

Development and Design of a Nursing Intervention Following a Theory and Evidence-Based Approach to Promote Maternal Sensitivity and Preterm Infant Neurodevelopment in the NICU

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Abstract

Background: Maternal sensitivity is an important predictor of long-term mother-infant attachment and infant development. Considering the behavioral specificities of preterm infants that may impede the development of maternal sensitivity, it is essential to promote these outcomes soon after a preterm birth. A systematic review showed that current evidence on the effectiveness of parent-infant intervention promoting parental sensitivity in the neonatal intensive care unit (NICU) is of low to very low quality. The aim of this project was to develop and design a novel nursing intervention to enhance maternal sensitivity and preterm infant neurodevelopment in the NICU.

Methods: The Medical Research Council's guidance to develop and evaluate complex health interventions, that is an evidence and theory-based approach, was used for this study. Thus, based on the MRC framework, three main steps were conducted: 1- Identifying existing empirical evidence; 2- Identifying and developing theory; 3- Modeling processes and outcomes.

Results: We developed a **guided participation** intervention for mothers to participate in their preterm infant's care and **positioning** (GP_Posit). GP_Posit is based upon the Attachment theory, the Guided participation theory as well as the Synactive theory of development.

Conclusion: This novel intervention is being tested in a pilot randomized controlled trial (NCT03677752).

1. Background

Maternal sensitivity is a primary predictor of long-term mother-infant attachment (1). It is defined as the mother's ability to recognize, interpret and respond in an appropriate and timely manner to her infant's behavioral cues (2). In a literature review synthesizing studies using modern neuroimaging techniques to study the parental brain, infant vocalizations and facial expressions were identified as specific cues that trigger regions of the brain to select appropriate caregiving behaviours (3). In fact, maternal sensitivity is a dyadic component of the mother-infant relationship that not only depends upon the mother's ability to detect and interpret infant cues but also on the infant's ability to demonstrate clear cues (4). Thus, being born preterm is an infant factor that may affect parental sensitivity as preterm infants use interaction cues that may be difficult to understand (5). For this reason, current evidence points out that preterm infants may be more susceptible to low-sensitive parenting (6) and require more sensitivity from their mother (7).

Systematic reviews have shown that mothers of preterm infants are as sensitive as those of term infants (7) and that mother-preterm infant dyads are not at greater risk of developing an insecure attachment (8). Nevertheless, it appears there is no consensus regarding the latter statement as attachment is still reported to be less secure in preterm infants compared to term infants between the ages of 12 and 36 months (9). Moreover, early quality of caregiving and mother-infant relationship have systematically been identified as significant predictors of the preterm infant development (10–15). In fact, there is a weak but significant correlation between maternal sensitivity and preterm infant development even after controlling for breastfeeding (16). In a group of 134 infants, neurodevelopment was significantly better in preterm infants whose mothers were qualified as sensitive (17). More specifically, higher levels of maternal sensitivity have been identified as significant predictors of better reading and performances in mathematics at ages seven and eight in children born preterm (6, 13). Higher levels of maternal sensitivity also significantly predict larger gray matter volumes and head circumference in preterm infants at the age of eight (18). In light of these results, maternal sensitivity seems to be an important factor having a direct effect upon preterm infants' short-term cognitive and brain development.

Regarding long-term neurodevelopment, impairments are still reported in those children that were born preterm. For example, a recent meta-analysis outlined that children born preterm, compared to children born at term, have significant deficits in mathematics and reading until at least 18 years of age (19). Interestingly, this sample included infants born as late as in 2018, confirming that those deficits remain even in preterm infants who received modern neonatal care (19). Even adults born preterm still report having social difficulties (20) and score significantly lower at neuropsychological tests (21). Thus, preterm infant long-term neurodevelopment is still a contemporary concern. Moreover, considering that early maternal sensitivity has a positive impact upon the preterm infant development, interventions promoting maternal sensitivity during Neonatal Intensive Care Unit (NICU) hospitalization seem necessary. In fact, evidence shows that early interventions implemented during NICU hospitalization enhancing parenting in mothers of preterm infants may act as a leverage for plasticity of the preterm infant's brain to enhance neurodevelopmental outcomes (22).

Our systematic review (23) evaluating the effectiveness of parent-infant interventions in the NICU on sensitivity concluded that these interventions, compared to standard care, did not enhance short-term maternal sensitivity, that being when the preterm infant is at term equivalent age (standardized mean difference [SMD] 0.11; 95% confidence interval [CI] -0.18 to 0.40; $p = 0.46$; $I^2 = 52\%$). Similar results were found at up to 6 months of corrected age (CA) (SMD 0.27; 95% CI -0.05 to 0.60; $p = 0.10$; $I^2 = 60\%$) and after 6 months of CA (SMD 0.17; 95% CI -0.07 to 0.41; $p = 0.17$; $I^2 = 8\%$). Results were the same for preterm infant neurodevelopment at term equivalent age (SMD 0.08; 95% CI -0.19 to 0.35; $p = 0.55$) and after 6 months CA (SMD -0.08; 95% CI -0.61 to 0.45; $p = 0.77$). However, it is important to consider that these results are based on low to very low quality of evidence. In other words, these results may not entirely be due to the ineffectiveness of the interventions, but rather to implementation failure (i.e., intervention not delivered as planned to all participants, dose of the intervention insufficient, contamination between study groups). Qualitative studies and literature reviews have highlighted that nurses have a central role in guiding mothers to develop their relationship with their hospitalized preterm infant (24, 25) and for the successful implementation of interventions. It is also recognized by parents that nurses have a key role in facilitating parenting in the NICU (26). In light of these results, it appears important to develop novel theory and evidence-based nursing interventions to add to this body of knowledge. Interventions that were in fact based upon a solid theoretical understanding (27) have shown promising results on maternal sensitivity (28, 29) and preterm infant neurodevelopment (30, 31). Therefore, the aim was to develop a novel nursing intervention to enhance maternal sensitivity and preterm infant neurodevelopment in the NICU.

2. Methods

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The novel nursing intervention was developed following a theory and evidence-based approach (32) and more specifically using the Medical Research Council (MRC) Framework for developing and evaluating interventions (33, 34). The MRC framework was selected because it offers guidance to develop interventions with a well-founded theoretical understanding to reasonably expect a positive effect on selected outcomes (32, 34). Based on the MRC framework, three main steps were conducted: 1- Identifying existing empirical evidence; 2- Identifying and developing theory; 3- Modeling processes and outcomes. For the reporting of this intervention development processes in a detailed and exhaustive manner, the Criteria for Reporting the Development and Evaluation of Complex Interventions in healthcare (CReDECI) revised guidelines proposed by Mohler, Kopke (35) for interventions in healthcare were followed. These reporting guidelines included four steps:

1. Description of the appropriate underlying empirical and theoretical basis for the intervention. We started by outlining specific theories as well as available empirical evidence which serve as the basis of the intervention to be developed.
2. Description of the intervention components. In this second step, we identified and described the intervention components, as well as reasons for selecting these components, their characteristics and their specific aim. For the purpose of this description, we defined intervention components as active ingredients that are selected for their potential to induce change on maternal sensitivity and preterm infant neurodevelopment.
3. Illustration of intended interactions between components. In step 3 we clearly illustrated the mechanisms of action and mediators that explain the link between the intervention components and the expected outcomes.
4. Description of contextual characteristics. Finally, we described micro-level context conditions that are relevant for intervention modeling.

After, we present the intervention structure as per the Better reporting of interventions: template for intervention description and replication (TIDieR) by Hoffmann, Glasziou (36). The intervention structure includes the name of the intervention, the materials, the procedures, the provider(s), the modes of delivery, where, when and how much (frequency, duration and dose) as well as possibilities for tailoring the intervention.

3. Intervention Development Steps

3.1. Step 1 – Theories and empirical evidence

This novel and multifaceted intervention integrates knowledge from experimental studies (empirical evidence) as well as three theories, those being the Attachment Theory (2, 37, 38), the Synactive Theory of Development (39) and the Guided Participation (GP) theory (40). Each theory contributes to the theoretical foundations of the novel intervention as the attachment theory offers a comprehensive understanding of the mother-infant relationship; the Synactive Theory of Development contributes to the conceptualization of the infant's behavior and development as being influenced by its environment; and the GP theory was identified following our analysis of the empirical evidence to describe the nursing role in the promotion of the parent-infant relationship.

3.1.1. Attachment Theory

The attachment theory was originally introduced by John Bowlby (37). Bowlby's ideas originated from animal naturalistic observations that he applied to human infants and their mothers. Bowlby first postulated that attachment encompassed a set of intrinsic behaviors in infants that aimed at maintaining proximity with the mother (37). Before the infant has gained mobility and can demonstrate approaching behaviors, that is behaviors where the infant reaches proximity with his/her mother, he/she will first demonstrate signaling behaviors such as crying, smiling and babbling, that normally bring the mother to the infant (37). Additionally, Bowlby suggested that the mother-infant relationship acts as the base for infant development (38). Our modern conception of the attachment theory is also influenced by Mary Ainsworth, Blehar (2)'s work. Ainsworth later worked on the mother-infant relationship where she was able, following observational studies of human infants and their mothers (41, 42), to define different patterns of attachment and components of the mother-infant relationship (2). In fact, Ainsworth introduced the concept of sensitivity where she observed that infants of highly sensitive mothers were more likely to have a secure attachment (41) and a more harmonious mother-infant relationship (43). Highly sensitive mothers are attuned to their infant's cues, respond promptly and appropriately, and understand the meaning of their most subtle signals (2). Infants who have a mother who responds to their needs in such a contingent way feel secure to develop an attachment and to explore their environment (2). The attachment theory oriented the aim of the intervention as it was designed to enhance maternal sensitivity during the first months of the infant's life, such as during NICU hospitalization.

3.1.2. Synactive Theory of Development

The Synactive Theory of Development was introduced by Als (39) to allow an understanding of each infant's individuality. Infant's organism develops according to five subsystems: 1) autonomic system, 2) motor system, 3) state-organizational system, 4) attention and interaction system, and 5) self-regulatory system (39). Each of these five subsystems is in interaction with each other and with the environment in order to reach and maintain a state of stability in the infant's organism (39). In fact, even preterm infants have the capacity to interact with their social environment, and this interaction is essential for an optimal development as sensitive interaction partners may help preterm infants to reach a state of stability (39). Infants communicate using cues that are classified in two categories: stress and stability cues. Stress cues translate a state of instability and call for interventions that may help the infant regain a stability state. On the other hand, stability cues call for minimal handling to maintain this state. The main behavioral stress and stability cues, which are most recognizable for parents, are presented in Table 1. In other words, the Synactive Theory of Development stresses the importance for parents and nurses to continuously read infant's behavioral cues as they have the ability of communicating their needs to their environment.

Table 1
Main stress and stability behavioral cues¹

| Sub-system | Stress | Stability |
|--|---|------------------------|
| Autonomic | Hiccuping | Smooth respiration |
| | Sneezing | |
| | Yawning | Stable color |
| | Coughing | |
| Motor | Flaccidity of the trunk and/or extremities | Hand and/or foot clasp |
| | Hyperextension of arms and/or legs and/or trunk | Hand-to-mouth |
| | Finger splays | Grasping |
| | Facial grimacing | Handholding |
| | Tongue extensions | Sucking |
| State | Crying | Consolability |
| | Irritability | Clear sleep state |
| | Staring | Focused alertness |
| ¹ Based on Als, Lawhon (44) | | |

3.1.3. Guided participation theory

Based on the empirical literature review on the components and composition of the interventions (see Table 2), we identified GP as being the most frequent mode of delivery of parent-infant interventions to enhance maternal sensitivity (45–51). GP is based upon the GP theory, specific on parenting, which has its origins from the Experiential Learning theory (40). Experiential learning is based upon pragmatist philosophers including mainly Dewey, Lewin and Piaget’s ideas (52). Among the pragmatist philosophers, Dewey’s strong epistemological foundation is, to its simplest expression, the conception of *knowing* and *doing* as being indissociable concepts (53). Dewey gave particular importance to experience that being situations where individuals are subject to the requirements of the environment and plan and adapt their actions according to these environmental conditions (54). Thus, the GP theory integrates these postulates to support the idea that mothers may gain their parental role and develop their relationship with their preterm infant while experiencing caregiving activities (40). Caregiving activities are a set of activities relevant to five main categories: 1) being with the baby, 2) knowing the baby as a person, 3) giving care to the baby, 4) communicating and engaging with others about infant and parental needs, and 5) problem-solving/decision-making/learning (40). Thus, GP is defined as the dyadic process where a novice (mother) engages in a relationship with an expert (nurse), where the former brings the latter to participate in caregiving activities using guidance, over a period of time (40, 55). Guidance is more than coaching as it aims to achieve a meaningful goal, that being to bring the mother to acquire an autonomous caregiving practice for her preterm infant (40). Ultimately, mothers develop their relationship with their infant through this caregiving practice (55). The GP theory strongly oriented the identification of main intervention components presented in Sect. 3.2.

Table 2
Components and composition of interventions

| References | Intervention aims | Intervention description | How much? • Number sessions • Length of sessions | When? | Modes of delivery | Professional delivering intervention | Parental role |
|-----------------------------|---|---|---|---|--|---|------------------|
| White-Traut and Nelson (56) | Directly modifying the interaction between mother and infant via maternally administered intervention. | RISS (Rice Infant Sensorimotor Stimulation Technique): mothers provided tactile stimulation (touch or massage), vestibular stimulation (rocking), auditive and visual stimulation (eye-to-eye contact). | • Mothers administered RISS protocol four times • 15 minutes | First three days after birth. | Verbal instructions, pictures that illustrated the technique, and demonstration of the technique on a doll, were used for teaching the RISS. | First author (nurse). | Passive + Active |
| Meyer, Coll (45) | Address the needs of parents and their high-risk infant and improve parenting and family factors likely to affect infant development. | Individualized intervention based on initial interview to identify parent's needs on four domains: o NBAS evaluation + strategies thought to support development; o Family organisation; o Modification of care environment + guided interaction; o Care after discharge. | • Number of sessions depended on family needs and duration of hospitalisation • 1hr to 1hr30min sessions | Started when infant health was stable and finished before discharge (2 to 8 weeks). | Individualized family-based intervention. | Pediatrician, nurse and physical therapist. | Passive + Active |
| Browne and Talmi (59) | Increase knowledge and contingent mother infant interaction and decrease parental stress. | Individualized demonstration of preterm infant's reflexes, motor capacities and sleep-wake cycles using the APIB. Then, mothers were instructed to interact with their infant using the Mother's Assessment of the Behavior of her Infant (MABI). | • One session • 45 minutes | From NICU admission to the week before discharge. | Individual session. | Not reported. | Active |
| Melnyk, Feinstein (63) | Strengthen parents' knowledge and beliefs about their preterm infants and their own parenting role and remove barriers that would inhibit them from participating in their infants' care and interacting with them in a developmentally sensitive manner. | COPE – Information given on 1) the appearance and behavioral characteristics of premature infants (infant-behavior information) and how parents can participate in their infants' care, meet their infants' needs, enhance quality of interaction with their infant, and facilitate their infant's development (parent-role information) and 2) activities that assist parents in implementing the experimental information. | • Content was given to parents in four phases • Duration not applicable | From first week after birth to first week post discharge. | Educational-behavioral intervention through audio and written information given to parents. | Not applicable. | Passive |

| References | Intervention aims | Intervention description | How much? • Number sessions • Length of sessions | When? | Modes of delivery | Professional delivering intervention | Parental role |
|-------------------------|--|---|--|---|--|--------------------------------------|------------------|
| Glazebrook, Marlow (60) | Enhance parents' observations of their baby and sensitivity to cues through a series of activities which follow the progression of care from incubator to home. | Parent Baby Interaction Program (PBIP): Tactile, discussion, verbal, observation and developmental care activities. | • Weekly sessions • 1-hr | From NICU admission to discharge. Option to continue six weeks after discharge. | Individual sessions. | Neonatal nurse. | Active |
| Chiu and Anderson (61) | Enhance mother-preterm infant interaction. | Preterm infants placed in skin-to-skin contact (SSC) after birth. SSC was encouraged as long as possible and as frequently as possible. Guidance provided to recognize hunger cues. | • One session + guidance during SSC • Not reported | From birth to NICU discharge. | At birth mothers are encouraged to begin SSC as early, as often, and for as long as possible. | Nurse. | Active |
| Newnham, Milgrom (46) | Enhance the quality of mother-infant interaction by teaching the mothers of low-birth-weight infants to be more sensitive and responsive to their babies' physiological and social cues. | Modified Mother-Infant Transaction Program (MITP): psychoeducational intervention on five main topics: 1) becoming acquainted, 2) Recognizing infant disorganisation/stress and availability and then applying those principles during care and play, 3) bath session, where mothers (who bathed their infants) were helped to recognize, and appropriately respond to infant disorganisation and stress, 4) regulate infant responses through play in home setting, and 5) Recognizing temperamental characteristics in infants and parenting to different temperaments | • Nine sessions • 30 min. to 1- hr | Weeks before discharge to 3 months CA. | Verbal instruction, infant observation, practical experience in handling infants and modeling, as well as written materials. | First author (psychologist). | Passive + Active |

| References | Intervention aims | Intervention description | How much? • Number sessions • Length of sessions | When? | Modes of delivery | Professional delivering intervention | Parental role |
|------------------------|--|--|---|--|---|--------------------------------------|------------------|
| Teti, Black (57) | <p>Promote parents' awareness of infant bodily and social cues and parents' sensitivity and confidence in handling their infants.</p> <p>Provide parents with information, via instruction and demonstration, about premature infants' capacities for interacting with the world, how to recognize and respond appropriately to infant cues, and the role of parent–infant interaction in optimizing infant development.</p> | <p>Parentally administered infant massage designed to promote infant development and, in this case, parental knowledge of subtle infant cues and feeling of intimacy toward their infants.</p> <p>Parent-focused psychoeducational intervention designed to foster parents' knowledge about preterm infants' capabilities and needs and how best to read, respond to, and facilitate infant social behavior.</p> | <ul style="list-style-type: none"> • Eight sessions • 1-hr | 20-week intervention from NICU to post-discharge. | Not reported. | Not reported. | Passive + Active |
| Ravn, Smith (47) | Help parents appreciate their infant's unique characteristics, temperament, and developmental potential, make the parents more sensitive and responsive to their infants' physiological and social cues, particularly those that signal stimulus overload. | MITP: Interaction guidance focusing on teaching the parents to understand the individuality of an atypical child, to establish a good pattern of interaction and to encourage the parents to enjoy their infants. | <ul style="list-style-type: none"> • Eleven sessions • 1-hr | Last week before discharge to 3rd month after discharge. | Individualized interaction guidance. | Neonatal nurses. | Active |
| Zelkowitz, Feeley (58) | <p>Reduce maternal anxiety and enhance maternal sensitivity by intervening at the level of both maternal distress and maternal interactive behavior to promote a better parenting environment and thereby optimize the child's cognitive and social development.</p> | <p>CUES: educational intervention for mothers to</p> <ul style="list-style-type: none"> o recognize signs of their anxiety/distress; o use various strategies to alleviate their distress; o read their infant's communication cues; o respond sensitively to their infant's cues and distress. | <ul style="list-style-type: none"> • Six sessions • 1-hr | Starting ~ 33 days after birth until 6–8 weeks of CA. | Individual sessions of teaching and one individual of video interaction guidance. | Nurse or psychologist. | Passive + Active |

| References | Intervention aims | Intervention description | How much? • Number sessions • Length of sessions | When? | Modes of delivery | Professional delivering intervention | Parental role |
|--------------------------|--|---|--|---|--|--------------------------------------|---------------|
| Milgrom, Newnham (64) | Enhance the quality of mother–infant interaction by teaching the mothers of low-birth-weight infants to be more sensitive and responsive to their babies' physiological and social cues. | Enhanced MITP (PremieStart program). Mothers trained to increase their sensitivity in recognizing signs of infant stress including "shut-down" mechanisms, alert-available behavior, facial expressions, quality of motor behaviors, posture and muscle tone; how to provide graded stimulation; and how to avoid overwhelming infants; focus on touch, movement and massage; SSC; multi-sensory stimulation; debriefing and normalizing parental feelings; challenging dysfunctional thoughts, and parental diary keeping. | • Nine weekly sessions and one session post-discharge • 1-hr | From first week after birth to first week post discharge. | Individual psychoeducational intervention. | Psychologists. | Passive |
| White-Traut, Norr (48) | Not reported. | H-HOPE (Hospital to Home: Optimizing the Infant's Environment) – combination of guided participation of mothers to Auditory Tactile, Visual and Vestibular-rocking stimulation (ATVV) | ATVV: • Twice daily • 15 min per session Maternal sessions: • 6 sessions | From 32 weeks of GA to 1-month CA. | Mothers were thought to administer the ATVV during the maternal sessions. Otherwise, mothers administered ATVV. | Nurse advocate team. | Active |
| Borghini, Habersaat (49) | Enhance the quality of parental caregiving as a support to the infant's global development by improving parents' observation and understanding of the specific competencies of their preterm infant (particularly interactional competencies) and promote parents' sensitivity and responsiveness towards their infant's behavioral characteristics. | At 33 weeks of GA: joint observation of infant's reactions to various stimuli during standard care procedures. At 4 months CA: 10-min mother-infant free play videotaped followed by video interaction guidance. | • Four sessions • 30–60 minutes | First session at 33 weeks of GA. Three sessions one-week apart during 4th month CA. | Individual sessions of interaction guidance and video interaction guidance. | Nurse and therapist. | Active |

| References | Intervention aims | Intervention description | How much? • Number sessions • Length of sessions | When? | Modes of delivery | Professional delivering intervention | Parental role |
|---------------------------------------|---|---|--|--|--|---------------------------------------|---------------|
| Hane, Myers (28) | Establish an emotional connection and a Calming Cycle routine between the mother and her premature infant. | Family Nurture Intervention (FNI): mothers are involved in calming interventions which is facilitated by a nurture specialist. o Scent cloth exchange; o Vocal soothing and emotion expression; o Eye contact; o Skin-to-skin and clothed holding. | • Average of 3.5 sessions/week • ~ 6hr/week | From NICU admission to discharge depending on availabilities of mothers. | Individual sessions of guided participation. | Nurture specialists (former nurses). | Active |
| Hoffenkamp, Tooten (50) | Facilitate parental bonding, to enhance the quality of parental interactive behavior, and to promote parental well-being using edited video recordings of parent-infant interactions. | Parent-infant interaction videotaped during daily moments of caregiving such as bathing, changing and feeding. Video is then reviewed and discussed with the parents. | • Three sessions • Duration not reported | During first week after birth. | Individual sessions of video interaction guidance. | Trained nurses and pedagogic workers. | Active |
| Evans, Boyd (65) | Prevent severe emotional, behavioral and developmental problems in both children and adolescents. | Triple P is an educational intervention covering four main topics: 1) survival skills, 2) partner support, 3) positive parenting, and 4) responding to your baby. | • Four sessions • 2-hr • Four post-discharge phone calls • 30-minutes | From NICU hospitalisation to 12 months CA. | Not reported. | Trained facilitators. | Passive |
| Sahlen Helmer, Birberg Thornberg (62) | Increase time spent in SSC to improve mother-infant interaction. | Continuous skin-to-skin contacts between mother and infant. | • Continuously (> 20-hr/day) | First seven days of life. | Not applicable. | Not applicable. | Active |
| Twohig, Segurado (51) | Not reported. | Reflective interview, observation of infant cues and video interaction guidance. | • Three sessions • 1-hr to 1.5-hr | Not reported. | Individual sessions. | First author (clinician/researcher) | Active |

3.1.4. Empirical evidence

We conducted a systematic review evaluating the effectiveness of parent-preterm infant interventions, conducted in the NICU, on parental sensitivity (23). Based on this systematic review, a secondary thorough analysis of the components and composition of the interventions (n = 18) was conducted (see Table 2). This content analysis has allowed the identification of the main intervention components as described in Sect. 3.2.

3.2. Step 2 - Components of the intervention

Based on the theories and empirical evidence, two main intervention components were identified: 1- an educational component, and 2- an active-participatory component. These two components are interconnected and both essential. The intervention developed is hence multifaceted as it includes both passive and active components, the former being educational activities where mothers receive information and the latter where mothers actively participate to caregiving activities. In fact, both passive and active components seem to have their importance in parent-infant interventions with a predominance of a combination of the two components (45, 46, 56–58), or an active component alone (28, 47–51, 59–62). As outlined in Table 3, the educational component encompasses different topics, and the active-participatory component relates to maternal participation to various caregiving activities of their preterm infant with direct guidance from a nurse. The rationale for selecting these two components is further explained in Sect. 3.2.1. and 3.2.2.

Table 3
GP_Posit intervention components

| Educational | | Active-Participatory | |
|-------------|---|-----------------------|--|
| Topics | Stress and stability behavioral cues of preterm infants | Caregiving activities | Diapering |
| | Supine, lateral and prone positioning | | Positioning (supine, lateral and prone) |
| | – | | Bottle-feeding and/or breastfeeding (optional) |

3.2.1. Educational component

The educational component includes teaching to mothers aspects about stress and stability behavioral cues of preterm infants, which is supported by both theory (2, 39) and empirical evidence (46, 47, 49, 51, 57–59, 63–65). In fact, if mothers are expected to detect and interpret their infant's cues (2), and considering that preterm infants communicate with cues that are difficult to understand (5), it becomes evident that those specific cues should first be thought to mothers before they may interpret and respond to them.

Additionally, in the studies identified in the systematic review, many parent-infant interventions were centered around teaching mothers about care activities that may enhance their preterm infant's neurodevelopment. Some interventions aimed at teaching mothers about sensorimotor stimulation (56), multisensorial stimulation (28, 48, 64), massage (57), developmental care (60), or skin-to-skin (61, 62).

In this intervention, mothers are being taught how to position their preterm infant in their incubator or crib. First, positioning is a central part of preterm infant's care while in the NICU intended to improve their neuromotor development (66). Maternal participation to positioning has been evaluated in one randomized controlled trial (RCT) (67) where, compared to standard care, preterm infants who received the motor intervention from their mothers had a significantly better motor performance at term equivalent age (68). Mothers in this study also noted that it empowered them to become competent in providing care and enhanced their feeling of attachment to their preterm infant (69). Based on this evidence, teaching mothers how to position their preterm infant while in the NICU was selected.

3.2.2. Active-participatory component

In addition to the educational component, the emphasis of the intervention is on the active-participatory component (40). In fact, in 50% of the parent-infant interventions from the systematic review, parents provided care to their preterm infant, and in 75% of those, parents were given specific guidance to do so (45–51). Thus, parents participate in caregiving activities of their preterm infant, while being guided by a nurse.

In this intervention, mothers will actively participate to caregiving activities with their preterm infants while being guided by a nurse. It is of importance to note that the caregiving activities are only the context provided to mothers so they can learn how to interact with their preterm infant. Thus, while providing care to their infant, guidance is given to mothers so they can learn to detect, interpret and respond to their infant's behavioral stress and stability cues. In fact, for preterm infants, caregiving activities are recognized as being stressful (70, 71), so care should be provided in accordance with their behavioral cues (72). In other words, the nurse's role during the sessions is to provide guidance to mothers by encouraging, praising, and supporting them in recognizing behavioral cues when they did or did not recognize or respond to a cue. As stated in Table 3, caregiving activities include diapering, positioning and feeding (optional). When providing care to preterm infants in the NICU, diapering is usually the first manipulation done, followed by repositioning. Thus, throughout the intervention sessions, mothers will progressively participate to their infant's diapering, then supine, lateral and prone positioning. This progression will be based both on the mothers' ability and level of confidence as well as the nurse's judgment. Nevertheless, the aim is to focus on the mother-infant communication while doing the caregiving activity and not necessarily go through every caregiving activity during the sessions. However, if both the mother and the nurse feel that the mother easily recognizes, interprets and responds to most behavioral cues of her infant while doing a specific caregiving activity, they may move onto the next caregiving activity. For infants nearing home discharge and who are learning to feed orally, the caregiving activity could be adapted to bottle or breastfeeding if mothers are already comfortable with positioning.

3.3. Step 3 - Interactions between components

Figure 1 exposes the intricate links between intervention components, mechanisms of action, mediators as well as expected outcomes of GP_Posit, based on theories and empirical evidence. These links are described thereafter.

3.3.1. Links between intervention components and mechanisms of action

The educational component about behavioral cues should increase mother's knowledge about their infant's cues as well as their belief about their competence in recognizing these cues (5, 39, 73, 74). Mothers of preterm infants verbalize the need to be educated about these cues (75). As for the positioning educational component, this should contribute to maternal ease in the guided participation to diapering and positioning. Maternal active participation to care through GP will trigger five mechanisms of action. First, in interventions where touching the infant is involved, the feeling of physical proximity within the dyad is increased (76). GP as well as maternal active participation to care increase the feeling of gaining confidence in maternal role and lowering maternal stress (77, 78). Moreover, having mothers participate to their preterm infant's positioning should promote optimal positioning practices for the preterm infant throughout the NICU stay. Finally, as the emphasis in GP is primarily to support mothers in communicating with their preterm infant, this entails that they give importance to recognizing in addition to interpreting the stress and stability cues. Respecting preterm infant cues while providing care helps them to self-regulate and keep their stress to a minimal level (39). Also, appropriate positioning of the preterm infant in the NICU allows them to improve autoregulation (79, 80).

3.3.2. Links between mechanisms of action, mediators and outcomes

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Mothers being more knowledgeable about their preterm infant's behavioral cues should allow them to be better prepared to detect and interpret these cues which is central to maternal sensitivity (2) and to reduce stress and anxiety (63). Physical proximity between the mother and her infant is the base of the attachment theory and also contributes to maternal sensitivity (37).

Mother-infant interventions in the NICU where parental participation is promoted have reduced maternal anxiety (81). On the opposite, physical proximity is limited, maternal anxiety increases (82), so promoting physical proximity in the intervention should reduce maternal anxiety.

Parental role adjustment is one of the most important sources of stress for mothers in the NICU (83, 84). Having mothers participate in their infant's care has been identified as an intervention promoting the mother's confidence in her maternal role (84) and thus will reduce maternal stress and anxiety (85).

Preterm infant positioning is an integral part of preterm infant care in the NICU (86) for its benefits on neuromotor development (80, 87, 88). Stress in the NICU is detrimental for the preterm infant's neurodevelopment (89), so promoting preterm infants' positioning and reducing their stress is expected to enhance their neurodevelopment.

3.3.3. Links between mediators and outcomes

A concept analysis of maternal sensitivity identified maternal anxiety as a negative affecting factor to maternal sensitivity (90). Lowering maternal stress has systematically been identified as favorable to improve maternal sensitivity (5, 90, 91). In other words, reducing maternal stress and anxiety should increase their sensitivity.

3.3.4. Links between the outcome of maternal sensitivity and infant neurodevelopment

Many studies have linked an increase in maternal sensitivity to preterm infants' neurodevelopment. For example, enhanced maternal sensitivity predicts larger gray matter volume and head circumference (18), improved mental development (14), more consistent and symmetric cortical thickness across brain hemispheres (92), improved cognitive performances (6, 13, 16) and improved cerebral white matter micro-structural development (93).

3.4. Step 4: Contextual characteristics

The intervention will be implemented in a NICU designed with single-family rooms (SFR). This is to take into consideration since it has been demonstrated that SFR ensure more privacy, promote family-centered care, and provide a more favorable environment to build trust between nurses and parents (94, 95).

4. Intervention Structure

4.1. Materials

This intervention mainly relies upon the relationship developed between the nurse and the mother which requires no material. However, to support the educational component of the intervention, an informative booklet and web-based modules are used to support the nurse's teaching.

Firstly, the informative booklet, developed by the first author (AL), contains pictures of various stress and stability cues so the nurse can use those pictures during the educational component of the intervention. Mothers can refer to it between intervention sessions. The booklet also contains pictures of appropriately positioned preterm infants so they can also have a reference if they want to participate in their preterm infant's positioning in between intervention sessions.

Secondly, the nurse also has access to web-based modules developed by a multidisciplinary team that provides written information as well as pictures and videos adapted for parents of preterm infants that demonstrate appropriate techniques of positioning in the NICU (96). The web-based modules were previously pilot tested, and results showed that parents were satisfied, and that the positioning module was most liked by parents (97). The advantage of the online modules is that mothers may refer to it at any time.

4.2. Name of the intervention

This intervention was named GP_Posit because it mainly focuses on **Guided Participation** of mothers to the **Positioning** of their preterm infant.

4.3. Procedures

The structure and procedures of the GP_Posit intervention sessions are presented in Table 4.

Table 4
GP_Posit intervention structure

| Sessions | Intervention passive and active components | Content of session |
|------------|--|--|
| Session 1 | Education | Preterm infant development Stress and stability behavioral cues |
| | Participation | Diapering |
| Session 2 | Education | Supine positioning |
| | Participation | Diapering + supine positioning |
| Session 3 | Education | Lateral positioning |
| | Participation | Diapering + lateral positioning |
| Session 4 | Education | Prone positioning |
| | Participation | Diapering + prone positioning |
| Session 5+ | Participation | Diapering + positioning Feeding (optional) |

4.4. Provided by who

GP_Posit intervention is meant to be administered by trained neonatal registered nurses as they have the expertise to work with preterm infants and their mothers. In fact, in our systematic review conducted to support this intervention, $\geq 55\%$ of parent-infant interventions were provided by nurses. However, for GP_Posit, nurses should be able to educate mothers about the behavioral cues of their preterm infants and appropriate positioning techniques. So, if this training is not already provided in the NICU where the intervention is to be implemented, the intervention nurses should receive appropriate training on those topics. Additionally, neonatal nurses should be trained in GP, about what GP entails, their role as expert nurses, as well as how to administer GP. Most importantly, the same nurse should always meet with the same mothers throughout the sessions as GP is based on the mother-nurse relationship developed over time (40).

4.5. Modes of delivery

GP_Posit is delivered through individual sessions, between the nurse and the mother. This choice was based on the fact that $\geq 60\%$ of the parent-infant intervention were provided through individual sessions. Also, GP entails that sessions should be individualized (40).

4.6. Where

GP_Posit will be implemented in a level III NICU of a university hospital center. Sessions are provided at each infant's bedside, in SFRs to ensure privacy and a calmer environment (94).

4.7. When and how much

In our systematic review, 11 out of the 18 identified interventions were mainly conducted during NICU hospitalization and finished, at the latest, one week after discharge (28, 45, 50, 51, 56, 59–64). Moreover, the average number of sessions that were delivered was 5 sessions throughout the intervention, varying from one to 11 sessions. As for the length of each session, the average reported in interventions from the systematic review was of 62 minutes per sessions, varying from 15 minutes to 2 hours.

Thus, GP_Posit is meant to be implemented as soon as possible after birth and should be performed until the infant reaches 35 weeks of gestational age (GA) or until discharge at home. The intervention will be offered to mothers of preterm infants born at 28 weeks of GA or more, as preterm infants start showing behavioral cues around that age (98). The number of sessions will depend on the age of the infant at birth and age at discharge. For example, mothers of infants born at 31 weeks of GA would participate in four sessions and mothers of infants born at 28 weeks of GA, seven sessions. The sessions should take place weekly, and each has a duration of 30 to 45 min or more depending on time needed for the completion of care. If possible, these sessions should be timed with each preterm infant's care plan in the NICU and should be clustered with other care as suggested (72), so that she/he is not awakened uniquely for the intervention purposes. Also, for pragmatic considerations, the schedule for the individual sessions should be determined with the mother, according to her availabilities.

4.8. Tailoring

Considering the importance of individualizing interventions for preterm infants (44), the care used to contextualize the mother-infant interaction could be tailored based on the mother's needs, abilities and level of confidence. For example, the content of each session is pre-planned (see Table 4), but nurses are free to adapt this content depending on specific infant and maternal needs at time of the session.

5. Discussion

In this paper we presented the development process of a nurse-led intervention of guided participation in the NICU designed to enhance maternal sensitivity and preterm infant neurodevelopment. The development of this intervention is novel as it is anchored in a theory and evidence-based approach such as the

MRC framework and brings a unique contribution to the neonatal body of knowledge. The strength of this approach is that it allowed to follow a systematic methodology to develop a thorough understanding of the underpinning processes that predict the effectiveness of the intervention components on selected outcomes. Theories to support GP_Posit were identified for their relevance to optimally understand the nurse's role to contribute to the attachment process between mothers and their hospitalized preterm infant. In addition to grand theories (2, 39, 40), we were also able to build upon strengths and limitations of previous interventions evaluated in RCTs and identified through our systematic review (23).

6. Conclusion

In the NICU, nurses are recognized as being the primary caregivers of preterm infants with parents. GP_Posit is a novel multifaceted nursing intervention aiming at building a stronger partnership between mothers and nurses to guide mothers in gaining faster their maternal role. In other words, based on empirical and theoretical evidence, we expect that mothers participating in GP_Posit will develop a stronger maternal sensitivity and that preterm infants will demonstrate enhanced neurodevelopment. Thus, this intervention has the potential to enhance neonatal nursing care and optimize both mothers' and preterm infants' short- and long-term outcomes. GP_Posit intervention was piloted according to a published protocol to evaluate mother's acceptability and satisfaction with the intervention as well as preliminary effects on maternal sensitivity and preterm infant neurodevelopment (99).

Abbreviations

CA: corrected age

CI: confidence interval

CReDECI: Criteria for Reporting the Development and Evaluation of Complex Interventions in healthcare

GA: gestational age

GP_Posit: Guided Participation to care and Positioning and care intervention

MRC: medical research council

NICU: neonatal intensive care unit

RCT: randomized controlled trial

SMD: standardized mean difference

TIDieR: Better reporting of interventions: template for intervention description and replication

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analysed during the current study.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

AL led intervention development and modeling. MA, JC, LB and BG provided guidance and feedback, read, edited and approved the final manuscript.

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Figures

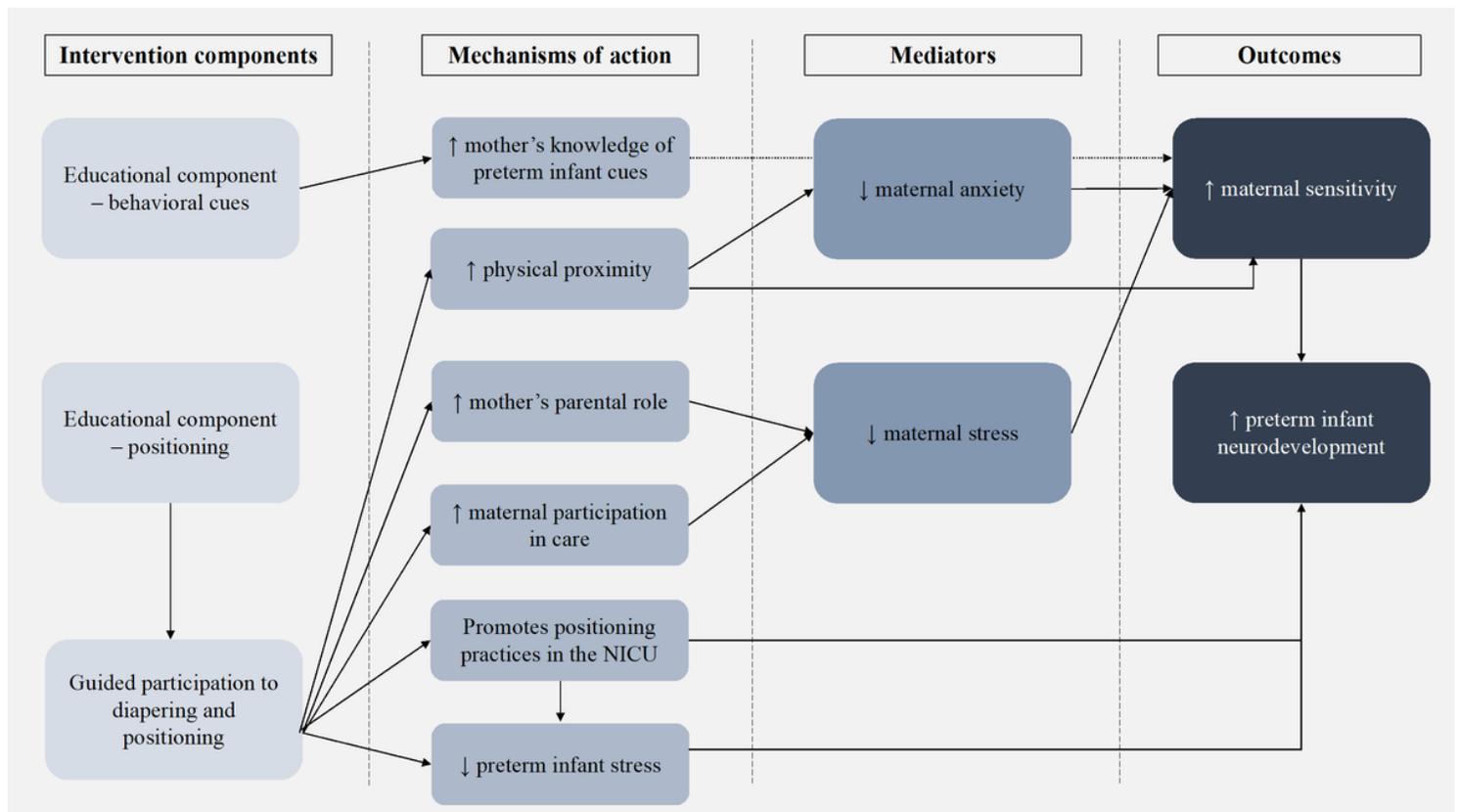


Figure 1

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