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ORIGINAL ARTICLE

The 10 steps to warmth: empowering optimal thermal care for newborns in Saudi Arabia

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ABSTRACT

Background: Newborn hypothermia, defined as an axillary temperature lower than 36.5°C, represents a major issue. It affects around 32% to 85% of newborns worldwide and is associated with an increased risk of complications. There is inadequate implementation of WHO guidelines in thermal care and limited evidence on the potential failures of their application.

Objectives: To significantly reduce the incidence of neonatal hypothermia Care Medical Hospital in Saudi Arabia by implementing the WHO thermal care guidelines.

Methods: The study was conducted at CARE Medical Al Rawabi in Saudi Arabia from December 2023 to June 2024. We implemented the 10 Steps to Warmth and followed a Six-Step Failure Mode and Effects Analysis (FMEA). Step 1: Identifying the process: Implementation of the WHO guidelines. Step 2: Identifying potential failure modes. Step 3: Rating the risk: Rating the occurrence, detection, and severity. Step 4: Develop action plans: Create strategies to reduce the occurrence, severity, or detectability of high-risk failure modes. Step 5: Implementing and monitoring: Implemented the action plans. Step 6: Re-evaluation: Periodically review the FMEA.

Results: The data showed that the implementation of the 10 steps of warmth reduced the incidence of hypothermia in newborns in the labor and delivery ward from 21% to 0%. Meanwhile, hypothermia during transfer to the normal newborn nursery was reduced from 34% to 0%. The incidence of hypothermia in the neonatal intensive care unit was reduced from 43% to 0%. The incidence of hypothermia after the first bath was reduced from 42% to 0%. The compliance of skin-to-skin adherence reached 100% following vaginal delivery and 95% following cesarean section.

Conclusion: The systematic implementation of the WHO 10 steps of warmth, using FMEA, reduced the incidence of hypothermia among newborns to zero and resulted in high adherence to skin-to-skin contact.

Keywords: 10 Steps, Warmth, optimal thermal care, Newborns.

Introduction

Newborn hypothermia, defined as having a temperature lower than 36.5°C, represents a major concern [1]. It is highly prevalent and affects 32%-85% of newborns delivered in hospitals worldwide and around 50% of the newborns in Saudi Arabia on admission [2,3]. Moreover, it is associated with an increased risk of complications, including intraventricular hemorrhage, infections, and respiratory disorders, and a high risk of death [1-5]. For instance, Laptook et al. [5] found that each 1°C drop in temperature of newborns increased the risk of sepsis by 11% and the risk of death by 28%. The WHO classified hypothermia according to the drop in temperature into mild when the temperature

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is from 36°C to 36.5°C, moderate when it is between 32°C and 36°C, and severe when it reaches less than 32°C [1]. Heat loss in newborns occurs through evaporation, conduction, convection, and radiation [6]. Furthermore, this is exaggerated in preterm and low-birth-weight newborns, considering that they have lower fat and higher heat evaporation [6]. Thus, strategies to optimize the thermal care of newborns are essential.

Several approaches have been suggested for reducing the incidence of hypothermia. For instance, the WHO proposed 10 steps to reduce the incidence of hypothermia in newborns [1]. These include a warm delivery room, drying of the newborn, skin-to-skin contact with the mother, encouraging breastfeeding, warm transport, warm resuscitation, delaying the first bath, and adequate training [1]. Although the implementation of these methods should reduce the incidence of hypothermia and, subsequently, the incidence of associated complications [7], suboptimal implementation of these strategies represents a challenge. For instance, Nyandiko et al. [8] found that 73.7% of the newborns experienced hypothermia on admission, with the mortality rates reaching 13% within the first 24 hours. However, less than 10% of them received adequate thermal care, which could be attributed to low adherence to the guidelines [8]. Thus, it is essential to identify potential failures in the application of these approaches.

Considering the inadequate implementation of WHO guidelines in thermal care and the limited evidence on the potential failures in the application of these approaches, we implemented the 10 Steps to Warmth project. The primary objective of the 10 Steps to Warmth project was to significantly reduce the incidence of neonatal hypothermia in Saudi Arabia by implementing the WHO thermal care guidelines. Additionally, in order to systematically identify and address potential failures in their application, we used Failure Mode and Effects Analysis (FMEA), which is a proactive method to identify systemic gaps in guideline adherence and reduce the associated risks [9].

Methods

Study design and setting

This is a quasi-experimental study with data collection in the pre- and post-intervention periods. The study was conducted at the maternity and neonatal units of CARE Medical Al Rawabi Hospital in Saudi Arabia. The program was implemented from December 2023 to June 2024 and followed the WHO 10 Steps to Warmth to optimize thermal care for newborns in the Labor & Delivery unit, Well Baby Unit, Neonatal Intensive Care Unit (NICU), and 4C maternity ward. The project involved a multidisciplinary team, including nursing staff, obstetric and gynecologic doctors, neonatologists, clinical instructors, and family. The project was conducted as a quality improvement initiative within the healthcare organization, and institutional approval was obtained per local policy requirements.

Intervention

We implemented the 10 Steps to Warmth and followed a Six-Step FMEA systematic approach to identify potential failures in a process and their potential consequences.

Step 1: Identifying the process: Implementation of the WHO 10 Steps to Warmth in the healthcare facility through maintaining a warm labor and delivery suite temperature, Pre-warming warming devices, drying the newborn, wrapping the newborn, promoting skin-to-skin contact, ensuring safe transportation, and extending the first bathing time.

Step 2: Identifying potential failure modes: Identify the potential failure modes causing newborn hypothermia.

Step 3: Rating the risk: Rating the occurrence, detection, severity, and risk priority number (RPN). Each of the occurrences, detection, and severity was given a score from 1 to 10, with 10 representing the highest risk. The risk priority number was calculated from the following equation (RPN = Occurrence × Severity × Detection) [10].

Step 4: Develop action plans: Create strategies to reduce the occurrence, severity, or detectability of high-risk failure modes. These strategies involved implementing the protocols, monitoring compliance, providing reminders, providing essential equipment, and providing adequate staff training.

Step 5: Implementing and monitoring: Implemented the action plan into effect and monitored the results to ensure they are effective.

Step 6: Re-evaluation: Periodically review the FMEA to identify new potential failure modes and update the risk assessment score.

Data collection and statistical analysis

We collected and quantitative data. The qualitative data involved feedback from stakeholders. The measured outcomes were the incidence of mild hypothermia and skin-to-skin contact compliance. Mild hypothermia was defined as an axillary temperature of 36°C-36.4°C. The incidence of hypothermia was assessed at birth, transfer from the labor and delivery ward to either the normal neonatal nursery or the neonatal intensive care unit, and after the first bath. The skin-to-skin compliance was stratified by the mode of delivery (either cesarean section or vaginal). The quantitative data were summarized using descriptive statistics (frequency and percentage). Using Excel, Bar graphs and line graphs were used to summarize the measured outcomes.

Table 1. Failure mode and effects analysis of the newborn thermal care process.

Step in Process	Failure mode	Potential effects	Likelihood of occurrence [1-10]	Likelihood of detection [1-10]	Severity [1-10]	Risk priority mumber (RPN)	Actions to reduce occurrence of failure	RPN score after project Implementation
1. **Low L&D temperature**	Increased risk of hypothermia for new-born		3	4	9	108	• Maintain adequate L&D temperature, monitor and adjust as needed	8
2. **Non – adherence to early skin to skin contact**	Increased risk of hypothermia for new-born		3	3	8	72	• Implement pre-warming protocols, monitor compliance, and provide reminders	9
3. **Non-compliance to pre-warming**	Increased risk of hypothermia for new-born		4	4	9	144	• Implement pre-warming protocols, monitor compliance, and provide reminders	32
4. **Less 1st baby bathing time**	Increased risk of hypothermia for new-born		3	3	8	72	• Extended first bathing time from 2 hours to 6 hours, monitor for signs of infection.	9
5. **Lack of essential resources and support**	Inability to maintain a warm environment		5	4	9	180	• Ensure adequate equipment availability, establish maintenance and replacement protocols.	8
6. **Inadequate training of healthcare providers**	Increased errors in thermal care, delayed intervention	Increased risk of hypothermia, infection, mortality	6	5	9	270	• Develop comprehensive training programs, • provide ongoing education and support on thermal care protocols and skin-skin to contact (kangaroo care) protocols	36
7. **Ineffective communication and coordination**	Delayed or incorrect interventions		4	4	8	128	• Establish clear communication channels, implement standardized protocols, and promote teamwork	36

Results

Failure mode and effects analysis

Following the FMEA approach, we analyzed the potential causes of failures throughout the process and their potential effects. Table 1 summarizes the pre- and post-implementation FMEA of thermoregulation processes. The identified seven causes of thermoregulation failure were inadequate training of healthcare providers, lack of essential resources and support, non-compliance with pre-warming, ineffective communication and coordination, low labor and delivery ward temperature, non–adherence to early skin-to-skin contact, and less first baby bathing time. The initial RPN ranged from 72 to 270. Post- intervention RPN scores demonstrated major reductions across all failure modes, ranging from 8 to 36. The highest baseline risk was associated with inadequate training of healthcare providers, with an RPN score of 270, due to moderate occurrence (with a score of 6), moderate detectability (with a score of 5), and severe potential consequences (with a score of 9). Implementing training programs reduced this risk by 87% to reach a score of 36. The lowest risk priority was associated with low labour and delivery temperature with a RPN score of 108, due to low occurrence (with a score of 3), moderately high detectability (with a score of 4), and severe potential consequences (with a score of 9). Implementing training programs reduced this risk by 92.6% to reach a score of 8.

Clinical outcomes

Incidence of newborn hypothermia

The data showed that the incidence of hypothermia in newborns in labour and delivery has significantly decreased following the implementation of our quality improvement initiative (Figure 1). The percentage of newborns with mild hypothermia was 21% before the implementation, 17% during the implementation, and reached 0% after the implementation. Meanwhile, 34% of the newborns experienced mild hypothermia during transfer from the labour and delivery to the Normal Newborn Nursery (NNN) ward before the implementation. This percentage decreased to 16% during the implementation and reached 0% following the implementation.

The data showed that the incidence of hypothermia in newborns in the normal newborn nursery has significantly decreased following the implementation of our project (Figure 2). The percentage of newborns with mild hypothermia was 7% before the implementation, 4% during the implementation, and reached 0% after the implementation. Meanwhile, 42% of the newborns experienced mild hypothermia after their first bath before the project implementation. This percentage decreased to 17% during the implementation and reached 0% following the implementation.

The data showed that the incidence of hypothermia in newborns in the neonatal intensive care unit has significantly decreased following the implementation of our project (Figure 3). The percentage of newborns with mild hypothermia was 43% before the implementation, 29% during the implementation, and reached 0% after the implementation.

Skin-to-skin contact adherence

The data showed that the compliance of skin-to-skin contact in newborns immediately after birth following

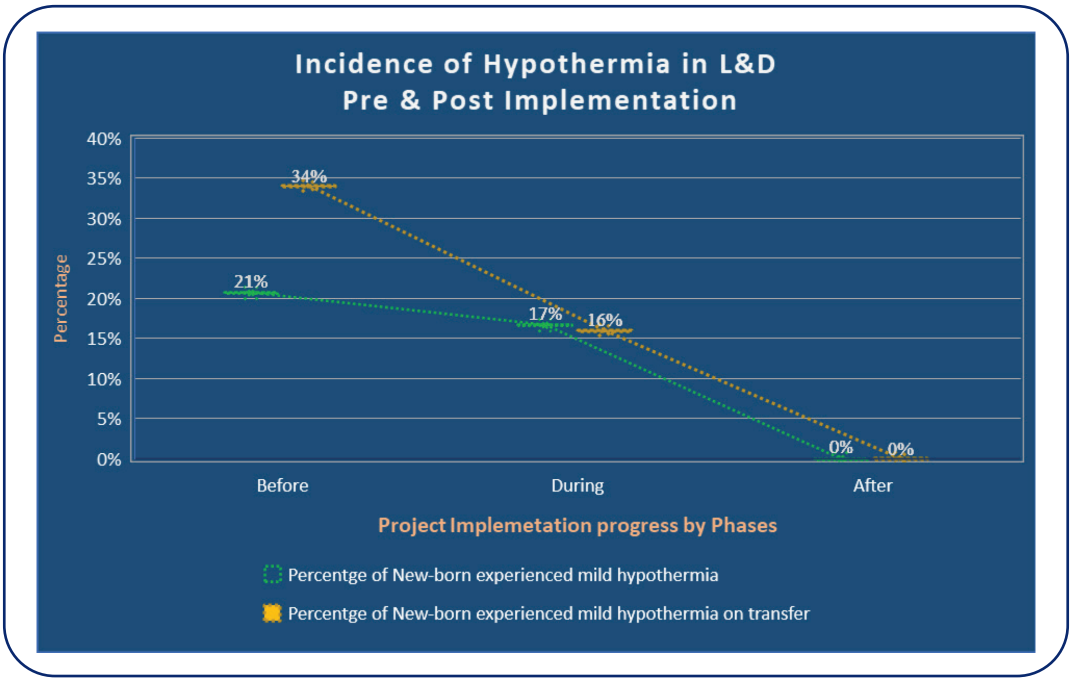


Figure 1. Incidence of hypothermia in labor & delivery (L&D).

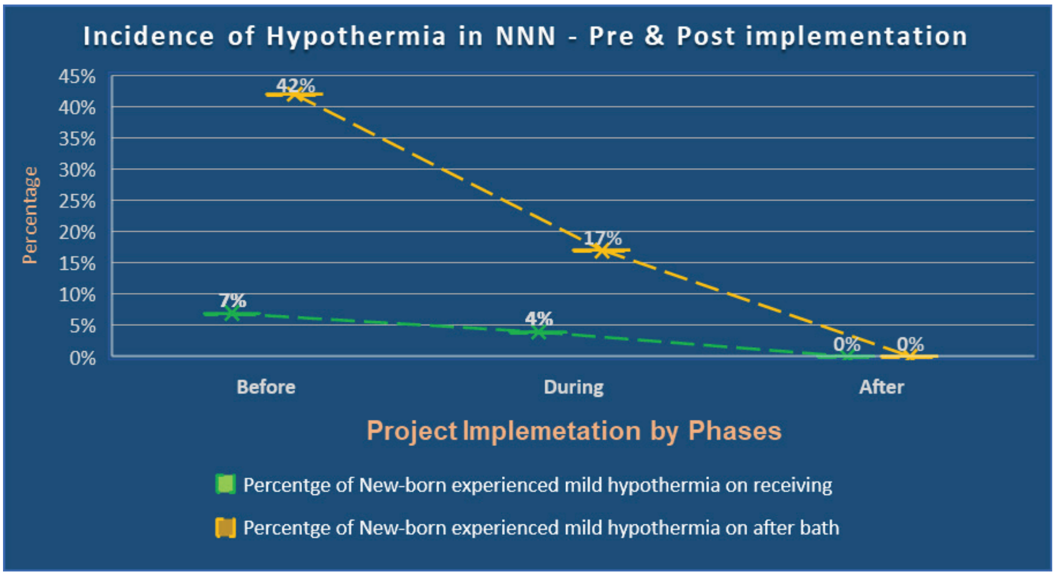


Figure 2. Incidence of hypothermia in the normal newborn nursery (NNN).

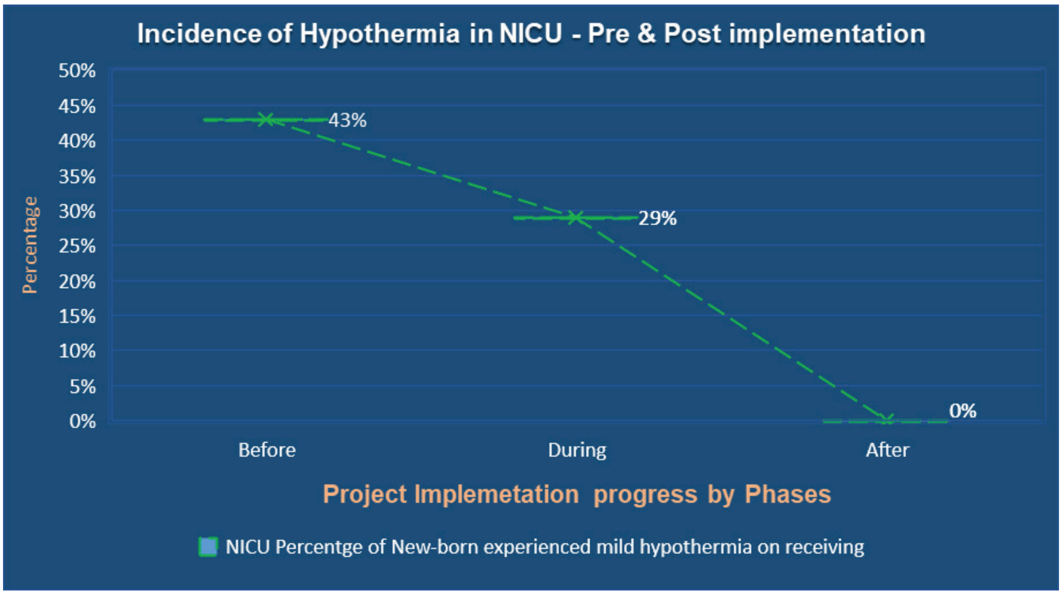


Figure 3. Incidence of hypothermia in the neonatal intensive care unit (NICU).

normal vaginal delivery has increased following the implementation of our project (Figure 4). Compliance rates ranged from 87% in January 2024 to 100% in August 2024. Additionally, the compliance of skin-to-skin contact in newborns immediately after birth, following cesarean section, has increased following the implementation of our project (Figure 5). Compliance rates ranged from 82% in January 2024 to 95% in September 2024.

Discussion

Achieving optimal newborn temperature is challenging, since inadequate thermal strategies could lead to hypothermia, while over-warming could result in hyperthermia, and both are associated with worse outcomes [1]. In our study, we found that the implementation of the 10 steps of the Warmth Project led to the complete elimination of the incidence of

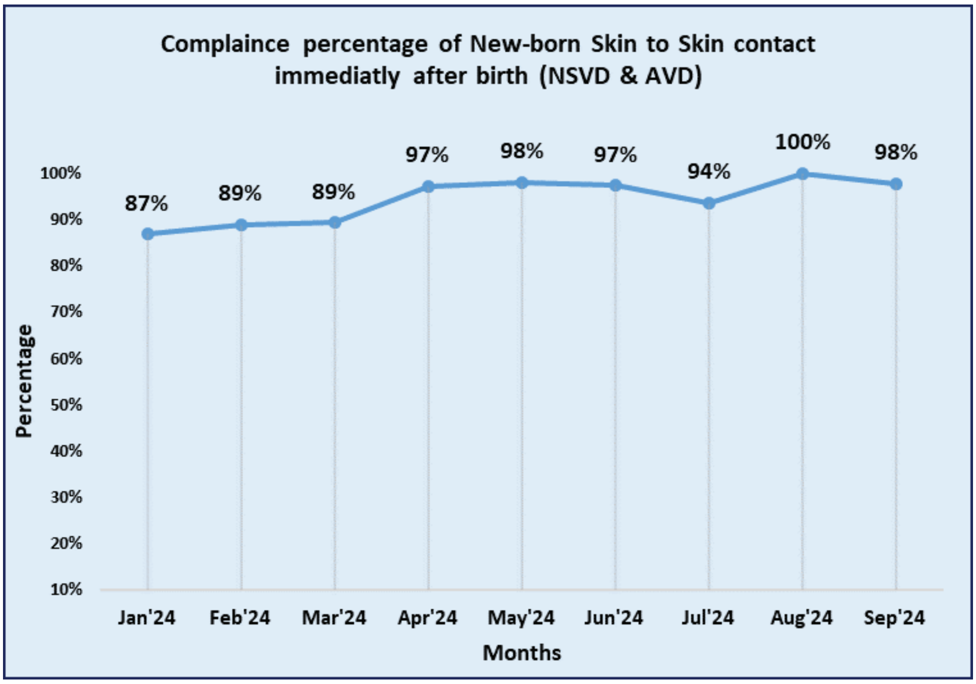


Figure 4. Compliance with immediate skin-to-skin contact after normal spontaneous vaginal delivery (NSVD) and assisted vaginal delivery (AVD).

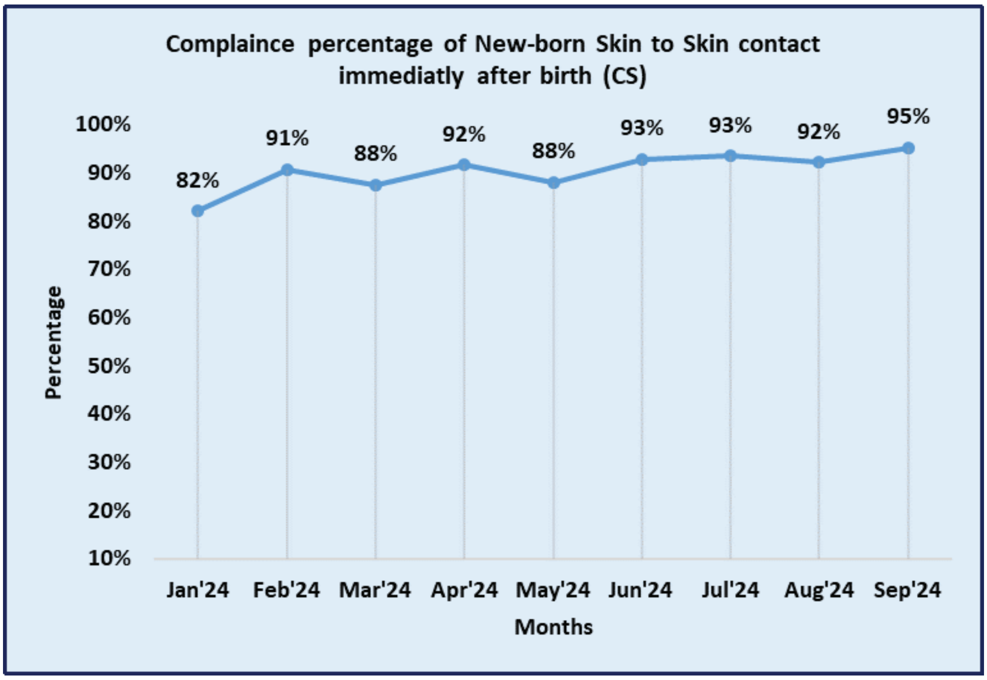


Figure 5. Compliance with immediate skin-to-skin contact after cesarean section (CS).

hypothermia. Moreover, the compliance of skin-to-skin contact reached 100% following vaginal delivery and 95% following cesarean section. This highlights the impact of adequate implementation of WHO guidelines.

As a part of the sustainability plan, the goal is to eliminate the preventable death of children under 5 years by 2030 [11]. Although newborn hypothermia is not commonly associated with mortality as a direct cause, it is associated with a great proportion of newborn deaths, reaching up to 52% [2]. For instance, for each 1°C drop in temperature, the risk of death increased by 28% [5]. Thus, reducing the incidence of hypothermia could contribute to reduced mortality rates. In our study, we found that the incidence of hypothermia was 21% among the newborns. Other studies reported variable incidences of hypothermia [2,3,12-14]. For instance, Mohamed et al. [12] reported that 48.3% of very low birth weight newborns experienced hypothermia. Lunz et al. [2] found that around 32% to 85% of newborns in hospitals experienced hypothermia, while it affected 11% to 92% of newborns delivered at home [2].

The variation in the incidence of hypothermia across different studies could be attributed to many factors, including the variation in climate, different definitions for hypothermia, different population characteristics, and variation in staff and available resources [2]. For instance, Darmstadt et al. [14] found the incidence of hypothermia varied from 70% to 20% depending on seasonal variation in climate. On the other hand, high incidences of hypothermia have been reported in places with temperatures from 26°C to 30°C [1]. This could occur due to poor newborn thermal care practices. Furthermore, the suitable surrounding temperature of newborns is higher than that of adults and should be around 32°C or higher for a wet newborn at birth [1,15]. Ideally, the newborn's body temperature should be between 36.5°C and 37°C [1].

Through FMEA, we found that the main causes of failure were inadequate training of health care providers, followed by the lack of resources and non-compliance with pre-warming. Similarly, several studies reported inadequate knowledge of healthcare providers regarding newborn hypothermia [16-18]. This was improved following training [16]. Also, since ineffective communication or coordination could result in delayed or incorrect interventions, we established a standardized protocol and clear communication channels. Also, the presence of inadequate resources, such as the limited number of incubators, inadequate radiant warmers, inadequate nurse-to-patient ratio, or the absence of wall thermometers for ensuring optimal ambient temperature, could contribute to the incidence of hypothermia [8,19].

Heat loss in the newborn occurs through various mechanisms. For instance, it occurs through amniotic fluid evaporation at birth. When the newborn's body is subjected to cold air or a cold surface, heat loss occurs through conduction and radiation. Also, heat loss could occur through convection with air movements [15]. The first step in the warm chain is keeping the delivery room warm, as each 1°C increase in the labor and delivery room is associated with a 10% reduction in the risk of developing hypothermia [1,20]. Thus, the minimum temperature of the delivery room should be 25°C [1]. Indeed, low adherence to WHO guidelines in warming the delivery room was associated with a significant increase in the risk of hypothermia [20]. In our study, we found that the incidence of newborn hypothermia was reduced from 21% to 0% following adequate warming of the labor and delivery room.

Meanwhile, maintaining the newborn's temperature in the hours following birth could occur through adequate clothing of the newborn, delayed bathing, and early skin-to-skin contact. Adequate clothing should include a cap since a significant amount of heat is lost from the head [1]. Early bathing could remove the whole vernix layer, which could protect against excessive heat loss. Thus, it is recommended to delay the first bath for at least 6 hours [1]. Indeed, Priyadarshi et al. [21] found that delaying the first bath for more than 6 hours reduced the risk of hypothermia by about 50%. We found that the incidence of hypothermia in the newborn nursery was 7%, and after the first bath was 43%; this was reduced to zero after adhering to WHO guidelines. Similar to our findings, other studies found a reduction in the incidence of hypothermia in the NNN; however, to our knowledge, none of them reported a zero incidence of hypothermia [22,23]. For instance, Joseph et al. [22] reported a reduction in the incidence of hypothermia from 20.9% to 14.5%, while Andrews et al. reported a reduction from 29.8% to 13.3% [22,23].

The WHO classified hypothermia according to temperature into mild, moderate, and severe [1]. Mild hypothermia occurs more commonly than moderate or severe hypothermia [24]. Moreover, heat loss is a progressive process. Thus, the incidence of moderate or severe hypothermia could be prevented through the initial prevention and management of mild hypothermia. Thus, our goal was to reduce the incidence of mild hypothermia. Indeed, the incidence of hypothermia was eliminated following our quality improvement initiative. This could be attributed to effectively applying FMEA analysis and mitigating the potential failure modes, in addition to the continuous monitoring and improvement.

Several studies showed that admission hypothermia (AH) is associated with worse outcomes [3,25]. For instance, Fneish et al. [3] found that it was associated with a 2.7-fold increase in mortality rates. Moreover, AH is associated with higher death rates irrespective of the performance of the hospital, as hospitals with relatively low mortality rates experienced an increase in mortality [25]. Thus, implementing effective strategies is essential. In our study, we found that

43% of the newborns had mild hypothermia on admission to the NICU before the implementation of the project. During the implementation, this was reduced to 29% and reached 0% following the implementation. Fenish et al. found that admission hypothermia was prevalent in 50% of newborns in Saudi Arabia, and that was reduced to 26.1% following their thermoregulation intervention [3]. The high rates of admission hypothermia could be attributed to many factors, including long transfer time from the delivery room to the NICU, insufficient incubator temperature during transfer, and failure to keep the plastic bag sealed [25]. Moreover, delayed skin-to-skin contact and breastfeeding are associated with AH [26,27]. Indeed, in our study, the incidence of hypothermia during transfer reached zero, and high compliance with skin-to-skin contact was achieved.

Skin-to-skin contact is one of the 10 steps suggested by the WHO to maintain adequate newborn temperature [1]. Moreover, it is described as the best method of maintaining the temperature of the newborn [1]. Skin-to-skin contact provides thermal and hypoglycemia control in the newborn. Moreover, it promotes early breastfeeding, reduces stress, and promotes parent-to-newborn bonding [28]. On the other hand, Yitayew et al. [29] found that delayed skin-to-skin contact for more than 1 hour is associated with a threefold increase in the rate of hypothermia. Nimbalkar et al. [30] found that newborns who did not experience early skin-to-skin contact had an 8-fold increase in the rate of hypothermia. Thus, the Saudi Arabia Ministry of Health supports early skin-to-skin contact following delivery [31].

However, Abdulghani et al. [32] found that the compliance with skin-to-skin contact was low following vaginal delivery among Saudi Arabian women; only 15% of them had direct skin contact, while 54% of them had indirect contact with the newborn with a sheet in between [32]. In our study, we found that it was one of the failure modes with an RPN score of 72, resulting from (3/10) in the likelihood of occurrence and detection, and (8/10) in severity. Non-compliance could result from unawareness [33]. Indeed, Nyandiko et al. [8] found that 40.3% of mothers did not receive education on the adequate thermal care of their newborn. However, following our strategies, which involve providing reminders and monitoring compliance, we found that skin-to-skin contact reached 100% in women following normal vaginal delivery and 95% following cesarean section. Similarly, Joseph et al. [22] found that promoting skin-to-skin contact and educating mothers about hypothermia reduced the incidence of hypothermia and NICU admission [22].

We stratified the compliance with skin-to-skin contact according to the mode of delivery since Ruan et al. [27] reported that cesarean section was associated with the incidence of hypothermia. This could be due to the lower temperature of the operating rooms and separation of the newborn from the mother, considering the potential admission to the NICU. Indeed, skin-to-skin contact without active warming is associated with a reduction in newborn temperature [34-36]. Thus, adherence to skin-to-skin contact is usually lower following cesarean section. However, we found high adherence levels, reaching up to 95%, while Thompson and Maeder [37] found that skin-to-skin increased from 20.3% to 24.7% following their initiative.

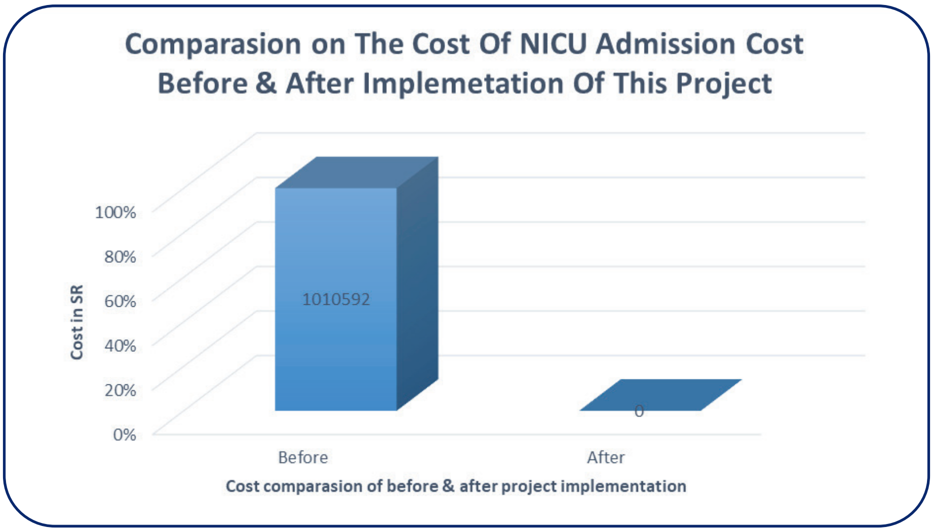
Strengths and limitations

Our study has several strengths. To the best of our knowledge, this is the first quality improvement initiative to apply the WHO 10 steps of warmth and successfully eliminate the incidence of hypothermia. We used FMEA analysis to effectively identify and mitigate the potential failure modes in a systematic way. Also, continuous monitoring and improvements were implemented. The study involved a multidisciplinary team, including obstetricians, neonatologists, and nurses, in addition to family members. Moreover, the project focuses on long-term sustainability through institutionalization and resource allocation, ensuring its continued impact. We assessed the incidence of hypothermia on different occasions. For instance, we assessed hypothermia in the delivery room, newborn nursery, after the first bath, during transfer, and on admission to the NICU. Additionally, we stratified the adherence to skin-to-skin contact by the mode of delivery.

Our study has some limitations. First, the study was conducted at a single institution in Saudi Arabia. Second, we found that the lack of resources is one of the main causes of failure in the application of WHO guidelines. Thus, our findings might not be applicable in other settings with poor resources. Also, the presence of possible confounding variables related to the mother's condition, race, and ethnicity could limit the generalizability of our findings in other countries with different population characteristics. The period of implementation and follow-up was relatively short. Thus, we plan for long-term assessment, improvement, and stakeholder involvement. The cost saved from the reduced incidence of hypothermia was not calculated. Thus, this needs further investigation.

Cost-effectiveness

Prior to implementing the 10 Steps to Warmth project, the annual cost of NICU stays for new-borns experiencing hypothermia was 1,010592 Saudi Riyals. This value was based on an average daily cost of NICU 10,527 Saudi Riyals, ALOS in NICU and a projected 43% incidence of hypothermia. After project implementation, the cost of NICU stays for hypothermic new-borns was significantly reduced from 1,010592 to 0 Saudi Riyals. This demonstrates the project's effectiveness in preventing hypothermia and the associated costs associated with NICU care.



Implications and Sustainability Plan

Our study has provided evidence of the efficiency of implementing the WHO 10 steps of warmth strategies. This is evident in achieving a zero incidence of hypothermia. Eliminating the incidence of hypothermia was successful at all the stages, including the labour and delivery room, during transfer, after the first bath, and on admission to the NICU. This signifies the importance of FMEA analysis in systematically identifying the potential failure modes and assessing the RPN scores following implementation of appropriate strategies. Additionally, the successful implementation of this model in a Saudi Arabian hospital provides a valuable guide for other healthcare institutions in the region aiming to improve care quality. The successful implementation of this model in a Saudi Arabian private hospital aligns with Saudi Arabia's Vision 2030 [38]. Although we did not evaluate the saved cost from reducing the incidence of hypothermia, a substantial amount should be saved considering the reduction in morbidity and mortality rates related to hypothermia. Furthermore, the elimination of hypothermia on admission to the NICU should save the cost associated with potentially unnecessary sepsis workups [39,40].

Our sustainability plan involves integration into the organization's policy, resource allocation, staff training, family engagement and awareness, continuous monitoring, stakeholder engagement, and knowledge sharing and collaboration. We plan to ensure that the 10 Steps to Warmth are embedded into routine healthcare practices at all levels of care and implement a system for ongoing monitoring and evaluation to identify areas for improvement and ensure sustained adherence. We will provide ongoing training and education for healthcare providers on the 10 Steps to Warmth, including updates on best practices and emerging evidence, and ensure adequate availability of essential equipment and supplies needed for effective thermal care. We plan to conduct health programmes and sessions for parents to raise awareness about the importance of newborn thermal care and its benefits. Also, establishing a robust system for monitoring and evaluation to track progress, identify challenges, and inform decision-making is essential in order to analyze data regularly to identify trends and areas for improvement and use evaluation findings to inform changes and adaptations. We plan to share best practices and lessons learned from the implemented project with other healthcare teams and facilities. By implementing these strategies, the initiative can be sustained and expanded to improve newborn health outcomes.

Conclusion

Our study showed that implementing the 10 steps of warmth using failure mode and effect analysis to systematically identify the potential failures and assess their impact led to a zero incidence of hypothermia among newborns. Additionally, it increased adherence levels to skin-to-skin contact following both vaginal delivery and cesarean section.

List of Abbreviations

FMEA	Failure mode and effects analysis
L&D	Labor & delivery
NICU	Neonatal Intensive Care Unit
NNN	Normal Newborn Nursery
RPN	Occurrence × Severity × Detection
WHO	World Health Organization

Conflicts of interest

The authors declare that they have no conflict of interest regarding the publication of this article.

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Informed consent

NA.

Ethical approval

NA.

Author details

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