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THERAPEUTIC ENVIRONMENT AND PREMATURE NEWBORNS DEVELOPMENT AN INTEGRATIVE LITERATURE REVIEW

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ABSTRACT

Introduction: Prematurity is the leading cause of neonatal mortality, however, the survival of preterm infants is guaranteed. Prolonged exposure to numerous sensory stimuli during early neonatal intensive care units contributes to the increased likelihood of organic and/or psychological sequelae.

Objectives: Identify the best measures to minimize the impact that the sensorial environment of neonatal intensive care units has on the development of premature newborns.

Methods: An integrative literature review was carried out in CINAHL, PubMed and MEDLINE databases, according to the PICOD methodology (participants, intervention, context, results and design).

Results: The analysis of the 6 articles included in the study showed a set of environmental measures to be included in the care of premature newborns. The main recommendations mentioned were organized into categories, namely, physical environment, sensory environment, technology and parental training.

Conclusion: From this review emerges the need to define consistent and consensual strategies for the optimization of the therapeutic environment in neonatal intensive care units.

Keywords: Sensory environment; development; premature newborn; neonatal intensive care unit.

INTRODUCTION

Around the world, approximately 15 million newborns are born preterm each year (PNB), a number that has increased progressively over the years⁽¹⁾. The rate of preterm births is between 5 and 18%, in a total of 184 countries⁽¹⁾. In Portugal, in 2016, compared to 2011, there was an increase in the rate of premature live births from 7.4% to 7.8%, corresponding to 6,801 births⁽²⁾ before 37 weeks of gestation, independently of birth weight^(3,4).

Factors such as technological changes, reflection on the quality of care and the marked improvement in perinatal care in Portugal, achieving perinatal mortality rates among the best in Europe, have contributed to a higher survival rate of newborns (NB) with lower gestational ages.

Premature birth is the leading cause of neonatal mortality, however the survival of PNB is increasingly guaranteed, including very premature infants (less than 28 weeks). Despite this data, increasing their survival is also accompanied by a commitment to a neurodevelopment rate of only 15 to 25%^(5,6). At the same time, studies on the behaviour and development of these infants and their hospitalisation in neonatal intensive care units (NICU), conclude that care in early life may culminate in organic and/or psychological sequelae⁽⁷⁾.

The literature points to the early differences in brain development and PNB term newborns, highlighting the influence of sensory cortical development⁽⁸⁾. So, the individualised care-centred development asserts a model of care in neonatal units that is essential to preserving the physical and mental well-being of premature infants and, concomitantly, the prevention of pathology associated with a traumatic early life⁽⁹⁾.

Even in PNB whose internment took place without complications, the neurodevelopment risk level is remarkable, particularly with regard to language disorders, learning, emotional and/or behavioural disabilities^(10,4). PNB with a gestational age of less than 32 weeks are 7.4 times more likely to develop bipolar disorders and 2.4 times more likely to suffer from depression, compared to full term infants⁽¹¹⁾.

The implementation of early intervention programmes in the neonatal period should be a goal of the multidisciplinary health team, due to the multiple benefits identified by several authors for both premature infants (more organised behaviours with better neurological and hemodynamic responses) and their families (lower level of anxiety and early perception of their parenting skills), as well as for professionals (higher sensitivity to environmental stimulus optimisation and excellence of care provided)^(9,12).

The therapeutic environment encompasses three dimensions assumed to be integrated, which are applied in different ways. It is supported by a body of evidence demonstrating its relevance in various fields, particularly with regard to clinical, psycho-emotional and economical areas⁽⁹⁾. Promoting the combination of various fields, according to the same author, facilitates neuroprotection of PNB and guarantees respect for human dignity and social-emotional support, through the constant presence of family promotion. The three dimensions explored by the author are the physical, human and organisational environment.

The physical environment includes the sensory environment, the physical presentation and aesthetic environment. The physical environment should correspond to a relaxing, spacious and aesthetically pleasing space, which is conducive to developing therapeutic relationships^(9,13).

The physical presentation and aesthetic environment are important factors that contribute to the welfare, relief and hope for patients and their families and also increase professional motivation. Although there are several definitions of what a pleasant environment is, the key is to provide a space that promotes parenting⁽⁹⁾.

Regarding the sensory environment, it is believed that all care should be based on promoting experiences that provide system development related to the senses (tactile sensory system, gustatory and olfactory system, auditory and visual system). Noise control and brightness also aids healthy development of these systems.

Regarding hearing, peripheral anatomical structures are developed at the gestational age of 22 weeks, and as of 24-25 weeks, behavioural and physiological reactions arise, such as blinking or flinching in response to abrupt changes in sound⁽¹⁴⁾.

In 1997, the American Association of Paediatrics published a statement which states that noise levels greater than 45db in NICU should be of concern. The Portuguese Society of Paediatrics (SPP) recommends that the noise level in NICU is kept at 45db and that transient sounds do not exceed 65dB⁽¹⁴⁾. This level is considered "near silence", as the infants' hearing threshold stands at 20-25 dB and human dialogue produces about 50 dB^(9,13). The proposed levels promote sleep protection, the reduction of stress signals and the stabilisation of vital signs^(13,14).

As well as the fact that the excessive noise constitutes a negative stimulus for the development of preterm infants, brightness has also been investigated in order to understand its impact on babies.

The process inherent in the development of human vision is complex, fully developing structurally and functionally from the age of 3 to about the age of 12. The period starting in intrauterine life and continuing into extrauterine life is essential in the development of a visually mature and effective system. The eyelids may remain closed until about 25-26 weeks, and after opening at 32 weeks they remain thin, having no ability to remain completely closed, which results in the unprotected eye being exposed to light. Pupillary constriction arises only after 30 weeks⁽¹⁵⁾. Intensity, artificial and bright light, sleep deprivation, among other factors, strongly affect overall development and sensorineural hearing loss⁽¹⁶⁾. Therefore, light source should not exceed 10-600 lux during the day (as

the baby is asleep or awake) and 5 lux at night⁽¹⁵⁾. It is unanimous that very intense stimulus, such as direct and sudden bright lights are a stress factor for babies. The luminous environment must be suitable for NB, as well as the care practices that are necessary in each moment, however it is recommended that eye protection is used when it is strictly necessary to use intense and direct light⁽⁹⁾. Furthermore, for the professional, a bright environment is also harmful, interfering with eyesight, technical implementation capacity and negatively influences your circadian rhythm, especially on night shifts⁽¹⁵⁾.

With regard to the human environment, Coughlin⁽⁹⁾ highlights effective communication as a foundation of the safety culture which generates trust, in order to facilitate the interprofessional and family team. According to the same author, the person-centred care and the family must respect an evidence-based paradigm, and to do so, institutions (organisational environment) must contribute to the implementation of standardised and uniform clinical actions, not allowing professionals to base their actions on their individual preferences or personal beliefs⁽¹³⁾.

The evidence states that the individualised care based on the development of PNB contributes to healthy development, but there are some limitations to its implementation, in particular because of the existing technological nature of NICU and also because of the need for urgent and priority medical care that is very often lacking for these babies⁽⁹⁾. Ferraz⁽¹⁷⁾ concluded in his study that this practice based on the philosophy of development-focused care is not being implemented consistently in Portuguese NICU.

In light of the above explanations, it is understood that providing an enabling environment for the development of PNB, which minimises the negative effects of hospitalisation in NICU, are aspects that should be inherent in nursing care which specialises in child health and paediatrics. Thus, the need arises to identify practical measures which in practice must be adopted in order to provide a suitable environment that promotes PNB development.

METHOD

This study will be an integrative literature review, which is a specific revision method that synthesises, in a systematic and organised way, scientific and theoretical production, aiming to increase knowledge about a phenomenon or problem^(18,19). This method includes critical analysis of multiple published studies, allowing the synthesis of the state of knowledge of a particular subject and for findings to be generated, while identifying gaps in scientific production^(18,19).

In view of the foregoing, it was considered necessary to conduct research on the measures required to minimise the impact that the sensory environment of the neonatal intensive care units has on the development of premature infants, in order to identify the best practices, and the nurse, as caretaker of PNB, should not only implement them but also promote them among the whole team and in hospitals. The impact of the sensory environment on the development of PNB is widely studied as well as the goals to be achieved, however, the need to identify how to obtain a consistent and universal result arises.

Therefore, the steps to be taken in the literature review are the development of the research in question, identification of relevant theoretical and scientific production, its analysis and eligibility, the extraction of relevant information to answer the research question, the organisation and synthesis of results and finally, the dissemination of the selected results⁽¹⁸⁾.

Thus, the following research question was formulated; Which interventions inherent in nursing practice, regarding the sensory environment of the neonatal intensive care units, contribute to the promotion of healthy development in PNB?

Given the research question posed, the inclusion criteria was built, following the mnemonic **PICOD** (Participants, Intervention, Context, Outcomes, Design), explained below.

- *Participants*: Preterm infants (born at gestational ages of less than 37 weeks) up to 28 days old, all requiring hospitalisation in NICU.
- *Intervention*: sensory environment of NICU, perspective of the impact on PNB, level of development.
- *Context*: Neonatal Intensive Care Units
- *Outcomes*: measures (interventions) that contribute to a proper sensory environment in the NICU, promoting PNB development.

- *Design:* The research will consider all types of studies.

Still, regarding the inclusion criteria, with respect to language, articles written in Portuguese, English (language used in research) and Spanish (Castilian) were included. All types of studies were also included, irrespective of the research model adopted, to ensure the widest spectrum of existing literature. The time specification was centred between 1 January 2013 and 1 January 2019, is aimed at the recognition of the current practices (six years).

The exclusion criteria were: articles that did not have the full text available, studies conducted outside the hospital, or with individuals with a corrected age of less than 28 days, and any which were restricted to parental problems.

The first phase of the research took place in December and corresponded to conventional research in electronic databases with keywords defined in advance, aimed at the recognition of words and more appropriate terms for the building of Boolean phrases, and identified the MeSH descriptors. Thus, the following descriptors were used: environment; infant, premature; intensive care units, neonatal; using the intersection between them through the Boolean operator AND.

The survey was conducted on the EBSCO platform with a selection of available databases, namely CINAHL Complete, Cochrane Central Register of Controlled Trials, Cochrane Database of Systematic Reviews, Cochrane Methodology Register, MedicLatina, MEDLINE Complete, Nursing & Allied Health Collection: Comprehensive, Library, Information Science & Technology Abstracts, and even on PubMed in the months of December 2018 and January 2019.

The research stage was completed and we proceeded with the removal of duplicate articles. We then began the eligibility process of the identified studies. Initially we proceeded to the evaluation of the documents by analysing the titles and abstracts, and from such selection, a full reading of the listed studies was performed. The selected studies should provide answers to the research topic, including, exclusively, all previously defined criteria.

The initial literature search resulted in 560 studies in EBSCO and 464 in PubMed. After the application of the criteria previously listed, 930 documents were excluded. Subsequently we proceeded to the analysis of the title and abstract of 104 potentially relevant articles. Because the inclusion criteria had not been applied, 89 were then excluded, and the full texts of 15 articles were subjected to analysis. After that procedure we also suppressed 9 studies. Thus, in this research we included 6 studies in order to answer the research

question. The study selection process incorporated an integrative literature review which is presented through the prism model, explained below (Figure 1).

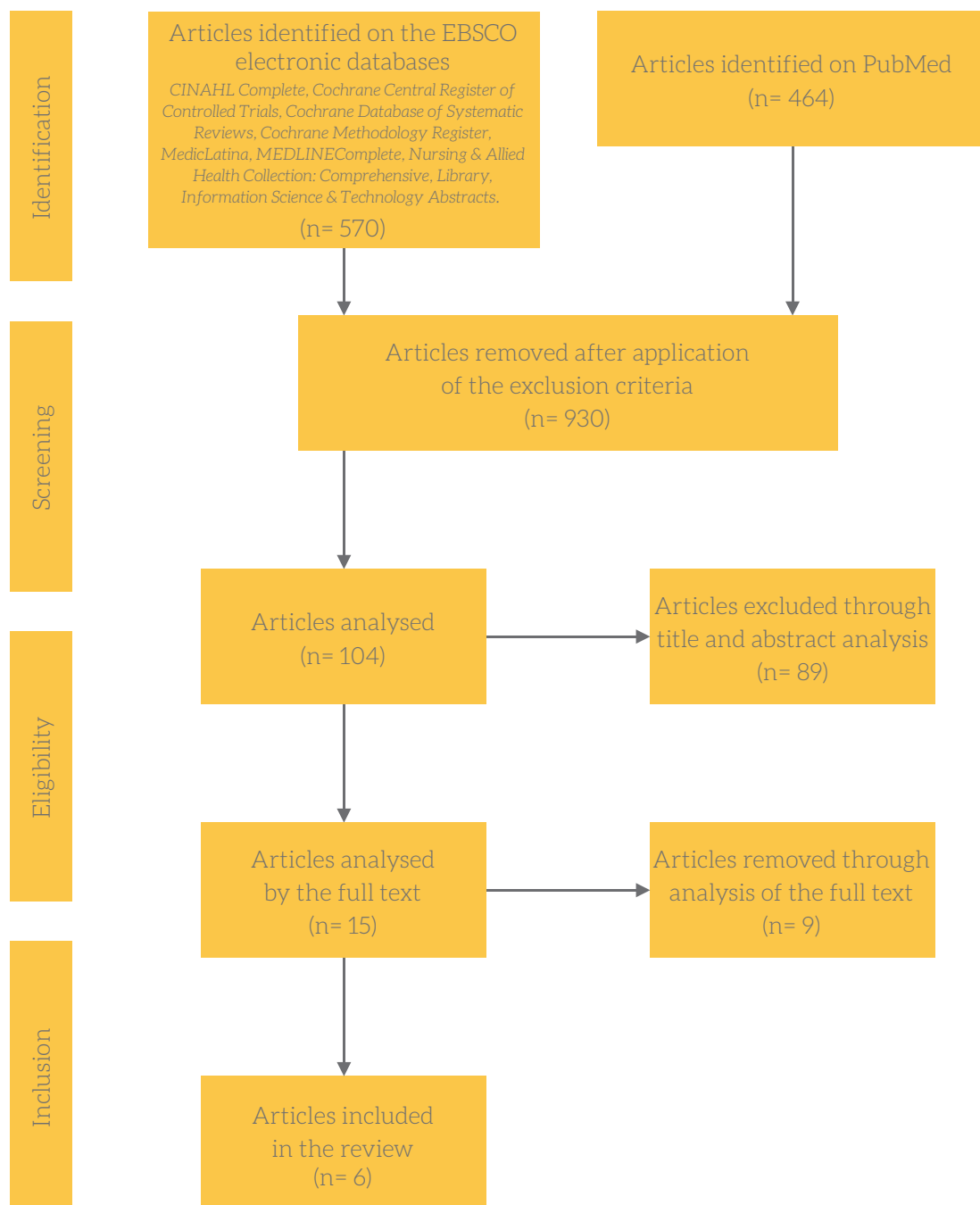


Figura 1 – Fluxo da informação das diferentes fases da revisão de acordo com o modelo PRISMA.

RESULTS

After the full reading of the selected studies, in order to organise, summarise and systematise the data obtained, we presented the table with that information (Table 1).

The main recommendations mentioned were organised into categories, namely, physical environment, sensory environment, technology and parental training.

Regarding the physical environment, the main recommendations are family rooms, sound-proofed walls, as well as the optimisation of all utensils that can cause noise (keeping washbasins away from the NB units) or intense light (keeping the incubators away from windows)^(20,21,22,23,24).

The recommended sensory environment includes, among others, adequate stimulation with a mother's voice, music therapy, appropriate tactile stimulation (restraint, kangaroo method), and avoiding the use of alcohol or antiseptics near newborns^(20,22,23,24).

Regarding the category related to technology, some measures were identified, namely the noise monitoring device, hearing protection, as well as the use of artificial intelligence to produce their own equipment that each professional can use and that inhibits the noise caused by alarms in the units^(21,22,25).

Finally, the authors also identified parental training as an important measure in optimising the therapeutic environment. Parents must be trained to take proper care of their babies, and be able to contribute with positive stimulation to the development of newborns^(20,22,23).

Table 1 - Presentation of studies selected for review.

Study (E)	Title	Authors/Year publication/Country	Aim of study	Study Design	Results (Measures identified)
E1	Enhancing sensory experiences for very preterm infants in the NICU: an integrative review.	R. Pineda, R. Gruth, A. Herring, L. Reynolds, S. Oberle & J Smith ⁽²⁰⁾ , 2017. USA.	Identify interventions that influence the sensory environment used in the NICU, which are promoting better results in PNB.	Integrative literature review.	<ul style="list-style-type: none"> • Kangaroo method; • Individual family rooms; • Music therapy and exposure to voice; • Positive tactile stimulation through massage; • Parental training to properly stimulate the PNB; • Maintenance of circadian rhythms (day and night).
E2	Noise in the NICU: how prevalent is it and is it a problem?	Andrea D. Edwards & Topun Austin ⁽²¹⁾ , 2016. England.	Identify existing recommendations to reduce the noise in the NICU and contributions for future research.	Literature review.	<ul style="list-style-type: none"> • Workrooms covered with sound absorbing material; • Use of protective covers on incubators; • Implementation of the procedures within the PNB incubators; • Extreme care in contact with incubators and avoid placing objects on top of it; • Use ear protectors (identified with limitations); • Use of noise monitoring apparatus in the unit.

Table 1 – Presentation of studies selected for review.

Study (E)	Title	Authors/Year publication/Country	Aim of study	Study Design	Results (Measures identified)
E3	Development care in the neonatal unit.	Nishani Lucas ⁽²²⁾ , 2015. Sri Lanka.	Identify the measures recommended to reduce sensory stimuli in the NICU.	Literature review.	<ul style="list-style-type: none"> • Use of adjustable pockets of the individual light unit; • Placement of curtains on the windows and doors; • Use of protective covers on incubators according to corrected age; • Maintenance of circadian rhythms (day and night); • Speaking softly, avoiding speaking loudly especially when the incubator portholes are open; • Alarm level placement of monitoring equipment as low as possible to maintain security; • Decrease the volume of phones; • Extreme care in contact with the incubators, closing doors smoothly and avoiding placing objects on top of it; • Avoid the use of alcohol and antiseptics with the PNB; • Promotion of non-nutritive sucking; • Group care; • Avoid by routine procedures respecting rest periods RNP; • Parental training; • Use of restraint to minimise the negative tactile stimuli.
E4	Impact of hospital-based environmental exposures on neurodevelopment outcomes of preterm infants.	Janelle Santos, Sarah E. Pearce & Annemarie Stroustrup ⁽²³⁾ , 2015. USA.	Summarise interventions related to environmental exposure in NICU given the best results with regard to neurodevelopment.	Literature review.	<ul style="list-style-type: none"> • Skin-to-skin contact; • Therapeutic massage; • Contention; • Individual family rooms.

Table 1 – Presentation of studies selected for review.

Study (E)	Title	Authors/Year publication/Country	Aim of study	Study Design	Results (Measures identified)
E5	Recommended standards for newborn ICU design, eight editions.	White, JA Smith & MM Shepley ⁽²⁴⁾ , 2013. USA.	Identify key recommendations for the design of the NICU.	Expert opinion.	<ul style="list-style-type: none"> • Individual family rooms with separate work preparation areas; • Preparation of feeding or medication outside of the PNB unit; • Remote hand washing areas at least 0.9 m from PNB; • Walls and floor with sound absorbing material, anti-glare, washable; • Alarm signalling using only light in PNB units; • Opt for natural light, windows over 0.6 m area of PNB; • Natural or artificial indirect light, with the possibility of immediate darkness; • Protect the eyes of the PNB from light when carrying out procedures.
E6	A quiet NICU for improved infant's health, development and well-being: a systems approach to reducing noise and auditory alarms.	A.Freudenthal, M. van Stuijvenberg & J.B. van Goudoever ⁽²⁵⁾ , 2013. Germany.	Identify measures to reduce noise in the NICU.	Literature review.	<ul style="list-style-type: none"> • Increase the monitoring devices through artificial intelligence to minimise artifacts; • Implementation of 3 alarm levels (urgent – sound and light, notification – sensitive and light, informative – visual on the screen); • Alarm sound reset; • Individual device by a health professional with sensitive and light alarm.

DISCUSSION OF RESULTS

The use of single family rooms is widely reported in the literature and their benefits are clearly explained^(20,23,24), but it is also mentioned that the deprivation of social contact is detrimental to the development of PNB⁽²³⁾. Thus, the 4th single-family represent a challenge to professionals, in avoiding social isolation of PNB, which is harmful to their development. Despite this challenge, this room comes as a sustainable strategy for environmental optimisation of the NICU, and there is evidence that they decrease infection associated with health care and reduce physiological stress, contributing to weight gain and promoting improved food tolerance⁽²³⁾. In the design of this type of room, an anteroom is provided.

After the close reading and analysis of the selected articles, it appears that authors are unanimous on the influence of sensory environment in the development of PNB. Negative sensory experiences translate into long-term negative impacts on the neurodevelopment of children⁽²³⁾. Despite this, the authors also emphasise the need to provide positive sensory stimuli to PNB, without affecting child development^(20,21,22,23).

Sensory stimulation can be positive, based on the behavioural responses of the PNB⁽²⁰⁾ (E1). Care must be individualised and avoid the absence of stimulation, however the authors state that the literature is not very concise regarding the stimulation model to adopt. The NICU environment should be controlled, suggesting individual family rooms as a key measure, emphasising the advantage in methods such as the kangaroo method, massage therapy, soft music therapy and the use of the maternal voice as a strategy to encourage appropriate and positive PNB development.

The use of a hearing protection device caused a noise reduction of about 7-12dB. Because of this noise reduction, longer periods of sleep and fewer episodes of crying were observed compared to the control group (group in which the PNB were not provided with ear protection). Regardless of the importance of this data, there were no apparent physiological changes in both study groups⁽²⁰⁾. The ear protection device prevents any potential risk of causing lesions on the skin of the ears due to the immaturity of PNB skin.

The technology mentioned supports the development of strategies that contribute to environmental optimisation⁽²⁵⁾. The use of artificial intelligence is proposed, so that robust algorithms are created and they can reduce false alarms (artefacts) and consequently, unnecessary noise. A new device, still in the prototype stage, appears in the literature, whose purpose is to convey information about the patient to the nurse responsible for

their care. It is a small object that is placed on the body of the health professional and if there is any complication detected by the monitor which is connected to the patient or medical device, an alarm is issued in the form of vibration and light. If the nurse responsible for the patient is busy, this alarm will appear on another professional's device⁽²⁵⁾.

The training of families is also referred to as a primary measure in environmental optimisation and consequent promotion of the development of PNB. Parents (caregivers) spend some time in the NICU and are partners of the PNB health care team. It is therefore important to know how to positively stimulate the PNB and prevent the harmful effects of hyper-stimulation, adopting appropriate behaviour and respecting the effective measures for a favourable sensory environment⁽²²⁾.

In Portugal, SPP emanates its consensus in the field of neonatology. Analysing the two documents of 2018^(14,15), referring to light and sound in neonatology units, it is concluded that many of the measures now presented are also listed in these documents, namely the use of covers for the incubators, or protective devices, and the preference for natural light. Regarding noise, SPP also recommends optimising the alarm sounds, preferring individual rooms whenever possible.

The need to produce knowledge through research, on the influence of the environment on the development of PNB, as well as on effective strategies to minimise the effects of negative sensory stimulation, is also widely referred to in the literature consulted.

All nursing professionals must be sensitised and trained in order to contribute to an adequate therapeutic environment in NICUs and to promote the development of PNB⁽²⁵⁾. Mary Coughlin corroborates this idea, hence encouraging the units to integrate and adhere to care standards to support development, stating that this change requires a change of heart and mind, for us to embrace and recognise our humanity by sharing it with the little beings that we care for around the world daily⁽¹³⁾.

The analysis of the various articles identified reinforces the idea that there are some measures and strategies that are easy to implement, so the team has the will and knowledge to do so⁽²⁴⁾. There is an urgent need for training and investment in professionals who care for PNB⁽²⁵⁾.

All nurses should be sensitised and trained in order to contribute to an appropriate environment in the NICU and promote the development of PNB⁽²⁵⁾.

The need to produce knowledge through research on the influence of environment on the development of PNB, as well as on effective strategies to minimise the effects of negative sensory stimulation, is also widely referred to in the literature.

The analysis of several identified articles reinforces the idea that there are some measures and strategies which are easy to implement⁽²⁴⁾. There is an urgent need for training and investment in professionals who care for PNB⁽²⁵⁾.

CONCLUSIONS

The sensory environment experienced in the NICU is consensually considered to hyperstimulate and is a source of stress for PNB, which is detrimental to their proper development.

The focus of care for PNB should be based on the promotion of positive experiences that provide systems development related to the senses (tactile sensory system, gustatory and olfactory system, auditory and visual system).

The benefits of the various interventions listed, which contribute to the reduction of sensory stimuli in the units, are proven. The dissemination and implementation these practices in PNB care are inseparable from the professional activity, which aims for (and requires) excellence and increased humanity. Analysing the measures identified, it appears that many of them are easy to implement.

The integration of care for PNB is an important measure, as it allows the rest of the time, when care is not being provided, to be used to promote rest and sleep.

The creation of universal protocols concerning the sensory environment of the NICU is determinant for units around the world, providing one important source of support to all professionals who care for PNB. These protocols should incorporate clear criteria for the construction, organisation and maintenance of the units.

In conclusion, from this literature review the need to define consistent and consensual strategies for optimising the sensory environment in neonatal intensive care units arises, as well as the need to disseminate and promote them.

Considering only noise and light is very reductive when reflecting on the optimisation of the therapeutic environment of PNB. The therapeutic environment encompasses the physical, sensory and structural aspects of the units, but also the human and even organisational ones. It is imperative that all health professionals, as well as the institutions that provide care to PNB, recognise that the environment is always present.

The last century has marked numerous advances in the level of medical knowledge and technology achieved in an attempt to ensure the survival of PNB. This century has a new goal, which is equally challenging, to continue to ensure the survival of PNB, guaranteeing them the necessary conditions for healthy development, offering them a full and high quality life.

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