training, emphasizing the efficacy of simulation-based training in improving and maintaining nurses' knowledge. This aligns with **El-Gilany et al. (2021)**, who reported that structured educational programs significantly improved neonatal nurses' awareness and understanding of neuroprotective practices in NICUs. Similarly, **Ali &El Sayed (2020)** concluded that continuous education and practical training are critical in enhancing nursing performance regarding evidence-based practices in neonatal care.

As regards nurses' knowledge, a significant improvement in the nurses' knowledge about neuroprotective strategies with a highly statistically significant difference observed before, immediately after, and four months following the simulation-based training. From the researcher's point of view, this may be related to the theoretical and practical sessions that were provided to cover all aspects of neuroprotective strategies.

The current study results revealed that a highly significant difference and improvement were noted in the knowledge levels before and after the simulation-based training regarding neuroprotective strategies. This suggests that the implementation of simulated-guided nursing education was highly effective, highlighting the success and critical need to comprehend the objectives of

such simulation-based training regarding neuroprotective strategies to enhance knowledge. This conclusion is further supported by **Cerra et al. (2020)**, who examined the 'Effects of high-fidelity simulation-based on life- threatening clinical condition scenarios on learning outcomes of undergraduate and postgraduate nursing students' and found that simulation training positively influenced nursing students' knowledge and performance.

The study results were supported by a quasi-experimental study conducted by **Ruiz- Fernandez** (**2022**), who studied the effectiveness of clinical simulation on home visits. The study findings found that when comparing the data before and after the simulation, a statistically significant increase was observed in the scores of self-efficacy ($p < 0.001$) and empowerment ($p < 0.001$).

As regards nurses' practice, the present study revealed that there were markedly significant enhancements in nurses' practices concerning neuroprotective strategies before, immediately after, and during follow-up of simulation-based training. From the researcher ' s point of view, this may be related to the integration of knowledge, which occurs when information is combined with performance. From the researcher's perspective, enhancing nurses' skills is crucial to meet the specific needs of patients requiring neuroprotective strategies, thereby reducing the incidence of adverse events during hospitalization and reflecting the effectiveness of the simulation-based training at pre-, immediate post-, and four months post- stages.

This finding supports the work of **Klingenberg et al. (2022),** who emphasized that care bundles, when implemented consistently, significantly enhance adherence to best practices and positively influence patient outcomes. The findings align with those of **Smith, (2020),** who reported that targeted neuroprotective education led to improved adherence to best practices in NICUs and a reduction in IVH rates among preterm neonates. Similarly, **Jones & Patel (2019)** emphasized that continuous nursing education contributes directly to the implementation of high-impact neonatal care strategies, reinforcing the value of regular competency-building initiatives.

From the researchers' perspective, this outcome reflects the beneficial impact of simulation-based training on enhancing the practice levels of the nurses studied, effectively raising their clinical practice scores. This finding corroborates earlier studies by **Gomes et al. (2020),** who explored 'Clinical simulation for the teaching of wound evaluation and treatment,' and **Nuraini et al. (2025),** who examined the effects of simulation-based education on nursing students' practical skills, both concluding that such educational methods significantly improved performance.

Additionally, the research conducted by **Saied (2020)** on "The impact of simulation on pediatric nursing students' knowledge" indicated that students expressed satisfaction with the simulation experience, and scores improved following the simulation session. Moreover, **Mattson (2023)**, who examined the effects of high-fidelity simulation on knowledge acquisition and self-confidence, found that participants significantly improved with the simulation learning activity.

Concerning the reduction in the Incidence and Severity of IVH, the implementation of the simulation-based training related to neuroprotective strategies resulted in a marked reduction in both the incidence and severity of IVH among preterm infants. No severe cases (Grade III/IV) were observed in the post- intervention group. These findings are consistent with those reported by **Papile et al. (2018)**, who concluded that minimal handling, proper head positioning, and thermoregulation significantly reduce fluctuations in cerebral blood flow, thus decreasing the risk of IVH. Likewise, **Griffin et al. (2020)** found that implementing neuroprotective care strategies in the early hours of life for preterm neonates led to a substantial decrease in the rates of severe IVH. This supports the notion that early and consistent application of evidence-based neuroprotective measures can improve neonatal outcomes.

As regards the correlation between nurses' practice and knowledge, there was a positive correlation between the nurses' knowledge and practice levels after participating in the simulation-based training on the neuroprotective strategies, with a statistically significant correlation. As well as a negative correlation between practice and the incidence of intraventricular hemorrhage. From the researcher' s point of view, continuing nursing education is very important to improve patients' outcomes and decrease the incidence of complications. These results confirm the favorable correlation between knowledge, practice, and the occurrence of intraventricular hemorrhage among the nurses examined concerning neuroprotective strategies.

Regarding the correlation Between Knowledge and Performance, there was a positive correlation found between knowledge and performance immediately post-intervention ($p = 0.001$), which indicates that theoretical understanding translates into improved clinical practice when supported by institutional training and monitoring. This finding is congruent with **White et al. (2019)**, who highlighted that knowledge acquisition alone is insufficient unless integrated into daily practice with organizational support. Interestingly, the lack of significant correlation at four months may indicate the need for ongoing reinforcement, supervision, and periodic refresher courses to sustain practice changes. This is echoed in studies by **Ahmed & El Sayed (2020)**, who recommended continuous professional development as a key element in retaining care quality in NICUs. From the researchers' point of view, it confirmed the benefits of simulation-based learning. Also, from the perspective of the researchers, it reflected the success of the simulation-based learning.

Because it integrates knowledge while addressing patient difficulties through the modelling of real-life scenarios and the direct execution of interventions, simulation is an active learning technique that promotes student participation and can lead to better and longer- lasting learning outcomes. This study contributes more evidence to the existing literature supporting the effectiveness of simulation as a teaching technique. Furthermore, nursing skills and knowledge are significantly enhanced by debriefing during simulation **(Kim & De Gagne, 2022).**

LIMITATIONS:

Limited generalization due to convenience sampling, a single scenario used, and cost-effectiveness not evaluated. Future research should use larger, randomized samples, include multiple scenarios, explore various learning methods, and assess cost-effectiveness.

Conclusion

Based on the findings of the current study, it was concluded that Training through simulation on neuroprotective strategies greatly improves nurses' performance and is linked to a reduced risk of intraventricular hemorrhage, cystic periventricular leukomalacia, and mortality in extremely preterm infants.

Recommendations:

Based on the current study findings, it can be recommended that:

- It is advised that simulation-centered training be included as a successful training approach for nurses concerning neuroprotective strategies.
- It is advised to incorporate Neuroprotective strategies into the standard practices of the Neonatal Intensive Care Unit to enhance neonatal outcomes.
- Further research: To confirm the efficacy of neuroprotective strategies in various clinical settings and investigate long-term neurodevelopmental consequences, more studies with larger sample sizes are advised.

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