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Original Article

The complexity of care for the thermal control of the premature infant*

A complexidade do cuidado para o controle térmico do recém-nascido prematuro

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ABSTRACT
Objective: to understand the perception of nurses about the complexity of care for thermal control of the premature infant. **Methods:** qualitative study conducted with 13 nurses from a public maternity hospital, through virtual interviews, with semi-structured script, submitted to Content Analysis and interpreted by the theoretical support of the complex adaptive care system model. **Results**: the factors present in nurses' care in thermal control of premature infants are related to the complexity permeated by environmental factors such as the temperature of the unit and distribution of air conditioning currents; institutional factors such as the availability and correct use of technologies, and those related to the professional, such as performance, training, and qualification. **Conclusion:** adjusting the temperature of the unit; better distribution of the air conditioning currents; availability of technologies; a policy of continued education in the service; training in handling the equipment; supervision and requirement for preventive and corrective maintenance of the devices can influence the reduction of thermal instability events in premature infants. **Contributions to practice:** stimulating professional qualification, planning of intersectoral actions for technological structuring and preventive maintenance of the units, systematization of assistance to premature infants in thermal control minimizing risk of neonatal morbimortality due to thermal instability.
Descriptors: Infant, Premature; Body Temperature Regulation; Neonatal Nursing; Neonatology; Nonlinear Dynamics.

RESUMO
Objetivo: compreender a percepção dos enfermeiros sobre a complexidade do cuidado para o controle térmico do recém-nascido prematuro. **Métodos**: estudo qualitativo realizado com 13 enfermeiros de maternidade pública, por meio de entrevista virtual, com roteiro semiestruturado, submetido à Análise de Conteúdo e interpretado pelo suporte teórico do modelo do sistema adaptativo complexo de cuidado. **Resultados:** os fatores presentes nos cuidados dos enfermeiros no controle térmico do recém-nascido prematuro estão relacionados à complexidade permeada por fatores ambientais como a temperatura da unidade e a distribuição das correntes de ar condicionado; fatores institucionais como a disponibilização e uso correto de tecnologias, e aos relacionados com o profissional, como atuação, treinamento e capacitação. **Conclusão:** adequar a temperatura da unidade; melhor distribuição das correntes do ar condicionado; a disponibilidade de tecnologias; política de educação continuada no serviço; treinamentos de manuseio dos equipamentos; fiscalização e exigência de manutenção preventiva e corretiva dos aparelhos podem influenciar a redução dos eventos de instabilidade térmica do recém-nascido prematuro. **Contribuições para a prática:** estimular a qualificação profissional, planejamento de ações intersetoriais para a estruturação tecnológica e manutenção preventiva das unidades, sistematização da assistência ao recém-nascido prematuro no controle térmico minimizando o risco de morbimortalidade neonatal por instabilidade térmica.
Descritores: Recém-Nascido Prematuro; Regulação da Temperatura Corporal; Enfermagem Neonatal; Neonatologia; Dinâmica não Linear.

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Introduction

Despite technological advances, thermoregulation disorder in Preterm Infants (PTIs) is still configured as an adverse event of greater notification in neonatal units in Brazil and worldwide. Nurses are among the professionals responsible for care and protection assurance to minimize the occurrence of this event[1-3].

Currently, in the international scenario, the incidence rates of hypothermia in PTIs admitted to neonatal intensive care units (NICUs) are high, regardless of the country's socioeconomic development, especially in Japan, which despite being a developed country, still has an incidence rate of 31.9% and mortality of 16%[4-7]. In Brazil, neonatal hypothermia was found in 100% of the admissions of these newborns in 20 neonatal units[8].

To prevent thermal instability in PTIs, it is necessary: maintenance of a thermoneutral environment, to minimize heat loss, prevent cold stress, continuous temperature monitoring, avoiding iatrogenic hypothermia, particularly when multiple interventions are performed simultaneously[9-10]. Use of the radiant heat crib[8]; use of transparent plastic bag to wrap the PTIs immediately after birth, plastic, and mesh caps on the head[1,8]; transfer to the inpatient unit in a transport incubator, previously heated[8]; in addition to staff training to ensure safe practices[11], strategies used to reduce the incidence of hypothermia immediately after birth.

However, in some cases, such measures are still not sufficient to eradicate adverse events related to thermal instability[8,11]. This may be related to the existence of unpredictable phenomena in a healthcare organization, resulting from the nurse's self-organization during care, from her relationship with other team members, and from her interaction with objects and the work environment, configuring complexity, interdependence, and influencing care[12-13].

This unpredictability composes the complexity scenario and requires adaptations for the effectiveness of care. Systematic review studies that sought to evaluate the effectiveness and safety of interventions aimed at preventing hypothermia in newborns revealed the challenge for this type of assistance and the use of different strategies for thermal control[10,14]. Such evidence indicates that, despite technological advances, care of the newborn requires understanding that reveals the complexity of relationships in assistance, and adaptation to unpredictable problems[15].

It is considered that nurses are the professional category responsible for care, planning, intervention, and evaluation. Thus, their perception of the factors that are present in their actions and in the complexity of care for the maintenance of normothermia dependent on the individual characteristics of PTIs, are indicative of how the planning and implementation of assistance will be[16], besides facilitating reflection and understanding of new behaviors that arise from the need for an alternative to the current paradigms in Health Science, such as immersion in the actions; self-organization of the agents with the environment, allowing daily changes in behaviors; non-linearity for presenting multiple paths for the resolution of problems and the unpredictability of occurrences in the field of work[12], characteristics that are present in a complex adaptive system. This study aimed to understand the perception of nurses about the complexity of care for thermal control of the premature infant.

Methods

This is a qualitative study supported by the Complex Adaptive System Model[12], which allows understanding the actions of nurses as professionals who act in connection with various systems (multi-professional team, healthcare institutions; environmental systems and personal aspects). To provide care in this model, it is necessary to be attentive to adaptations in the face of the unpredictability that guides leadership and decision-making. The complexity lies in the dynamics of leading, interacting, and planning care with attention to aspects of clinical practice, preventive actions, and health promotion through interac-

tions, exchanges, and experiences with other systems, promoting a new form of problem-solving within the health care environment[12,15].

For this study, the complex adaptive system model allowed us to understand the thermal control of care of PTI with its interconnections and variability through interpersonal, environmental relationships and institutional aspects that directly permeate care. The construction of this article was based on the Consolidated Criteria for Reporting Qualitative Research (COREQ).

The research was conducted in the NICU of a medium-sized public maternity hospital, located in the state of Bahia, registered in the *Rede Cegonha* (in Portuguese), with outpatient and inpatient care. It has 15 beds, 10 of which are allocated to NICU patients, which are intended for the care of severe or life-threatening newborns, and five beds of Conventional Neonatal Intermediate Care Unit. The unit has 17 nursing assistants, 54 nursing technicians, 10 physiotherapists and 21 medical assistants, including assistance to the newborn in the delivery room.

The selection of participants was based on the invitation by telephone application to the contacts provided by the coordination of the unit. The inclusion criteria for participation were nurses with length of service equal to or greater than one year; nurses involved in the care of PTI in the first 24 hours of life; working at the NICU; specialization in Neonatology. As exclusion criteria: nurses in temporary activities in the work schedule at the NICU.

After consent from the institution and unit coordination, a virtual invitation was sent to 15 nurses according to the inclusion and exclusion criteria, containing the Informed Consent Form, which was read and signed in two copies by 13 nurses, with no withdrawals. Two nurses did not participate, one due to withdrawal and the other due to refusal. To ensure anonymity, the names of the participants were replaced by Nurse and following the numerical sequence according to the order in which the interviews were conducted.

Data were collected by the main researcher, a specialist in Neonatology, between September and December 2020, through a virtual interview conducted individually through the Teams® Platform, with a semi-structured script composed of sociodemographic data for the characterization of research participants and the guiding question: Tell us about your perception regarding the factors that are present in the care for thermal control of PTI? The main researcher attended the space of data collection before the beginning of the collection to perform the recognition of the routine and activities performed by the study participants.

The data collection instrument was previously applied in pilot interviews, to adapt the script and virtual space. These interviews did not make up the sample. Lasting between 25 and 40 minutes, the interviews were recorded and transcribed in full, with corrections made that did not alter the meaning of the speeches to facilitate understanding. Later, the transcripts were sent to each participant to validate the records made.

The findings of each interview were discussed among the group of researchers for the interpretation and understanding of the findings according to the proposed objectives. The invitation of new participants was suspended when the peer validation converged to the consensus of saturation, and it was no longer relevant to persist in data collection because the absence of new information was observed after extracting the maximum possible significance of the interviewees' speech with the response to the proposed objective[17].

The NVivo software helped in the organization, coding, and characterization of each category. The grouping of codes based on their similarity gave rise to subcategories. For data analysis, the Content Analysis method was used, through the three recommended poles: pre-analysis; exploration of the material and the treatment of results, inference, and interpretation[18]. To enhance the interpretation of the results, the Complex Adaptive System Model was used. The categories and subcategories were built as shown in Figure 1.

Codes	Subcategories	Categories
Air Conditioning Air Current Environment	External Factors/Environment	Complexity permeated by environmental factors
Technology Maintenance Equipment	Availability and use of technology	Institutional factors present in care
	Inadequate equipment maintenance	
Procedures Multi-professional team Knowledge Adaptation Qualifications	Acting during procedures	Professional-related factors
	Working dynamics with the multi-professional team	
	Knowledge	
	Qualifications	

Figure 1 – Description of the thematic categories. Salvador, BA, Brazil, 2020

The study was conducted following the recommendations of Resolutions numbers 466/2012 and 580/18 of the National Health Council and approved by an Ethics and Research Committee of the Maternity where the study was conducted Opinion: 4,270,156/2020 and Certificate of Submission for Ethical Appreciation: 36886420,6,0000,5543.

Results

There were 13 nurses, aged between 32 and 45 years, with an average time of work in the unit of more than four years, all specialized in Neonatology. The analysis of the interviews resulted in three thematic categories that show the factors present in the nurses' care in the control of thermal instability of PTI in the NICU. The categories permeate issues related to the environment, the institution, and the professionals, showing that care is permeated by connections and exchanges between different systems - a complex adaptive system demanded in the care of PTIs.

Complexity permeated by environmental factors

The NICU is a closed and artificially air-conditioned environment, a condition that can reduce the temperature of the environment, predisposing the PTI to thermal instability. The air conditioning temperature control and the organization of incubators in the sector directly influence the thermal control of the PTI: *If the incubators are in the wind direction of the cold air conditioning, the tendency to lose temperature is much higher* (Nurse 02). *There are two air conditioners that stay on top of some beds that may be throwing cold air directly on top of the cribs and incubators* (Nurse 04). *If the newborn is extremely premature, the incubator should not be placed with the opening position of the hatches towards the airflow from the air conditioner* (Nurse 05).

Institutional factors present in care

Over the years, health technology has been improving, becoming increasingly more sophisticated, contributing to quality and safety in the care of the PTI and increasing their chances of survival, as well as in the systematization of care related to the prevention of thermal instability of the newborn. For the proper use of technological equipment in the care of the PTI, it is necessary to know its purpose and tools of use so that it does not cause negative effects on the care of premature babies by incorrect use: *Not all incubators currently have the skin temperature sensor working, making it difficult to control the newborn's temperature* (Nurse 06). *If you have the skin sensor in the baby, you can safely control the incubator in skin mode, which is much better than controlling it in air mode* (Nurse 11). *If we have a lot of technology, and we don't have a team that knows how to use it, we can't provide adequate care; and in the same way, if we have a highly trained team, and we don't have the technology to be used by this trained team, we can't provide adequate care* (Nurse 07).

The equipment and technological materials used in the care of PTI require preventive maintenan-

ce to reduce the likelihood of failure or degradation of these materials and ensure their proper functioning and safe care. However, in the research scenario it was identified the lack of preventive maintenance of equipment primordial in the care to prevent thermal instability of PTI, requiring a communication system between the team responsible for these actions and the unit nurse: *The incubators do not work properly when they are not correctly maintained and suddenly stop working causing thermal shock in the newborn. The humidification is also not ideal and takes a long time to humidify, besides the temperature sensor that often does not work* (Nurse 12).

Professional-related factors

Based on scientific knowledge, nurses plan and provide care to PTI, and recognize that having scientific basis is an aid to problem-solving in their professional practice: *You start to search in books, articles, and scientific literature for appropriate ways to improve hypothermia control actions* (Nurse 01). *Participation in the unit's continuing education has had positive results not only in terms of thermal stability care, but also in other care issues* (Nurse 10).

The equipment, technological devices and training for proper use were factors that guided the nurses' perception of care delivery: *Training is significant to update practices at the NICU* (Nurse 09). *The last training came precisely to explain the importance not only of the temperature issue, but also other issues of the baby* (Nurse 13). *There are things I didn't do that I also learned during the NICU training, which is not to leave the baby wrapped in a heated crib when he is hypothermia* (Nurse 02).

The premature infant, when admitted to the NICU, undergoes several procedures that are fundamental to his/her vitality. However, its exposure to the interventions of Nursing and the multi-professional team may bring consequences such as thermal instability, making it difficult for nurses to establish normothermia: *What hinders most in achieving this ideal temperature are the needs of the procedures ...to roll the baby up and only keep the limb of the procedure, or the baby stays inside the bag when you need to perform an umbilical catheterization ...you try to make him not lose the heat; but even so, his temperature drops* (Nurse 3).

Healthcare professionals play an important role in preventing thermal instability in premature infants, so it is important that the multi-professional team acts in an organized and synchronous manner to avoid multiple interventions that may predispose premature infants to adverse events of hypothermia or hyperthermia: *The nursing team came in together with the physical therapy team, saw the newborn, organized it, left everything neat and tidy, the doctor comes half an hour later, comes in to assess and ends up destabilizing the newborn's temperature* (Nurse 05).

As well as excessive manipulation due to lack of synchronization of care performed by the team, care performed inappropriately, such as opening the incubator door instead of the hatches, may increase the risk of the newborn destabilizing his/her temperature, and consequently, require increased actions and interventions by the nurse to reestablish normothermia in the neonate: *Some professionals work with everything open and do not pay attention to the baby's temperature loss, he will start losing temperature and then nursing has to run to stabilize, this entails a very great damage not only for the baby, but for the entire nursing team demanding a greater work* (Nurse 12).

The assistance provided by health professionals who are not part of the multi-professional team at the NICU may also negatively influence the thermal stabilization of PTI if they do not have the knowledge about the necessary care to prevent thermal instability, which may cause harm to the neonate: *The doctor who came only to check the baby, the cardiologist, the ultra-sonographer the X-ray technician, they should all have the notion of how important temperature is for the stability of this baby's organic functions. If the ultra-sonographer leaves the baby with gel, disorganized, uncovered, this baby will destabilize its temperature* (Nurse 08).

Discussion

For this research, the care of PTI in thermal control is understood as a complex adaptive system characterized by interconnections of the various elements present in the environment[15]. The nurses' perceptions revealed that the impact of environmental, institutional, and human systems influence care, sho-

wing that nursing care at the NICU for thermal control is a complex, dynamic, interrelated, systematized, and articulated phenomenon with everything around it[13].

Premature neonates exposed to low temperatures at NICU admission (<36.5ºC) not only have an increased risk of early mortality but may also suffer long-term consequences such as a poor developmental quotient during infancy[19]; therefore, it is important to follow measures such as ensuring warm environmental temperatures and avoiding air currents to prevent heat loss of PTI[11] and reduce energy expenditure[20].

This study indicates the perception of nurses regarding environmental aspects and the need for action planning to minimize the impacts caused by issues of this space to maintain normothermia in PTIs. The nursing leadership is responsible for managing and organizing the environments that the newborn goes through from birth to the hospitalization unit[1], developing important functions in reducing the impacts of thermal instability and, consequently, in neonatal morbidity and mortality.

The assistance to PTI in the context of a NICU is performed thanks to technological equipment and the incubator is the most used for the prevention of hypothermia because it provides a stable microclimate with temperature and humidity adjustable to the needs of the newborn but may have technical failures and be subject to improper handling by professionals[21]. Thus, the technical and scientific knowledge of the entire multi-professional team is necessary, especially for the nurse who manages this equipment, through training to use it safely and only when undergoing preventive maintenance of the equipment, which is essential to provide safe and efficient health care[22].

When considering the dynamics of the relationships understood for the complex care with PTI, communication and exchange with external, institutional systems, such as the preventive maintenance team, was indicated as fundamental to the quality of care. In this sense, nurses must be attentive to the dialogue and actions correlated with sectors of clinical engineering, maintenance, and continuing education. Since the management of interconnected actions between the different sectors of the institution is necessary and provides the improvements in the quality of care and safety in the care provided, to prevent the occurrence of thermal instability.

It is noteworthy that, to ensure neonatal normothermia, nurses need to be aware and articulate the various dimensions of care and the complexities involved[23]. Among these dimensions, the skills related to professionals stand out because nurses who keep their knowledge updated may perform well in thermal control, since they increase the possibilities of acting as advocates of change, influencing the implementation of good care practices, reducing the risks, injuries, and damage to the health of PTIs that can be caused by thermal instability[9].

This research also demonstrated that one of the factors predisposing to neonatal thermal instability is related to the performance of routine procedures, especially during the admission of PTI in the NICU. However, if these actions are performed in compliance with international guidelines for reduction of heat loss by the whole multi-professional team, it may result in reduction of hypothermia rates[24], and thus avoid negative outcomes such as neonatal sepsis, periventricular hemorrhage, bronchopulmonary dysplasia, respiratory distress syndrome, pulmonary hemorrhage, and death[25-26].

The care provided by nurses to PTI can bring benefits to thermal control, but can also become harmful, causing imbalance in thermoregulation[9,27]. Thus, the importance of the systematization of nursing care directed to the thermal control of premature newborns is highlighted, starting from the delivery room, during transportation, during admission and hospitalization at the NICU to reduce risks, damages, and injuries[1].

There are several factors that may influence nurses' care in the control of thermal instability of PTI.

They are not restricted to the physiological conditions of premature infants' immaturity and adaptation, but to actions and events that permeate their care in an environment where actions of a multidisciplinary team are interconnected and may be sudden and require quick and effective intervention. The complexity of promoting thermal control requires the understanding of multi-systemic and interconnected aspects such as environmental, institutional, and personal.

In this context, there is a need for clarification about the behaviors that allow actions for thermal control through strategies, with an expanded perception of the experienced context, and not only the techniques described in protocols[23]. Therefore, the importance of care based on the complex adaptive system, which indicates the management of care through actions and strategies that understand care as an interconnected network of actions that extend beyond the Nursing team[28]. To be effective in the implementation of practices oriented on the care of temperature in PTI, it is necessary to have extensive and continuous education with the involvement and adherence of the multidisciplinary team, and with periodic presentation of results regarding the improvement of thermal instability rates[27].

In addition, there is a need for training on the importance of care with maintaining the temperature of PTI for the institution's professionals who provide services at the NICU because, since this unit is a complex system, all activities developed reflect on the actions of other team members. Nurses report that the actions of the multi-professional team reflect on their care, which can be positive as well as negative, if developed without the proper effort to maintain the temperature.

It is observed that there is a lack of knowledge about thermal control of neonates for nurses, which can cause some damage to the newborns due to erroneous conducts, highlighting the importance of continuing education and constant updating to better offer nursing care, reducing iatrogenic events[29].

The nurse is a fundamental part in the mechanism of preventing thermal instability, since he/she is responsible for the management of nursing care of neonates in all environments that they go through[1]. Therefore, the assessment of the knowledge of nursing professionals cooperates for the qualification of care, since by raising the points of weakness, the team can readjust and self-promote a process of continuous improvement in addition to raising the points to be addressed in continuing education programs[29]. Since the nursing team is present during all stages of care of PTI, and therefore, should use their knowledge to ensure neonatal normothermia, to enable a qualified and safe assistance, thus reducing neonatal morbidity and mortality[1]. These aspects reveal the links with the personal aspects of each professional who is in the leadership, planning and performance of care.

It is noteworthy that the thermal control of PTI in NICUs is still a challenge for the nursing team, and to correct the failures, it is necessary the articulation of the entire multidisciplinary team, since the nursing care for the newborn is a complex adaptive system that undergoes interaction of people, objects, and environment present in the care process that links the multiplicity of interdependent factors and influencers of the assistance provided. Thus, the actions and strategies for preventing thermal instability in premature infants need to be described in clinical care protocols, to guide the work of all professionals in the team, as well as the development of the intervention package to improve management in thermal control of premature infants and the establishment of body temperature as a quality indicator of the care provided.

Study limitations

As a limitation, it is identified that the perceptions of the complexity of care for thermal control were understood by the experience of nurses without identifying the impressions and experiences of other professionals who are directly involved in the assis-

tance and institutional systems for technological and preventive adequacy.

Contributions to practice

Understanding the perception of nurses about the complexity of care for the thermal control of PTI is to understand that care should be developed around the interaction of various knowledge, practices, and knowledge in a flexible approach to changes and adaptations. It is necessary to implement strategies that stimulate professional training, intersectional and multi-professional dialogue, directed to the improvement of the care of premature newborns. Looking only at the technical aspects does not answer the totality of the complexity of care. Thus, it is suggested: encouragement of professional qualification, planning of intersectoral actions for technological structuring and preventive maintenance of the units, systematization of assistance in thermal control of premature newborns, and thus have actions to minimize the risk of morbidity and mortality due to thermal instability.

Conclusion

In the perception of nurses, the complexity of care in the thermal control of premature newborns is related to environmental conditions, institutional factors, and the professional's work process, and this occurs in a dynamic, interactive, and interconnected way.

Care actions are connected between different environmental, institutional, and personal systems. Adjusting the temperature of the unit; improving the distribution of the air conditioning currents; making available technologies that aid in care; a policy of continued education in the service; training for proper handling of the equipment; and supervision and requirement for preventive and corrective maintenance of the devices can influence the reduction of thermal instability events in premature newborns.

Authors' contribution

Conception and design or analysis and interpretation of data; Writing of the manuscript or relevant critical review of the intellectual content; Final approval of the version to be published; and Responsibility for all aspects of the text in ensuring the accuracy and integrity of any part of the manuscript: Oliveira AC.

Conception and design or analysis and interpretation of data; Writing of the manuscript or relevant critical review of the intellectual content: Camargo CL.

Conception and design or analysis and interpretation of data; Writing of the manuscript or relevant critical review of the intellectual content; and Final approval of the version to be published. Whitaker MCO, Martins LA.

Final approval of the version to be published: Santos LF, Oliveira EA, Silveira LC.

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