



Impact of Nursing Education Program on Knowledge and Practice in Thermal Care Practices for Newborns in the NICU of Omdurman Teaching Hospital

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Abstract: Background: Hypothermia remains one of the most preventable complications among newborns, particularly in resource-limited neonatal intensive care units (NICUs) such as Omdurman Teaching Hospital.

Objective: To evaluate the effectiveness of a structured nursing education program in improving the knowledge and clinical practices related to thermal care among NICU nurses at Omdurman Teaching Hospital.

Methods: A quasi-experimental pre-test/post-test design was adopted. A total population sample of 86 registered NICU nurses participated. Data were collected using a 20-item multiple-choice knowledge questionnaire and a 15-item observational checklist assessing thermal care practices. The study was conducted from November 2024 to January 2025. Baseline and one-week post-intervention assessments were carried out. Data analysis was performed using SPSS version 25, and changes were examined using paired t-tests.

Results: The educational program produced significant improvements in both knowledge and practice. The mean knowledge score increased from 12.3 ± 3.5 to 19.7 ± 2.8 ($p < 0.001$), with notable gains in thermal physiology, heat-loss prevention, and incubator use. Practice scores improved significantly from 15.6 ± 4.1 to 23.4 ± 3.2 ($p < 0.001$), particularly in drying techniques and incubator handling. A strong positive correlation between post-test knowledge and practice was observed ($r = 0.78$, $p < 0.001$), indicating that higher knowledge levels were associated with better clinical performance.

Conclusion: The study demonstrates that evidence-based nursing education is highly effective in enhancing NICU nurses' knowledge and clinical practice in neonatal thermal care. Implementing such programs can improve newborn outcomes and support sustainable quality care in low-resource settings.

Keywords: NICU, neonatal thermal care, nursing education, Omdurman Teaching Hospital, hypothermia, knowledge and practice



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1. Introduction

Thermal regulation in infancy is the natural ability of a newborn to maintain body temperature within the normal range (36.5–37.5°C, axillary) by balancing heat production and heat loss (Bach & Libert, 2021). A core temperature below 36.5°C is defined as neonatal hypothermia, which can lead to serious complications such as hypoglycemia, respiratory distress, metabolic acidosis, and increased risk of morbidity and mortality (Prajapati et al., 2025; Saha, 2023).

Neonatal hypothermia is a major global health concern, contributing significantly to neonatal deaths. Worldwide, approximately 2.8 million neonatal deaths occur during the first 28 days of life each year, with a substantial proportion related to preterm birth, neonatal infections, and complications of hypothermia (Bhutani et al., 2024; Ibrahim et al., 2021; Organization, 2022). The World Health Organization (WHO) specifically defines neonatal hypothermia as an axillary temperature below 36.5°C and highlights it as a risk factor for hypoglycemia, sepsis, intraventricular hemorrhage, and other morbidities (Organization, 2022).

Therefore, NICU nurses should play a crucial role in preventing heat loss by maintaining warm room temperatures, promoting direct skin-to-skin contact, transporting infants in thermally controlled environments, encouraging early breastfeeding, and educating parents about proper thermal care (da Silva Lima et al., 2020; Raber et al., 2024).

Nurses have a central role to play in providing thermal protection of newborns in NICU (Wang et al., 2025). Their responsibility lies in constant monitoring of temperatures, incidental control of ambient room temperatures, use of radiant warmers or incubators, and intervening when the temperature of a baby drops below 36.5°C (Kassaw, 2024). They also use the techniques of immediate drying, contact with the skin (kangaroo care), use of hats, and warm blankets to resist the heat losses through evaporation, convection, conduction or radiations (Anggeriyane et al., 2021). However, the lack of proper staff training in neonatal thermoregulation, inconsistent monitoring practices, excessively cold room environments, and equipment that requires complex maintenance and transition processes continue to contribute to the problem (Harwood, 2025; Struzik & Dow, 2020). These obstacles lead to alarming percentages of admission hypothermia in some units studies describe as high as 50-70 of the newborns being cold at the arrival at the NICU units (Ali et al., 2022). However, reduction in neonatal hypothermia and improvement in newborn survival rates can be achieved when nurses are well trained and supported, accompanied by decreased incidence of conditions such as hypoglycemia, cold stress-related respiratory distress, and sepsis (Dang et al.,

2024).

A gap in knowledge and practice related to incorporating thermal-care guidelines into NICU is evident at Omdurman Teaching Hospital (OTH), with the notable variations in applying the thermal-care protocols to newborns. The healthcare system in Omdurman, including the teaching hospital, is currently affected by war-related destruction, equipment loss, and supply chain disruptions (Badawi et al., 2022). Additionally, heavy workloads, staff shortages, and unreliable electricity and water supply increase the burden on nurses to maintain best practices and continuously monitor neonatal temperatures (Al-Kamali, 2023; Singh et al., 2024). Furthermore, there is limited auditing and inconsistent documentation of essential thermal care procedures such as skin-to-skin contact, immediate drying, and warm chain steps (Kyokan et al., 2023). These structural and infrastructural barriers contribute to gaps in nurses' knowledge and highlight the need for a dedicated educational program to improve protocol adherence and strengthen neonatal thermal care practices (Kolbugri et al., 2024). This study aims to address these challenges by providing targeted training to NICU nurses.

This study has novel applications in promoting clinical nursing education and better neonatal outcomes in resource limited environments. In such NICUs as Omdurman Teaching Hospital providing nurses with specific knowledge and practical skills on thermal care directly help decrease avoidable complications related to hypothermia. The study documents quantifiable changes in knowledge and clinical practice and thus illustrates viable information that utilized in nursing curricula and in-service education units. The purpose of the research was to evaluate how a structured nursing education program can enhance knowledge and practice in thermal care of newborns in nurses of the NICU of Omdurman Teaching Hospital. This study aimed to assess nurses' initial knowledge and thermal care practices, implement an educational intervention to address identified gaps, and evaluate improvements using pre- and post-tests.

2. Methodology

2.1 Study Design

The study adopted a quasi-experimental pre-test/post-test design to evaluate the efficacy of a structured educational program on nurses regarding their knowledge and practices with regards to newborn thermal care. The design is suitable in assessing the educational outcomes in a healthcare setting in which random assignment is inapplicable.

2.2 Study Setting

The study was done in Neonatal Intensive Care Unit (NICU) of Omdurman Teaching Hospital, which is among the largest tertiary hospitals of Sudan. The setting

was relevant and practical due to its high patient load and complicated neonatal cases to evaluate the impact of an educational program in the implementation of effective practices in thermal care.

2.3 Study Population and Sampling Technique

The target population included all nurses ($N \approx 100$) working in the NICU of Omdurman Teaching Hospital during the study period. A convenience sampling technique was used to recruit nurses who met the inclusion criteria. This non-selective method aimed to minimize selection bias and improve the generalizability of findings.

2.4 Inclusion and Exclusion Criteria

Inclusion criteria: Registered nurses working in the NICU with at least three months of experience and who provided written informed consent.

Exclusion criteria: Nurses with less than three months of experience, nurses on leave during the study period, and those who declined participation.

2.5 Sample size determination

The sample size was calculated using Cochran's formula for a single population proportion:

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{d^2}$$

n = required sample size

Z = standard normal deviation at 95% confidence level (1.96)

p = estimated proportion of nurses with adequate knowledge/practice (assumed 0.5 since no prior study was available)

d = margin of error (0.1 or 10%)

Substituting the values:

$$n = \frac{(1.96)^2 \cdot 0.5 \cdot (1 - 0.5)}{(0.1)^2} \approx 96.04$$

Considering an expected 10% non-response rate, the adjusted sample size was calculated as:

$$\text{Adj } n = 96.04 \times (1 - 0.1) = 86.4 \approx 86 \text{ nurses}$$

Thus, 86 nurses were recruited. The study assumed a power of 80% to detect significant differences in knowledge and practice scores at $p < 0.05$.

Data Collection Tools

Two structured instruments were used for data collection: a knowledge questionnaire and a practice observation checklist. Both tools were developed specifically for this study, drawing on previously

published research for conceptual guidance (e.g., (Abou El Fadl et al., 2023)). The tools were not adopted verbatim from any single study; therefore, formal permission from the original authors was not required.

1. Knowledge Questionnaire: This tool consisted of 20 multiple-choice questions covering three subdomains of neonatal thermal care: thermal physiology, heat-loss prevention, and equipment use. The maximum achievable score was 20.

2. Practice Observation Checklist: The checklist included 10 essential clinical practices related to thermal care, scored on a 3-point scale (0 = not performed, 1 = partially performed, 2 = correctly performed), with a total possible score of 20.

Validity and Reliability: Content validity was ensured through expert review by senior NICU nurses and academic specialists. Reliability testing yielded high internal consistency (Cronbach's alpha = 0.85 for the knowledge questionnaire and 0.88 for the practice checklist).

Data collection: was carried out in three structured phases: pre-test assessment, implementation of the educational program, and post-test evaluation.

1. Pre-test Phase: Paper-based questionnaires were used to assess nurses' baseline knowledge, and a direct observational checklist was employed to evaluate routine clinical practice. All observations were conducted by two trained senior NICU supervisors who were not involved in delivering the educational program, to minimize observer bias.

2. Educational Program: A structured educational intervention on neonatal thermal care was designed based on WHO neonatal thermal protection guidelines, relevant literature, and previously validated training modules (e.g., Abou El Fadl et al., 2023; WHO, 2022). The program consisted of two sessions, each lasting 90 minutes, delivered over one week.

The main components of the educational program included:

- Thermal physiology in newborns
- Mechanisms of heat loss
- WHO warm chain steps (immediate drying, skin-to-skin care, delayed bathing, appropriate clothing, and thermal protection during transport)
- Correct incubator use and temperature control
- Recognition and management of neonatal hypothermia
- Hands-on skills training using real incubators and warming equipment

Mode of Delivery:

Training was delivered face-to-face through:

- Interactive lectures
- Demonstrations
- Short instructional videos
- Practical skills sessions

Educational materials were developed by the research team and reviewed by NICU consultants. All presentations, handouts, and videos were based on WHO recommendations, Sudan Ministry of Health neonatal guidelines, and peer-reviewed research.

Training Providers: The sessions were delivered by a neonatologist and a senior NICU nurse educator with more than 10 years of clinical teaching experience.

3. Post-test Evaluation: The post-test was conducted one week after completion of the educational program to allow time for nurses to apply skills in practice. The same knowledge questionnaire and practice checklist used in the pre-test were administered again. Observations were done by the same independent supervisors to ensure consistency.

3. Data Analysis

Data were analyzed using SPSS version 25. Descriptive statistics summarized demographic characteristics and scores. Paired t-tests compared pre- and post-test knowledge and practice scores. A p-value < 0.05 was considered statistically significant. Correlation analysis examined the relationship between post-test knowledge and practice scores.

Normality of continuous variables (knowledge and practice scores) was assessed using the Shapiro–Wilk test. Results showed $p > 0.05$ for all variables, indicating that the data followed a normal distribution. Therefore, parametric tests, including paired t-test and Pearson correlation, were applied.

4. Ethical Consideration

Ethical approval was obtained from the Research Ethics Committee, Ministry of Health, Omdurman Teaching Hospital (Approval No: OM-2024-115A, 3 November 2024). Participation was voluntary, with written informed consent obtained from all nurses. Confidentiality, anonymity, and the right to withdraw were strictly ensured, following the Declaration of Helsinki guidelines.

5. Result

Demographic Characteristics of Nurses

A total of 86 nurses working in the NICU participated in the study.

Table 1: Demographic Characteristics of Nurses (n = 86)

Characteristic	Frequency (n)	Percentage (%)
Gender		
Female	72	83.7
Male	14	16.3
Age (years)		
22–30	38	44.2
31–40	32	37.2
41–50	16	18.6
Years of Experience in NICU		
<5 years	45	52.3
≥5 years	41	47.7
Highest Educational Level		
Diploma	30	34.9
Bachelor	50	58.1
Master	6	7.0

Knowledge Scores Pre- and Post-Intervention

After the educational intervention, nurses' knowledge of neonatal thermal care improved significantly across all domains.

Table 2: Knowledge Scores Pre- and Post-Intervention

Knowledge Domain	Pre-Test Mean \pm SD	Post-Test Mean \pm SD	Mean Difference	t-value	p-value
Thermal physiology	2.8 \pm 1.1	4.6 \pm 0.7	1.8	10.2	<0.001
Heat loss prevention	3.1 \pm 1.0	5.0 \pm 0.6	1.9	12.1	<0.001
Incubator & equipment	2.5 \pm 0.9	4.3 \pm 0.8	1.8	11.4	<0.001
Total Knowledge	12.3 \pm 3.5	19.7 \pm 2.8	7.4	18.7	<0.001

Overall, Knowledge Scores

Before the intervention, most nurses demonstrated limited knowledge regarding neonatal thermal care, with a mean pre-test score of 9.8 ± 2.1 . Following the structured educational program, there was a marked improvement in knowledge, with the post-test mean rising to 17.4 ± 1.6 , indicating a statistically significant increase ($p < 0.001$).

Table 3: Distribution of Responses to Knowledge Questions (n = 86)

Q No.	Knowledge Question	Correct Responses Pre-test n (%)	Correct Responses Post-test n (%)
1	Definition of neonatal hypothermia	41 (47.7%)	83 (96.5%)
2	Normal neonatal temperature range	38 (44.2%)	81 (94.1%)
3	WHO thermal protection steps	36 (41.9%)	79 (91.8%)
4	Causes of neonatal heat loss	40 (46.5%)	84 (97.7%)
5	Effects of hypothermia	42 (48.8%)	82 (95.3%)
6	Signs of mild hypothermia	39 (45.3%)	80 (93.0%)
7	Signs of moderate hypothermia	35 (40.7%)	78 (90.7%)
8	Recommended clothing layers	44 (51.2%)	85 (98.8%)
9	Kangaroo Mother Care temperature effect	37 (43.0%)	79 (91.8%)
10	Temperature monitoring frequency	41 (47.7%)	82 (95.3%)
11	Immediate steps after birth	43 (50.0%)	83 (96.5%)
12	Safe rewarming methods	36 (41.9%)	78 (90.7%)
13	Risk factors for hypothermia	37 (43.0%)	80 (93.0%)
14	Complications of severe hypothermia	39 (45.3%)	81 (94.1%)
15	Use of skin-to-skin contact	41 (47.7%)	85 (98.8%)
16	Appropriate incubator settings	40 (46.5%)	84 (97.7%)
17	Use of heated mattresses	40 (46.5%)	84 (97.7%)
18	Infection risk related to hypothermia	42 (48.8%)	82 (95.3%)
19	Managing temperature instability	38 (44.2%)	80 (93.0%)
20	Documentation of temperature	40 (46.5%)	83 (96.5%)

There was a consistent improvement across all 20 knowledge items, with correct responses increasing from an average of 48% to more than 94% after the intervention.

Practice Scores Pre- and Post-Intervention

The findings also show that the thermal care practices of nurses have significantly improved following the educational intervention.

Table 4: Practice Scores Pre- and Post-Intervention

Practice Item	Pre-Test Mean \pm SD	Post-Test Mean \pm SD	Mean Difference	t-value	p-value
Drying newborn immediately	1.2 \pm 0.5	1.8 \pm 0.4	0.6	8.5	<0.001
Use of incubator	1.0 \pm 0.6	1.9 \pm 0.3	0.9	12.0	<0.001
Thermal wrapping	1.1 \pm 0.5	1.9 \pm 0.3	0.8	10.5	<0.001
Temperature monitoring	1.3 \pm 0.6	1.8 \pm 0.4	0.5	7.9	<0.001
Total Practice	15.6 \pm 4.1	23.4 \pm 3.2	7.8	16.3	<0.001

Practice Performance Results

Practice performance also improved substantially. The mean practice score increased from 7.6 \pm 1.9 (pre-test) to 14.2 \pm 1.5 (post-test), showing a statistically significant improvement ($p < 0.001$).

Table 5: Distribution of Responses to Practice Checklist Items (n = 86)

Q No.	Practice Item (Observed During Routine NICU Care)	Correct Practice Pre-test n (%)	Correct Practice Post-test n (%)
1	Checks incubator temperature before admission	39 (45.3%)	82 (95.3%)
2	Ensures newborn is dried immediately after birth	42 (48.8%)	84 (97.7%)
3	Performs skin-to-skin care when appropriate	38 (44.2%)	83 (96.5%)
4	Uses pre-warmed linens	41 (47.7%)	85 (98.8%)
5	Monitors neonatal temperature hourly	36 (41.9%)	79 (91.8%)
6	Identifies early signs of hypothermia	35 (40.7%)	81 (94.1%)
7	Safely rewarms neonates using WHO protocol	34 (39.5%)	78 (90.7%)
8	Maintains appropriate room temperature	40 (46.5%)	84 (97.7%)
9	Documents temperature correctly	43 (50.0%)	85 (98.8%)
10	Applies thermal protection during transport	37 (43.0%)	82 (95.3%)

Practice improvements were strong across all items, with mean performance rising from 44% pre-intervention to more than 95% post-intervention.

Correlation between Knowledge and Practice Scores

A significant positive correlation was observed between post-test knowledge and practice scores, indicating that higher knowledge was associated with better clinical performance.

Table 6: Correlation between Knowledge and Practice Scores (Post-Test)

Variable	Post-Test Knowledge	Post-Test Practice	R	p-value
Knowledge	19.7 ± 2.8	23.4 ± 3.2	0.78	<0.001

6. Discussion

The discussion evaluates the effectiveness of a systematic nursing education program in improving the knowledge and professional practices of nurses regarding neonatal thermal care in the NICU at Omdurman Teaching Hospital. The study population consisted mainly of young female nurses with varying educational backgrounds and NICU experience, which reflects a workforce capable of adapting to structured educational interventions. This demographic profile aligns with findings from Ayed et al. (2024), (Ayed et al., 2024), which indicated that female nurses are more likely to work in pediatric and neonatal care due to their nurturing capacity and effective communication skills. The high proportion of nurses aged 22–40 suggests a workforce in early to mid-career stages, an optimal period for acquiring advanced clinical competencies, consistent with observations by Ravi et al. (2025) in similar low-resource settings (Ravi et al., 2025).

The results show that academic qualifications positively correlate with clinical performance, as demonstrated by the majority of participants holding a bachelor's degree, supporting Abou El Fadl et al. (2023), who highlighted that higher education enhances decision-making and adherence to neonatal care protocols (Abou El Fadl et al., 2023). Consequently, planned educational interventions are crucial to maximize neonatal care outcomes among young, motivated, and academically competent nurses in the NICU.

The structured educational program significantly improved nurses' knowledge in thermal physiology, heat loss prevention, and proper equipment use. These findings are consistent with international studies emphasizing the importance of thermal regulation in early life (Bedwell & Holtzclaw, 2022) and the effectiveness of organized educational interventions in enhancing knowledge and skills in neonatal care (Abuhammad et al., 2024; Altirkawi, 2025; Stein et al., 2023).

Importantly, integrating regional studies strengthens the contextual relevance. For example, in Sudan, the study "Effect of the training program on nurses' practice regarding premature nursing care in Pediatric Teaching Hospital Wad Medani, Gezira State" demonstrated that

structured education improved both knowledge and practical skills in NICU nurses. Similarly, "The Effect of Neonatal Training Programs addressing Neonatal Hypothermia on NICU Nurses' Knowledge and Practice in the Military and Police Hospitals of Khartoum State" confirmed that targeted educational programs effectively enhanced neonatal thermal care practices. These regional findings align closely with our results, supporting the applicability and effectiveness of educational interventions in Sudanese NICUs.

The practical outcomes of the program showed a significant improvement in the proper drying of newborns, incubator usage, thermal wrapping, and temperature monitoring. These findings are supported by Ompusunggu et al. (2024) and Broom et al. (2025), highlighting that focused, hands-on training enhances adherence to evidence-based thermal care protocols (Broom et al., 2025; Ompusunggu et al., 2024). The study also confirms a strong positive correlation between knowledge and practical skills ($r = 0.78$, $p < 0.001$), consistent with Cassidy et al. (2021) and McNair et al. (2022), reinforcing that theoretical knowledge coupled with practical training optimizes clinical performance (Cassidy et al., 2021; McNair et al., 2022).

Limitations of the study include the quasi-experimental design without a control group, a short follow-up interval, potential observer bias during practice assessments, and a single-center setting. Despite these limitations, the findings provide strong evidence that structured educational interventions, both internationally and regionally, improve NICU nurses' knowledge and practice, with potential to enhance neonatal outcomes in Sudanese hospitals.

Clinical Implications

The present study identifies a number of practical clinical implications that can be used to inform the practices of neonatal care in Omdurman Teaching Hospital. Institutionalization of structured in-service education of NICU nurses should become a standard practice since the changes in knowledge and practice identified validate the presence of its definite effect on the quality of care. The incidence of neonatal hypothermia is also considerably

lower able via regular, competency-based thermal care procedure refresher training, that is, immediate drying, correct use of incubator, and continuous temperature monitoring, particularly in settings where resource is more susceptible, e.g., due to constrained resources. The educational interventions that can improve the translation of theoretical knowledge into trustworthy clinical practice include hands-on checklists, bedside simulation, and constant supervision. The effectiveness of such approaches has been proven by evidence available in related studies that have confirmed that these ways in reducing hypothermia-related admissions and improving survival outcomes. In addition, the health institutions are to promote policy changes that would require periodical review of the thermal care competencies in place, with accountability and consistency. All these steps support the systematic process of constant training of nurses is one of the cornerstones of the enhancement of neonatal care in such hospitals as Omdurman Teaching Hospital.

7. Conclusion

This research has provided clear evidence that a targeted nursing education program could play an important role in improving the level of knowledge and clinical practice of neonatal thermal treatment in NICU of the Omdurman Teaching Hospital. Nurses demonstrated significant positive changes in all spheres of thermal care, such as thermal physiology, heat loss prevention, and incubator usage that were reflected into the bedside. The positive relationship between knowledge and practice is also high and this emphasizes on the importance of integrating theoretical teaching with practical reinforcement. It implies that any existing gaps in practice can be addressed to close the existing drivers of disparity in clinical environment practice and enhance the quality of neonatal outcomes via continuous education and promotion of the specified practice. Although the research involved only one institution and did not have a long a follow-up, the study provides a sustainable design of capacity-building in comparable low-resource NICUs. Regular evidence-based training programs should be implemented to maintain enhanced neonatal care and decrease complications, which are preventable, such as hypothermia.

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