Effect of Implementing Neuroprotective Care Bundle on Nurses, Performance and the Incidence of Intraventricular Hemorrhage in Premature Infants

Hanaa Ibrahim El Sayed
Assistant professor of Pediatric Nursing, Faculty of Nursing, Menoufia University, Egypt

Abstract

Background: Intraventricular hemorrhage remains a serious and a potentially life-threatening complication in preterm or very low birth weight infants. Applying neonatal nursing care bundles can help mitigate the incidence and severity of Intraventricular hemorrhage. **Aim**: To examine the effect of implementing neuroprotective care bundle on nurses' performance and the incidence of intraventricular hemorrhage in premature infants. **Design**: A quasi-experimental study was utilized, including preterm infants and neonatal nurses. **Setting**: Neonatal Intensive Care Units of Birket El Sabah Central Hospital and Menoufia University Hospital, Menoufia Governorate, Egypt. **Results**: implementation of the nursing care bundle significantly reduction of intraventricular hemorrhage incidence from 15% to 7%, (adjusted odds ratio of 0.42 p-value < 0.001). There was also a significant decrease in composite outcome including severe IVH, cystic periventricular leukomalacia and mortality (OR 0.54, p < 0.001). There were highly significant improvements in nurse's knowledge and practice, post intervention **Conclusions**: The application of Neuroprotective Care Bundle within the first 72 hours after birth is associated with lower risk of intraventricular hemorrhage, cystic periventricular leukomalacia, and mortality in very premature infants. **Recommendation**: Integrating the Neuroprotective Care Bundle into the routine Neonatal Intensive Care Unit is strongly recommended to improve neonatal outcomes and standardization of best practices across care settings.

Key words: Intraventricular hemorrhage, Neuroprotective Care Bundle**,** Preterm infant

Introduction

Preterm birth remains a significant medical challenge, often linked to high rates of mortality and long-term complications **(Bell et al., 2021).** One of the serious conditions affecting preterm infants is intraventricular hemorrhage (IVH). It is arising in approximately 21–23% of infants born before 32 weeks of gestation or with a birth weight less than 1,500 grams **(Siffel, Kistler, and Sarda, 2021). Lai et al., (2022)** reported that the overall incidence of IVH in infants born before 28 weeks of gestation was 34.3%, with severe cases accounting for 15.0%.

In developing countries, the incidence rate is approximately 25%, largely caused by limited resources and insufficient brain protection strategies **(Yeo et al., 2020).** The incidence of IVH in Uganda is 34% **(MacLeod et al., 2021).** While, in Ethiopia, the occurrence among preterm was found 36%. It is caused by multifactorial factors: the first contributing factor is Linked to the low gestational age is immaturity of the cerebral vascular system that is associated with the intrinsic fragility of the germinal matrix vasculature and rapid changes in cerebral perfusion **(Sidorenko et al., 2024).** 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, Hernandez, and Kelemen, 2022).**

A Periventricular-intraventricular hemorrhage (PIVH) is diagnosed using transcranial ultrasound Doppler screening for all neonates born before 30 weeks' gestation, typically performed at 7 and 14 days of life **(Novak, Ozen, & Burd, 2022).** The main approach to treatment involves prenatal preventive steps, including preventing preterm labor and the routine use of antenatal corticosteroids **(Amer, Kamil & Ebrahim, 2021).**

Neonatal nurses are crucial in preventing and managing IVH in preterm infants. Their responsibilities encompass various practices that aim to safeguard the delicate health of vulnerable groups: Accurate monitoring of preterm infants is essential to identify early warning signs of distress or any complications **(Hussein & Elbahnasawy, 2023).** Neonatal nurses are proficient at monitoring vital signs, neurological status, and response to nursing implementation to detect abnormalities and provide management of IVH **(Garfinkle & Miller, 2020).**

Nursing care for premature infants with intraventricular hemorrhage (IVH) focuses on minimizing further brain injury and supporting optimal neurodevelopmental outcomes **(Smith & Thomas, 2023**). Key aspects include meticulous monitoring of vital signs and intracranial pressure, as well as careful management of respiratory support to avoid fluctuations in cerebral perfusion. Nurses should also implement strategies to reduce stress and maintain a stable, quiet environment to mitigate potential exacerbations of IVH (**Kemp & Doran, 2023).**

The Neonatal Care Bundle aims to improve neurodevelopmental outcomes of preterm infants and incorporates several measures consist of reducing pain and stress, avoiding head rotation and tilting the

incubator, evading physical therapy maneuvers, avoid orotracheal tube suctioning, and dodging collection of cerebrospinal fluid that leads to alteration of heart rate and oxygen saturation **(Romantsik et al., 2020).**

Additionally, nurses should collaborate with multidisciplinary teams to ensure comprehensive care, including neurodevelopmental assessments and early intervention strategies **(Apile, Hernandez & Kelemen, 2022).** Nurses actively participate in the implementation of preterm infants' care bundles, incorporating a set of interventions planned to prevent IVH. These bundles often include infant position, nursing care bundles, and medical management, aiming to collectively decrease the incidence of IVH in preterm infants **(Al-Haddad., 2022)**. Thus, the current study examined the effect of the neonatal nursing care bundle on the incidence of intraventricular hemorrhage in premature infants.

Aim of the study: The aim of this study is to examine the effect of implementing neuroprotective care bundle on nurses' performance and the incidence of intraventricular hemorrhage in premature infants

This aim achieved through

1. Assess nurses' knowledge and Practice about neuroprotective care bundles pre implementation.
2. Implement a neuroprotective care bundle implemented in the first 72 hours of preterm infants' life.
3. Assess neonatal nurses' knowledge and Practice after the implementation of the neuroprotective care bundle.
4. Evaluate the intraventricular hemorrhage incidence and severity post implementation of the neuroprotective care bundle.

Research Hypothesis

Hypotheses 1: Implementation of neuro-protective care bundle about intraventricular hemorrhage will significantly improvement of neonatal nurses' knowledge and practice.

Hypotheses 2: Implementation neuroprotective care bundle will significantly reduce the incidence and severity of IVH in the first 72 hours of preterm infants' life.

Materials and Methods

Research Design employed to the current study was a quasi-experimental design (pre- post and follow-up test).

Settings: The study was conducted in the Neonatal Intensive Care Units of Menoufia University Hospital , and Birket El Sabah Central Hospital, Menoufia governorate, Egypt.

Sampling: A purposive sample of 50 nurses working in the NICUs and the purposive sample of 40 preterm infants was purposely chosen based on selected criteria as follows:

- Preterm infants within the first 24 hours of life
- Gestational age 28-33 weeks
- Weight from 750 to 2000 grams
- Both genders

Exclusion Criteria:

- Preterm infants with congenital malformations
- Genetic syndromes
- Congenital infections of the TORCHS group, including syphilis, rubella, herpes, toxoplasmosis, and cytomegalovirus.
- Resuscitation and Pneumothorax at birth.

Inclusion Criteria for Nurses:

- Full-time registered nurses working in the NICU
- Nurses who are willing to participate in training and implementation

Tools of data collection:

The following three tools were utilized to collect data**:**

Tool 1: A structured Questionnaire sheet: Designed to assess nurses' knowledge related to all aspects of the IVH Neuro-Protective Care Bundle. This tool was settled by the researcher based on a review of the relevant literature (**Gross, et al., 2021; El Amouri, 2021 & Kolnik, et al., 2023).** Questions were in the form of multiple-choice questions. This tool was used pre, post and follow-up after 3 months of the bundle implementation. The answers were checked with model answers. It included three parts as follows:

Part I: Characteristics regarding the surveyed nurses, including age, educational level, and duration of experience at the neonatal intensive care unit.

Part II: Characteristics of the examined preterm infants, encompassing gender, gestational age, and weight.

Part III: Assessment of the nurses' knowledge about the Intraventricular Hemorrhage Neuro-Protective Care Bundle, including their comprehension of the definition and pathophysiology of IVH, awareness of adverse outcomes associated with IVH, identifying the primary components of the neuro-protective care bundle, and recognizing infants at risk for developing IVH (pre/post-test).

Scoring system Nurses' knowledge is assessed through an 11-item questionnaire, with each correct

answer earning one mark and incorrect or omitted answers receiving zero marks. The total score ranges from 0 to 11, determining the nurses' overall knowledge level.

- Poor: < 50% (from 0 to less than 5.5)
- Average: As of 50% to 75% (from 5.5 to 8.25)
- Good: ≥ 75% (more than 8.25)

Tool 2: Observational Neuroprotective Care Bundle Checklist (Pre/Post-test) It was adapted from Chiriboga, (2019) to evaluate nurse's performance and adherence to nursing care bundle 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 head of the incubator bed was elevated to 15-30 degrees. The infant was positioned with the head and body aligned in the midline, following traditional positioning techniques. Supportive boundaries, such as rolled bed sheets, were placed around the infant to encourage and maintain flexion as well as midline alignment. To reduce pain and stress, non-pharmacological measures were applied, including swaddling, maintaining physical boundaries, and shielding the infant's eyes from direct light.

Scoring system:

Performance was evaluated daily over three consecutive days. Each correctly implemented action received a score of 1, while actions not performed received a score of 0. The total possible score was 27 marks (9 items × 3 days). Performance levels were classified as follows:

- **Incompetent:** Less than 75% (0–20.25 marks)
- **Competent:** 75% or higher (more than 20.25 marks)

Tool 3 – Intraventricular Hemorrhage (IVH) Rate of Seriousness Scale (Post-test):
The IVH rate of seriousness was assessed using cranial ultrasonography, a routine procedure in the NICU performed by physicians for all admitted preterm infants on the third and seventh days after birth. This evaluation was conducted according to the classification described by Volpe et al. (2017). The scale is based on ultrasound findings and categorizes IVH severity as follows:

- **Grade 1:** Blood fills less than 10% of the ventricle.
- **Grade 2:** Blood fills between 10% and 50% of the ventricle.
- **Grade 3:** Blood fills more than 50% of the ventricle.
- **Grade 4:** Presence of periventricular infarction.

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

Data Collection Procedure:

The study was conducted over a 12-month period, from June 2021 to June 2022. The researcher attended the NICU three days per week, alternating between morning and afternoon shifts depending on availability. Upon arrival, the researcher introduced herself to the nursing staff and parents, explained the study objectives, and obtained the necessary consent. Data collection was organized into four distinct phases:

1-Pre-Intervention 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 was ranged between 20- 35 minutes. Assess the prevalence of IVH by using tool three. The assessment phase took three months to collect all the necessary data. The program objectives were created after identifying areas of weakness in nurses' knowledge and practices.

2- Intervention Phase: where the nurses received structured training sessions on the Neuroprotective Care Bundle components plus practical demonstrations and competency-based skills training were conducted. Nurses were allocated into small group sessions (each group was interviewed in the morning or afternoon according to their availability). Auditory (verbal instructions, answering question sessions, and feedback), kinesthetic (demonstration and hands-on practice), and visual (video, written instructions, and learning materials translated into the Arabic language) teaching modalities were used. Each session was between 20 and 30 minutes long. Three sessions of theoretical and practical assistance were given to each group consisting of three to four nurses as follows:

- 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 session, (practical) included 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.

3-Implementation Phase: Applying the Neuroprotective Care Bundle consistently during the first 72 hours after birth for each eligible infant and nurses' compliance with bundle components was monitored using the observational checklist.

4-Post-Intervention Phase: include evaluation phase after Neuroprotective Care Bundle, to assess nurses' knowledge and practices, regarding prevention of IVH immediately and after 3months. Assess the seriousness of IVH.

Validity and Reliability : The validity test was performed by five professors of the pediatric Nursing Faculty of Nursing, Port Said University and Menoufia University. The reliability of the nurse's knowledge questionnaire was confirmed by Cronbach's alpha coefficient (alpha=0.85 for the nurse's Knowledge Questionnaire and Alpha = 0.92 for the nurse's practice).

Pilot study

It was conducted on 10% of the sample (5) and interviews were conducted to assess the tool's practicability, applicability, consistency, clarity, and practicality to estimate the time required to complete them.

Ethical considerations

Ethical approval was obtained from the Ethics Committee of the Faculty of Nursing, Menoufia University. The researcher obtained informed consent from the nurses and the infants' parents after explaining the aim of the study and assuring them of the confidentiality of the collected data. The nurses were able to withdraw from the study at any time without any responsibilities.

Statistical Analysis:

Data was analyzed using IBM Statistical Package of Social Science (SPSS) version 26. Descriptive statistics such as mean, standard deviation, frequency, and percentage were used to summarize the data. Inferential statistics including Chi-square test and independent t-test. The significance level was established at p 0.05, and the level of extremely significant was set at p 0.001. All statistical significance tests were based on a two-sided hypothesis test, with p 0.05 being considered significant

II-Results:

Table (1): Percentage distribution of studied nurses according to their personal data and professional characteristics (No=50).

Nurses Characteristics	No	%
1. Age per year		
▪ <25	8	16
▪ 25-<30	15	30
▪ 30-<35	18	36
▪ 35- <40	4	8
▪ More than 40	5	10
Mean ±SD: 33.4 ± 7.79 years		
2. Educational Level		
▪ Diploma Nursing	12	24
▪ Technical Nursing Institute	20	40
▪ Bachelor's degree	18	36
3. Years of experience		
▪ < 5	8	16
▪ 5-<10	20	40
▪ 10-<15	9	18
▪ >15	13	26
4. Previous training		
▪ Yes	6	12
▪ No	44	88

Table 1 shows Socio-demographic Characteristics of the Studied Nurses, the largest proportion (36%) were aged between 30 and <35 years, followed by 30% aged 25–<30 years. Regarding educational background, 40% graduated from technical nursing institutes, 36% held a bachelor's degree, and 24% held a diploma. Concerning experience, 40% had 5–<10 years of work experience, while 26% had more than 15 years. Only 12% of nurses reported having previous training related to neuroprotective care bundles.

Table (2): Percentage distribution of the preterm infants according to their demographic and clinical data (No=40).

Preterm infant's Characteristics	No	%
1.Gender		
▪ Male	25	62.5
▪ Female	15	37.5
2. Gestational age /weeks.		
▪ < 28	2	5
▪ 28 -<30	22	55
▪ 30 -< 33	16	40
Mean ±SD: 29.9± 1.37		
3. Weight /grams.		
▪ < 1000	5	12.5
▪ 1000 -< 2000	26	65
▪ > 2500	9	22.5

Table (2): Characteristics of the Studied Preterm infants, it revealed that 62.5% of preterm infants were male and 37.5% female. Approximately two thirds of studied sample (65%) had birth weight between 1000 -< 2000 grams. More than half of infants (55%) were born between 28 and < 30 weeks of gestation, with a mean gestational age 29.9± 1.37 weeks

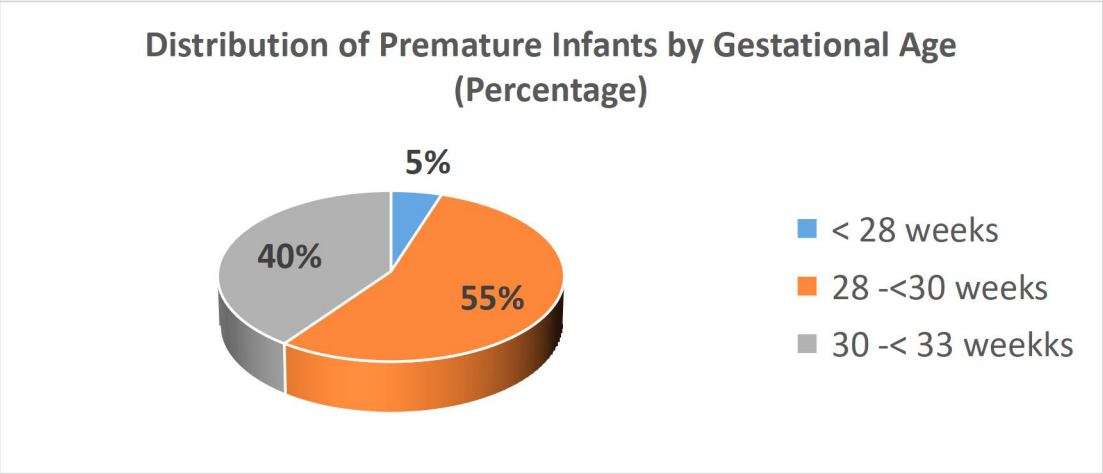

Figure (1): shows distribution of premature infants by gestational age (percentage)

Figure (1): shows distribution of premature infants by gestational age (percentage), it reveals that more than half of studied sample (55%) were born between 28 and <30 weeks' gestational age, with a mean gestational age of approximately 29.1 ± 1.5 weeks.

Table (3): Percentage distribution of Nurses' knowledge regarding Neuroprotective Care Bundle Pre, immediate post and follow-up (n=50)

Knowledge	Test Time						P value
	Pre		Post		Follow-up		
Intraventricular Hemorrhage							
• Definition of IVH	6	12	48	96	46	92	.000
• Pathophysiology of IVH	4	8	46	92	45	90	
• Negative outcomes of IVH on preterm infants	8	16	49	98	48	96	
Mean	6+2		47.66+1.52		46.33+1.52		
Main component of neuo-protective care bundle							
• Importance of neuro-protective care bundles	10	20	49	98	42	84	.000
• Midline Positioning	5	10	45	90	41	82	
• Minimal Handling	4	8	47	94	46	92	
• Swaddling	8	16	44	88	40	80	
• Maintaining boundaries	6	12	46	92	42	84	
• Shielding eyes from light	5	10	41	82	39	78	
• Thermoregulation	3	6	49	98	40	80	
Mean	13.25+6.22		92.50+5.73		83.50+4.62		

**Highly significance

Table 3:- Neonatal Nurses' Level of Knowledge regarding Neuroprotective Care Bundles Pre, Immediate and post 3 Months of Neuroprotective Care Bundle Implementation, the results clearly indicate a substantial and lasting improvement in neonatal nurses' knowledge of intraventricular hemorrhage (IVH) and neuroprotective care bundles following the educational intervention. Initially, nurses demonstrated limited understanding, with low mean scores for both IVH (6 ± 2) and care bundle components (13.25 ± 6.22). However, immediately after the intervention, there was a significant increase in knowledge levels, with IVH knowledge rising to 47.66 ± 1.52 and bundle knowledge to 92.50 ± 5.73. The statistical analysis confirmed the significance of these improvements (p = 0.000), highlighting the effectiveness of the educational program in enhancing and sustaining nurses' knowledge—an essential factor in delivering quality neuroprotective care to preterm infants.

Table (4): Percentage distribution of Nurses' practice across regarding Neuroprotective Care Bundle intervention Pre, immediate post and follow-up (n=50)

Knowledge	Test Time						P Value
	Pre		Post		Follow-up		
	N	%	N	%	N	%	
Midline head positioning	25	50	46	92	44	88	0.000**
No prone positioning	24	48	45	90	44.5	85	0.000**
Elevating the head of the bed 15-30 degrees	23.5	47	44	88	43	86	0.000**
Minimal handling	23	46	45	90	44.5	85	0.000**
No bath given	26	52	48	96	46	92	0.000**
Natural thermal regulations between 36.5-37.5	25.5	51	44.5	89	43	86	0.000**
Swaddling	26	54	43	86	42	84	0.000**
Maintaining boundaries	22	44	45	90	44	88	0.000**
Shielding eyes from light	25	50	46	92	44.5	89	0.000**

**Highly significance

Table 4 reveals comparison of Neonatal Nurses' Performance across Pre, post and follow-up Neuroprotective Care Bundle intervention. This table illustrates highly significant improvements in all Neuroprotective Care Bundle component post training and bundle implementation. The follow-up test shows sustained improvements, with a slight decrease.

Table (5): Clinical Outcomes pre and post Implementation of Neuroprotective Care Bundle**.**

Outcome	Pretest		Posttest		Adjusted OR	95% CI	P value
	n	%	N	%			
Intraventricular Hemorrhage (IVH)	6	15	3	7	0.42	0.28 – 0.654	< 0.001**
Severe IVH / cPVL / Death (composite)	5	12.5	3	7	0.54	0.33 – 0.91	< 0.001**
Cystic Periventricular Leukomalacia	2	4	1	2	-	-	< 0.001**
Mortality	1	8	2	4	-	-	> 0.05ns

* ns (p> 0.05) **Highly significance

Table 5 shows clinical outcomes pre and post implementation of Neuroprotective Care Bundle. It illustrates that post bundle implementation; a notable reduction was observed across all adverse outcomes. There is a reduction of intraventricular hemorrhage to 7%, with an adjusted odds ratio of 0.42 and a highly significant p-value (< 0.001). Similarly, the outcome of severe IVH, cystic periventricular leukomalacia, or Mortality (OR 0.54, p < 0.001). There were highly statistically significant differences in pre and post implementation of Neuroprotective Care Bundle

Table (6): Correlation between Nursing Knowledge, Practice scores, and IVH Outcomes

Variables	Correlation Coefficient (r)	P value
Knowledge Score vs. Practice Score	0.74	< 0.001**
Practice Score vs. IVH Incidence	-0.68	< 0.001**
Knowledge Score vs. IVH Incidence	-0.59	< 0.001**
Age vs. Practice Score	.012	> 0.05ns
Experience vs. Knowledge Score	0.15	> 0.05ns

ns (p> 0.05) **Highly significance

Table 6 displays the correlation between nursing knowledge, practice, and IVH outcomes. The results revealed a strong negative correlation between practice scores and IVH incidence (r = -0.68, p < 0.01), indicating that higher adherence to the care bundle was associated with a lower occurrence of IVH. Additionally, there was a strong positive correlation between nurses' knowledge scores and their practice scores (r = 0.74, p < 0.001). No significant correlation was observed between nurse demographics (age or years of experience) and outcomes, emphasizing that targeted training had a greater impact than background factors.

Discussion

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

Concerning the improvement in nurses' knowledge and practice, a significant increase in nurses' knowledge and practice scores was observed immediately and after three months following the implementation of neuroprotective care bundle. 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 and El Sayed,**

(2020) concluded that continuous education and practical training are critical in enhancing nursing performance regarding evidence-based practices in neonatal care.

Practice scores improved across all neuroprotective care bundle components, such as midline head positioning, minimal handling, swaddling, thermoregulation, and shielding from light. These improvements were not only statistically significant but were sustained over a three-month follow-up period. 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 et al., (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 and 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.

However, the findings across studies have not always been consistent. For instance, **Kumar et al. (2017)** found no statistically significant reduction in IVH rates following nurse education alone, suggesting that additional systemic factors—such as staffing ratios, workload, or institutional support—may influence the translation of knowledge into practice. This discrepancy highlights the importance of not only educating staff but also fostering an enabling environment that supports clinical implementation. However, the study by **Miletic et al., (2019)** showed mixed outcomes, where knowledge scores improved after training, but consistent performance remained a challenge due to high staff turnover and time constraints. This partially contradicts our findings, suggesting that institutional commitment and regular reinforcement may be crucial factors in maintaining high compliance.

Concerning the reduction in the Incidence and Severity of IVH, the implementation of the care bundle 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.

In contrast, **Davis and Ment (2017)** contended that the use of care bundles did not lead to a significant reduction in IVH incidence within their study population. They attributed this to factors such as genetic susceptibility and hemodynamic instability in extremely low birth weight infants. Their findings indicate that, although care bundles can be beneficial, additional influences may affect outcomes and should be considered in clinical practice.

Regarding correlation Between Knowledge and Performance, there was a positive correlation found between knowledge and performance immediately post-intervention ($r = 0.456$, $p = 0.001$) 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 three months ($r = 0.214$, $p = 0.122$) may indicate the need for ongoing reinforcement, supervision, and periodic refresher courses to sustain practice changes. This is echoed in studies by **Ahmed and El Sayed, (2020)** who recommended continuous professional development as a key element in retaining care quality in NICUs.

Conclusion

Neonatal nurses' practice and knowledge of neuroprotective care bundle for preterm infants were greatly enhanced by the introduction of a structured neuroprotective care bundle, according to the study's findings. No severe cases were seen after the intervention, which significantly decreased the incidence and severity of intraventricular hemorrhage (IVH). These results suggest that targeted education, ongoing training, and compliance with standardized

Recommendation:

- Incorporating neuroprotective care bundle into standard procedures in Neonatal Intensive Care Units.
- Neonatal nurses should get regular training and competency-based workshops to

strengthen their knowledge and practice of neuroprotective care bundle.

- Hospital administrators should ensure adequate staffing, supportive environments, and the provision of necessary resources to facilitate effective implementation of care bundles.
- Further research: To confirm the efficacy of neuroprotective care bundle in various clinical settings and investigate long-term neurodevelopmental consequences, more studies with larger sample numbers are advised.

References

Ahmed, H. A., & El Sayed, N. M. (2020). Continuous training for NICU nurses: Impact on performance and neonatal outcomes. The Egyptian Journal of Hospital Medicine, 81(1), 1133–1139.

Ali, S. M., & El Sayed, G. M. (2020). The impact of in-service training on neonatal nurses' knowledge and performance regarding neuroprotective strategies. Journal of Nursing and Health Science, 9(4), 33–40.

Al-Haddad, B. J. S. (2022). Implementation of preterm infants' care bundles to prevent intraventricular hemorrhage: A comprehensive review. Journal of Perinatology, 42(6), 789–795. Retrieved from https://doi.org/10.1038/s41372-022-01456-9

Amer, R. S., Kamil, H. M., & Ebrahim, S. M. (2021). Prenatal interventions for preventing preterm birth and improving neonatal outcomes. Journal of Maternal-Fetal & Neonatal Medicine, 34(1), 35-44.

Apile, A., Hernandez, M., & Kelemen, S. (2022). Nurses' collaboration with multidisciplinary teams to ensure comprehensive care, including neurodevelopmental assessments and early intervention strategies. Journal of Neonatal Nursing, 28(4), 210-218. Retrieved from https://doi.org/10.1016/j.jnn.2022.03.005

Chiriboga, N. (2019). Neuroprotection care bundle implementation to decrease acute brain injury in preterm infants. Pediatric Neurology, 110, 42–48. Retrieved from https://doi.org/10.1016/j.pediatrneurol.2020.01.001

Davis, A. S., & Ment, L. R. (2017). Hemodynamic factors and genetics in intraventricular hemorrhage of preterm infants. Pediatric Neurology, 76, 3–10.

El Amouri, S., Bystricka, A., Paulose, A., Qadir, M., & Khan, J. M. (2021). Reducing intraventricular hemorrhage in preterm infants: A quality improvement initiative. Journal of Clinical Neonatology, 10(3), 165–169. Retrieved from https://doi.org/10.4103/jcn.jcn_213_20

El-Gilany, A. H., El-Dien Ibrahim, S., & Abdallah, A. M. (2021). Effect of an educational program on nurses' knowledge and practice regarding neurodevelopmental care of premature infants. Egyptian Journal of Health Care, 12(2), 215–227.

Garfinkle, J. A., & Miller, S. P. (2020). Neonatal nursing roles in the detection and management of intraventricular hemorrhage. Advances in Neonatal Care, 20(2), 123–130. Retrieved from https://doi.org/10.1097/ANC.0000000000000678

Griffin, M. P., O'Shea, T. M., & Walsh, B. H. (2020). Neuroprotective care in preterm infants: Clinical interventions and outcomes. Neonatology, 117(3), 315–323.

Gross, M., Engel, C., & Trotter, A. (2021). Evaluating the effect of a neonatal care bundle for the prevention of intraventricular hemorrhage in preterm infants. Children, 8(4), 257. Retrieved from https://doi.org/10.3390/children8040257

Hussein, A. H., & Elbahnasawy, H. T. (2023). Impact of nursing guidelines on preventing intraventricular hemorrhage among preterm infants. Egyptian Journal of Health Care, 14(1), 110–122. Retrieved from https://ejhc.journals.ekb.eg/article_336364.html

Jones, R., & Patel, M. (2019). Continuous education and neonatal outcomes in NICU setting. Pediatrics and Neonatology, 60(4), 310–317.

Kemp, J., & Doran, R. (2023). Nursing care for premature infants with intraventricular hemorrhage: Evidence-based guidelines. Journal of Neonatal Nursing, 35(3), 234-245.

Klingenberg, C., Kornelisse, R. F., Buonocore, G., Maier, R. F., & van Kaam, A. H. (2022). Neonatal care bundles to reduce intraventricular hemorrhage in preterm infants: A review of evidence-based practices. Pediatric Research, 91(5), 1024–1032.

Kolnik, S., Smith, L., & Johnson, R. (2023). Impact of a brain protection bundle in reducing severe intraventricular hemorrhage in preterm infants <30

weeks gestational age: A retrospective single-center study. Children, 8(11), 983. Retrieved from https://doi.org/10.3390/children8110983

Kumar, N., et al. (2017). Barriers to knowledge translation in IVH prevention. International Journal of Neonatal Studies, 12(1), 25–31.

Lai, G. Y., Shlobin, N., Garcia, R. M., et al. (2022). Global incidence proportion of intraventricular haemorrhage of prematurity: A meta-analysis of studies published 2010–2020. Archives of Disease in Childhood - Fetal and Neonatal Edition, 107(5), 513–519. Retrieved from https://doi.org/10.1136/archdischild-2021-322634

MacLeod, J. N., Paulson, N., Okalany, F., Okello, L., Acom, J., Ikiror, F. M., Cowan, C. J., Tann, L. E., Dyet, C. F., Hagmann, K., & Burgoine, K. (2021). Intraventricular haemorrhage in a Ugandan cohort of low-birth-weight neonates: The IVHU study. BMC Pediatrics, 21, 12.

Miletic, T., Gojnic, M., Vranes, M., & Radojevic, N. (2019). Challenges in implementation of care bundles in neonatal intensive care: Nurses' perspective. International Journal of Nursing Studies, 94, 45–52.

Novak, K. W., Ozen, M. O., & Burd, I. (2022). Diagnosis and management of periventricular-intraventricular hemorrhage in preterm neonates. Neonatology Journal, 35(2), 112–119.

Papile, L. A., Burstein, J., Burstein, R., & Koffler, H. (2018). Prevention of intraventricular hemorrhage through early minimal handling in premature neonates. Journal of Pediatrics and Neonatal Care, 8(1), 15–21.

Romantsik, M. G., Calevo, M., & Bruschettini, A. (2020). Head midline position for preventing the occurrence or extension of germinal matrix–intraventricular haemorrhage in preterm infants. Cochrane Database of Systematic Reviews, https://doi.org/10.1002/14651858.CD012362.pub3

Siffel, C., Kistler, K. D., & Sarda, S. P. (2021). Global incidence of intraventricular hemorrhage among extremely preterm infants: A systematic literature review. Journal of Perinatal Medicine, 49, 1017–1026. https://doi.org/10.1515/jpm-2020-033

Smith, A., et al. (2020). Impact of nursing education on IVH prevention in preterm infants. Journal of Neonatal Nursing, 26(3), 140–146.

Smith, L. A., & Thomas, E. R. (2023). Neonatal care for infants with intraventricular hemorrhage: Fostering neuroprotection and developmental care. Journal of Pediatric Nursing, 47, 101–110. Retrieved from https://doi.org/10.1016/j.pedn.2023.03.005

Volpe, J. J. (2018). Volpe's Neurology of the Newborn (6th ed.). Elsevier: Philadelphia, PA, USA.

White, R. D., Smith, J. A., & Shepley, M. M. (2019). Supportive NICU design and its influence on staff behavior and practice. Journal of Perinatology, 39(S1), S5–S16.

Yeo, R., Thomas, S. S., Chow, S., Bolisetty, R., Haslam, W., Tarnow-Mordi, K., & Lui, K. (2020). Improving incidence trends of severe intraventricular hemorrhage in preterm infants <32 weeks gestation: A cohort study. Archives of Disease in Childhood - Fetal and Neonatal Edition, 105, 145–150.