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Family Intervention Programs Supporting Parasympathetic System in Preterm Infants : Analysis of the Programs' Consistency with the Polyvagal Theory

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Abstract

Preterm birth is defined as a birth that occurs before the 37th week of gestation, as a result infants are born before their full maturation. Preterm infants encounter unique developmental challenges as a result of their early exposure to stressors related to physiological interventions, sensory overload from the multiple stimulation sources surrounding them inside neonatal intensive care units (NICU), and separation from their parents. This thesis explores, through the lens of the Polyvagal Theory, how developmental and family-centered care programs in NICUs contribute to the regulation of autonomic responses in preterm infants. The Polyvagal Theory highlights how the autonomic nervous system reacts to stress and safety, and by implementing interventions such as parental involvement, individualized sensory modulation, and nurturing care environments, it impacts preterm infants' autonomic regulation, growth, neurodevelopment, bonding, and long term health. The findings of these programs demonstrate the importance of early interventions that promote parasympathetic regulation and the positive impact in the overall growth and wellbeing of the preterm infant, emphasizing the role of developmental and family-centered care interventions in their early life.

Keywords: preterm birth, developmental care, family-centered care, neonatal intensive care units, polyvagal theory

Introduction

Preterm birth is defined as those births that occur before the 37th week of gestation (World Health Organization, 2023), although science and technology have made great advances to improve life of infants born prematurely, it is still a very important public health concern due to the widespread consequences of their development and well-being (Sanders & Hall, 2017; Pas, 2017). The NICU, while medically critical for the care of preterm infants, is also an important source of serious stress for both the infants and their families (Woodward et al., 2014). Babies are removed from their stable environment to a place with unfamiliar noises, painful procedures, and different lighting and temperature from what they were used to inside the womb. The NICU, even though it is necessary to ensure the right environment for the preterm infant to continue growing, can also be a source that enhances stress on parents, as they have to let health professionals care for their premature newborn.

According to the World Health Organization (WHO) (2023), preterm birth prevalence has not diminished in the last decade, over the last ten years the rates of prematurity have been stable, although science and technology are advancing, no positive repercussion on preterm birth rates has been seen. The need for effective interventions is crucial to support the health and development of this population.

Developmental care and family-centered care programs have grown as a topic of interest for research in NICU settings (Anderson & Cacola, 2017; Sanders & Hall, 2017; Vanderveen et al., 2009). These types of programs promote the participation and involvement of parents along with health staff in the NICU, constructing a supportive environment that can improve the development and enhance better long-term overall

health outcomes for preterm infants (Ulvund, 2022). One of the central components of these types of programs is the focus on regulating the parasympathetic nervous system of the infants', this system has an important role in physiological and behavioral responses to the NICU environment (Sanders & Hall, 2017). The importance of analyzing the core practices of the programs and understanding the link to premature infants' regulating system is a key factor for this population.

A theory that can enlighten the understanding of these types of programs, is The Polyvagal Theory, developed by Dr. Stephen Porges. This theory proposes a framework for explaining the role of the autonomic nervous system in humans to autoregulate the inside of the body, examining whether an interaction is safe or dangerous. In this theory, the vagus nerve plays a major role in regulating the body's response and facilitating social engagement and bonding when a safe interaction is sensed. In this context, a stable and supportive environment provides a better scenario for premature infants to regulate their autonomic functions, as a result, a better health and developmental aftereffect (Sanders & Hall, 2017).

This thesis aims to explore the efficacy of developmental and family-centered care programs in regulating preterm infants' physiological and behavioral responses in accordance with the principles of the Polyvagal Theory. How these programs support autonomic regulation and overall development in preterm infants will be examined. This study includes a theoretical review of topics related to the theory and the models that set the base of the programs, and to have a better understanding of the population group it covers preterm birth definitions, the current prevalence of prematurity and the multiple types of classifications and risks factors that exist in this context, and highlights the experience that a preterm infant faces when entering a NICU environment. Next, an overview of the Polyvagal Theory to deepen into the framework

proposed by Dr. Stephen W. Porges of physiological states as reactions to our interaction with the environment, and how to apply this theory to the context of prematurity, specifically in autonomic regulation. Lastly, a review of the literature on developmental and family-centered care to explore the various aspects of the analyzed programs according to these concepts. A review of the importance of application, the challenges and benefits of NICU care, and how these family intervention programs significantly contribute to the wellbeing and improvement of premature infants.

The aim is to contribute to the awareness of the importance of developmental care and family-centered care when implementing specialized programs in the NICU setting, to contribute to the lives of the preterm infants.

Chapter 1. Early Arrival: Understanding Preterm Birth

This first chapter aims to establish the characteristics of the population of interest, preterm infants. Since preterm birth comes with specific risk and health conditions, this has had a direct influence on the development of specialized care programs for this specific group. We will therefore focus on the preterm birth population, and will examine the current definition stated by the WHO, along with the important key marker for the global health system which is the prevalence of premature births, and how premature births are classified by their nature of occurrence during gestation or labor. There can be several environmental, mother related or gestation related that have been associated to conduct a preterm birth, and lastly, here are mentioned the components that influence the experience of premature infants in the context of the NICU setting.

Definition and Prevalence of Preterm Birth

Preterm birth has been a significant topic of interest and research for many years, drawing the attention of medical professionals, researchers, and public health organizations. According to the WHO (2023), a preterm birth is defined as a birth that occurs before the thirty-seventh week of gestation. This definition is important because a typical pregnancy lasts around forty weeks for it to be considered full term.

Preterm birth has a global impact. Every year, there are more than one hundred and thirty million births worldwide, according to the United Nations (2022). Of these births, approximately thirteen million infants are born prematurely, reported by the

WHO (2023). This number represents about ten percent of all the births globally, and this means that one in ten infants is born before the full term of gestation, a premature infant.

In a systematic analysis conducted by Ohuma et al. (2023), it was found that there has been little to no change in the annual prevalence of premature births in the last decade, even though there is ongoing research and public health interventions. This analysis, which reviewed data from 2010 to 2020, highlights the persistent challenge that preterm births have on a global scale, for the health systems and for the parents.

In Europe, the prevalence of preterm birth varies greatly across the countries and regions. According to Zeitlin et al. (2013), the rate of preterm births in 2008 ranged from five to eleven percent, indicating some difference in the occurrence of preterm births within the continent. These variations can occur due to multiple factors, such as healthcare access, socioeconomic conditions, and gestational conditions.

Within the broad category of preterm birth, there are further classifications that provide more detailed information regarding the health status of the premature infant and the mother. These classifications determine the medical care and interventions needed to support both the infant and the mother during and after delivery.

Classification of Preterm Birth

Acknowledging the different classifications that exist for preterm birth is essential, as it gives the opportunity for a deeper understanding of the complexities involved in premature infants. These classifications not only provide critical insight into the care that a premature infant may require but helps to predict potential outcomes

following the birth. Moreover, they serve as valuable tools in advancing scientific research and improving neonatal care interventions.

Gestational age and birth weight are two key factors broadly used to classify a preterm birth. The gestational age refers to the duration of the pregnancy at the time of birth. The WHO (2023) proposes a detailed classification based on the gestational age, which includes three categories: Extremely Preterm, which are those infants born at less than twenty-eight weeks of gestation; Very Preterm, those infants born at twenty-eight to thirty-one weeks of gestation; and Moderate to Late Preterm, those infants born at thirty-two to thirty-six weeks of gestation. This classification reflects the different degrees of prematurity, and each is associated with different levels of medical assistance.

However, gestational age alone does not cover the entire panorama of a premature birth. As not all premature infants born at the same gestational age weigh the same. Another aspect for classification is proposed (Cutland et al., 2017): Extreme Low Weight for those infants who weigh less than 1000 grams; Very Low Weight for infants that weigh from 1000 to 1.499 grams; and Low Weight those infants who weigh from 1.500 to 2.500 grams. These weight-based classifications are important for individualizing neonatal care, weight being an indicator of the infant's at-birth needs.

In addition to these classifications, other different systems have been developed in order to address the multiple different aspects of preterm birth. This contributes to establishing a classification among prematurely born infants taking in consideration other different aspects, for healthcare professionals to administer effectively the proper care to the premature by not only considering one aspect. For instance, clinical presentation at labor time is another crucial aspect of classification. According to Goldenberg et al. (2008), preterm births can be classified based on the onset labor, it

includes the spontaneous preterm labor with intact membranes, spontaneous preterm labor with rupture of membranes, and induced labor or prelabor cesarean section due to medical indication. The different scenarios of preterm birth come with challenges and need specific medical responses, classifications may contribute to clarify these needs to cover in time.

Furthermore, a classification based on the mother's health pathologies, such as placental pathologies, infectious/inflammatory, vasculopathy/infarction, and stress-induced (Kramer et al., 2012) preterm birth. These different classifications are tools to better understand the etiology of preterm births and to identify cases where maternal health may have contributed to early onset of labor.

As illustrated, preterm birth is a complex phenomenon that cannot be classified under one single aspect. The multiple classifications reflect the diversity of factors that can lead to a premature birth. Moreover, not all preterm birth cases present a previous pathology or health risk condition that health professionals can link to the event of a premature birth (Vogel et al., 2018).

Risk Factors Associated with Premature Birth

There have been a series of risk factors that have been found to be linked to preterm birth, that reflect the complexity of this phenomenon. These factors range from environmental agents, social conditions, and biological elements, all have been associated with the risk of increasing the possibility of premature birth. Through an extensive analysis of various systematic reviews and meta-analysis, Vogel et al. (2018) reported the following list of risk factors, a numerous list related to maternal, obstetric, fetal, environmental and psychosocial factors. This extensive study sheds light on the

complexity of the preterm birth and the wide range of factors that can contribute to its occurrence.

The risk factors identified by Vogel et al. (2018) include the following:

- Black ethnicity;
- Male biological sex;
- Teenage (highest risk when first child and below 18 years old) or advanced maternal age pregnancy;
- Low maternal education;
- Previous history of preterm birth;
- A period of 6 to 12 months gap between pregnancies;
- Poor nutrition and vitamins deficiency of the mother;
- Cervix length shorter than 25 mm;
- In vitro fertilization and multiple pregnancy;
- Smoking or drug consumption during pregnancy by the mother;
- Infections acquired before and during pregnancy;
- Preeclampsia;
- Pregestational and gestational diabetes;
- Obesity;
- Depression, stress and anxiety during pregnancy;
- Placental abruption, or placenta previa.

Environmental factors like outdoor air pollution, lower socio-economic status, and partner violence during pregnancy are also considered to play a role as potential factors for prematurity.

Despite the efforts of researchers in finding potential risk factors, in many cases, the main cause leading to premature birth is not clear (Vogel et al., 2018). This possibility highlights the importance of considering the multiple possible causes, external causes and internal causes, when evaluating the possibility of a preterm birth occurrence.

Understanding the risk factors that can cause a preterm birth is crucial, as they can help to prevent or determine the care needed at the moment of birth. The transition from the intrauterine environment to the outside world is an important and critical process, in a particular way for infants that have not completed their gestation time. How is the new environment, outside of the womb, for an infant that is born before their full gestation? For neonatal care, understanding how the new environment outside of the womb impacts the newborn life and development is of vital importance.

Experiences of Preterm Infants in the Neonatal Intensive Care Unit

When a baby is in the womb, the baby is experiencing an environment that provides the care, nurture, and the environment to continue developing, but when a situation provokes a necessity for the infant to be born in an early stage, causing a premature birth, the experience of the premature infant has important changes. The prenatal period, inside the woman's womb is the stage for a baby to fully develop biologically. The postnatal period, in the case of a premature infant, is impacted by the admission to the NICU. Even if it provides a well controlled and safe space for a premature baby to develop and grow, it's important to mention that prematures are not fully developed by the moment of the start of their postnatal experience in this new setting out of the woman's body.

Environmental stimuli such as bright lighting, noises from the incubators, ventilators, different monitors that are constantly alerting the state of the infant, IV pumps, and other type of life-supporting devices, care manipulation by nurses, interaction with parents and medical interventions that are painful like, heel lancing, blood samples, nasogastric or endotracheal tubes, these to name some, are a source of organism stability disruption for the premature infant (Cheong et al., 2019; Maltese et al., 2017; Aita et al., 2021).

Furthermore, the lack of proximity to parents can be a cause of higher induced instability in preterm infants. Flacking et al. (2012) mentions that the quality of parental care, in the same context of physical and emotional closeness, has been found to be crucial for preterm infant's brain development and long-term outcomes. Early mother and infant interactions, such as skin-to-skin contact, an action that promotes physical closeness, is able to synchronize the levels of cortisol between the preterm infant and the mother (MöRelius et al., 2005).

One of the topics that has been researched and it is of great importance for this thesis, is the stress and pain caused during the NICU stay, according to Cheong et al. (2019) these have been found to be influencing factors in the development of very premature babies, where a higher number of painful procedures while admitted in the NICU, are linked to a reduction of the white matter and shrinkage of the subcortical gray matter. In other words, early pain procedures serve to impaired brain development in very preterm infants (Brummelte et al., 2012).

As mentioned by Montirosso & Provenzi (2015), elevated and chronic early stress experiences in infants has been found to contribute to stress responses and brain alterations. The numerous painful and non-painful physical stressors in a NICU justifies a high stress experience for preterm infants, which can contribute to alterations in

regulation of cortisol levels, the hormone of stress. As noted by authors in evidence from maltreated young population, there have been observed alterations in the hypothalamic-pituitary-adrenal (HPA) axis. These alterations may not only concern maltreatment or abuse experiences but also chronic stress and pain exposure in early life experiences.

Recent findings propose that the HPA axis, a pathway involved in mediating stress regulation (Sheng et al., 2021), is influenced by epigenetic modifications in gene transcription. Epigenetics is involved in changes of gene expression that do not alter DNA sequence, and are due to environmental and situational factors. One of the main epigenetic mechanisms is DNA methylation, a process of gene expression control.

Montirosso & Provenzi (2015) reported that prenatal DNA methylation, specifically for gene NR3C1 associated with stress response, is influenced by maternal stress during the last trimester of pregnancy. In addition, abuse in the early life of infants can influence DNA methylation in other genes. Thus, more evidence is needed to understand how prematurity and the multiple factors related to the NICU environment impact the epigenetics of early neonatal experiences.

There are factors that are still being debated whether they are positive or negative, and this factor is directly linked with the possibilities a family can acquire, referring to economic social status. This factor is the possibility to have a single-family where the neonate is placed, in comparison with a standard bay area where there are multiple infants under the care of the health staff. The reason why this is linked with the economical social status, is because not all public health hospitals may have the option to invest in this solution, and having the option to attend to a facility that does can be a disadvantage for other realities. As mentioned before, both effects have been seen, Cheong et al. (2019) included results in their article related to the modality of the room

where premature infants were placed, and they found positive short-term results for single-family rooms, weight gain, feeding starting point and only breastfeeding modality after discharge, and neurobehavioral development. In the same modality, contrary outcomes have also been found. The contrary effect results are not strong enough to disqualify one modality or another. Socio-economic status and parenting involvement, translated as active presence with the premature, play an important role in the development of the premature, not only during the stay in the NICU but along the neonate period.

To sum, a preterm birth is a global and actuality problem, itself is a complex condition with multiple risk factors and multiple classifications due to its naturalness. The place where a premature baby completes its development process, a NICU setting, has important effects on the experience and development for these babies. Exploring theories that put light on possible paths to continue understanding the condition of a preterm baby, is of major importance.

Chapter 2. Neurobiological Insights: The Polyvagal Theory and Preterm Birth

We have observed the particularity of a preterm birth, the complexity of multiple determinants in the context of a pregnancy that can lead to an early delivery of a baby. The environment where they continue to develop, a NICU setting, is where their first interactions with the world occur. Separation from the parents, painful procedures, stress from the care interactions, sounds, light, all of these factors are the world of a preterm infant for days, weeks, or months. Dr. Stephen Porges proposed a framework for better understanding the part of the autonomic nervous system in the regulation of the heart, lungs, guts, and how this autoregulation occurs through the vagus nerve, detecting safety or danger through neuroception, that will be further explained but contribute to two main biobehavioral outcomes, rest-and-digest, and freeze response. We will therefore explore the Polyvagal Theory, in order to understand how enhancing vagal tone and building up safe connections can be beneficial, this translated to the process of autoregulation in preterm infants, and how their context impacts their wellbeing.

Fundamental and Core Principles of Polyvagal Theory

The main objective of this section is to explore deeply into the description of the fundamentals and core principles of The Polyvagal Theory. This exploration aims to enhance our understanding of the anatomical regulation, the particularities of the anatomy, the behavioral response systems, and the social components of this model.

Additionally, this chapter seeks to view through the lens of The Polyvagal Theory, the premature experience and the actual approach of this theory in this population. With these elements, we are able to gain a more comprehensive grasp of how the theory explains the complex relationship between autonomic regulation and the physiological and psychological outcomes.

Dr. Stephen Porges is a distinguished neuroscientist and psychologist, author of the Polyvagal Theory. His groundbreaking work ended with the proposal of this theory in 1994, marking a significant change in the understanding of the autonomic nervous system. In 1995, Dr. Porges published his first journal article of the model, including the base of a theory that would be groundwork for other fields in science. After an extensive career investigating mechanisms of stress, emotion, and regulation of the heart rate, eventually led him to focus on the vagus nerve.

The Polyvagal Theory proposed a phylogenetic framework of biological and behavioral functions that explains the neural regulation of the autonomic nervous system of mammals (Porges, 1995). This marked the beginning of his journey towards the development of a social and co-regulation approach, supported by safe or threat experiences.

The autonomic nervous system is an important element of the nervous system, it controls involuntary physiological functions, without the central nervous system control, and it is in charge of the control of several organ systems in the body (Pratt et al., 2008; LeBouef et al., 2023). The autonomic nervous system regulates and downregulates the organ systems, and by exerting these two opposite functions it is able to maintain the body in homeostasis (LeBouef et al., 2023).

It is in charge of unconsciously regulating physiological processes such as heart rate, blood pressure, respiration, and digestion (Waxenbaum et al., 2023). The

autonomic nervous system, the visceral feedback system, is further divided into two main pathways: the sympathetic nervous system and the parasympathetic nervous system (Porges, 2023), these two pathways differ in their structure and function (Pratt et al., 2008).

The activation of the sympathetic nervous system results in an elevation of activity and attention; elevation of the blood pressure and heart rate, dilatation of pupils for better far vision, bronchodilation of the lungs, gastrointestinal movement stops, more secretion from the sweat glands, increased metabolism, higher blood flow to muscles, higher levels of glucose production, and suppression of the immune system (Waxenbaum et al., 2023; LeBouef et al., 2023). It is located in the inside of the spinal cord (Dana & Porges, 2018), and it enhances the physiological activation, preparing the body, promoting the fight-or-flight state when facing a dangerous encounter. The sympathetic nervous system is present in almost every tissue in the body (Waxenbaum et al., 2023).

The parasympathetic nervous system primary function consists in reducing the physiological activity, thereby promoting a rest and recovery state during a safe encounter; decrease in the heart rate and blood pressure, constriction of pupil for near vision, more secretion of lacrimal and salivary glands, digestion continues, and activation of the immune system (Waxenbaum et al., 2023; LeBouef et al., 2023). The Polyvagal Theory sheds new light on the capacity of the parasympathetic role in the autonomic nervous system to regulate the activation through its key component, the vagus nerve. It is found in the head, viscera, and musculoskeletal system. The parasympathetic branch consists of two pathways within the vagus nerve. The vagus nerve works in two directions: down through the lungs, heart, diaphragm, and stomach, and up, connecting the nerves in neck, throat, eyes, and ears (Dana & Porges, 2018).

A concise and clear description of the anatomical essence of the Polyvagal Theory is captured in the next lines:

“The theory proposes that the successful adaptation of mammals is dependent on systematic and reliable withdrawal and reengagement of the vagal brake as a mechanism to rapidly regulate metabolic output in response to environmental demands” (Porges et al., 1996).

The autonomic nervous system, through both its pathways, has a direct effect on the emotional and behavioral regulation in humans through the vagus nerve. This significant element of the Polyvagal Theory, is able to detect safe and dangerous cues from the environment. Through neuroception (Porges, 2009), the body is able to identify these cues without conscious awareness, it helps to be aware if a situation or person is safe, dangerous, or life threatening (Porges, 2004). This feedback affects physiology and behavior, allowing a person to be socially engaged, mobilized or immobilized to guarantee survival. Neuroception is a brain function that allows humans and other mammals to recognize a safe or dangerous environment, affecting in turn the social behaviors and interactions (Porges, 2004). As Dr. Porges mentions:

“Neuroception explains why a baby coos at a caregiver but cries at a stranger, or why a toddler enjoys a parent’s embrace but views a hug from a stranger as an assault” (Porges, 2004).

Depends on how safe and secure one feels in a situation or environment to engage in social interactions and connection, which according to Dr. Porges is the

human's "*lifelong quest and motivator throughout our life*" (Porges, 2022). On the contrary, if one feels unsafe and threatened by the environment or an individual, body responses to protect arise.

Hierarchy of Physiological Response Systems

Dr. Porges, observing the evolutionary line of the species, established a hierarchy of physiological responses that arise from the autonomic nervous system (Dana, 2015; Porges, 2022). Linked to the bodily ability to detect safety or threat, neuroception (Porges, 2007), Dr. Porges proposes a three part hierarchy of human response systems:

- Activation from the ventral vagal pathway of the parasympathetic nervous system means that the social engagement system is functioning. In this state, the body detects safety, allowing it to emotionally relate and connect with others (Porges, 2009). The related emotions include relaxation, engagement, curiosity, and a sense of hope. Physiologically, this state is characterized by normal heartbeat and regular muscle tone.
- Conversely, when there is a perception of danger, the body prepares by activating the sympathetic nervous system, triggering the fight or flight response (Porges, 2009). The system prepares the body to mobilize to escape the threat through physiological reactions such as increased heart rate, hormone flow and increased muscle tone. Emotions characteristic of this state include stress, anxiety and fear.

- Activation of the dorsal vagal of the parasympathetic nervous system results in a state of immobilization (Porges, 2009), also referred to as shutdown or freeze. In this state, the nervous system is highly activated, it attempts to mitigate a threat by minimizing the body functions. This state is physically characterized by low heart rate, low muscle tone and low energy. And, the emotions associated with this system are hopelessness, unhappiness, and loneliness.

In this quote, from Dr. Porges, is described concisely the function and meaning of the hierarchy of state responses:

“The state of the autonomic nervous system provides a neural platform for an expanded range of feelings from threat to safety that provides a neurophysiological substrate for higher brain structures to elaborate these feelings. If the feelings are negative and dependent on autonomic states supporting defense, the feelings may evolve into diffuse states of anxiety or specific emotions such as fear or anger. Alternatively, if the feelings are positive and dependent on an autonomic state of calmness, thus enabling interpersonal accessibility and co-regulation, then these feelings may be associated with trust, love, and intimacy” (Porges, 2022).

The Social Engagement System is a crucial part of the nervous system, it activates when the ventral vagal pathway is functioning correctly. According to Dr. Porges (2007), the social engagement system is in charge of promoting both physical and emotional well being, by helping individuals experience feelings of safety and connection. When the ventral vagal pathway is active, it produces a state of calmness

and relaxation, and as a result, this enables the capacity for social interaction and active co-regulation, influencing each other's emotional states (Porges, 2007) .

In summary, the Polyvagal Theory proposes that the body, through neuroception, can detect safety or danger in the environment and uses this information to modify the physiological state via the vagus nerve. Environment information and physiological reactions give feedback to the brain, which then regulates the body according to the perceived safety or danger from the information received. The Polyvagal Theory's primary aim is explaining the crucial part the vagus nerve has in fear/danger response regulation, social connectedness and emotion regulation.

It recognizes how significant events, such as stressful situations, dangerous scenarios or safe environments have a direct effect on the body and brain through the regulation of the autonomic nervous system. Understanding the mechanisms behind the Polyvagal Theory in the context of prematurity offers new insights into the challenges that a premature infant may encounter in their development. It highlights the major role of the autonomic nervous system in shaping the early life experiences in the NICU.

Polyvagal Theory in the Context of Prematurity

Prematurity affects the development of the autonomic nervous system, which is in charge of regulating vital functions such as breathing, heart rate and temperature. Preterm infants born as early as thirty-two weeks of gestation are at major risk of developing a vulnerable health complication. The autonomic nervous system is found to reach maturation around the thirty-seventh week of gestation (Filippa et al., 2023), but

as mentioned earlier, premature infants are born weeks before the maturation is reached, a delayed development can be exhibited in premature infants.

Researchers have studied the maturity differences between preterm and full term infants, using different physiological parameters to observe the differences between one population and the other. Addressing interventions that target the development of the autonomic nervous system during the early days of premature infants is crucial for their well being and development.

Clinical Impact of Prematurity on Autonomic Regulation

Understanding the impact of prematurity on the regulation of the autonomic nervous system is of major importance. As mentioned before, the autonomic nervous system, through the parasympathetic system, has the role of controlling vital functions such as the heart rate, temperature, and breathing, which are essential for human survival. Very premature infants, born before the thirty-second week of gestation, have the highest risk of developing health complications, including respiratory, neurological, infectious and circulatory diseases, as well as vision and hearing impairment, and cognitive disabilities (Patural et al., 2004). Anatomically, it is expected that the autonomic system reaches a maturation level around the thirty-seventh of gestation (Filippa et al., 2023). However, a preterm infant is born before this period of time in gestation.

In the study by Patural et al., (2004), autonomic nervous system maturity was evaluated by measuring R-R intervals (the time between beats, measured in milliseconds). A total of thirty-one infants were evaluated, divided into two groups: twenty-three premature infants measured at their theoretical term age, and 8 full term

infants in their first week after being born. The findings were that preterm infants exhibited significantly decreased levels of High Frequency activity. In the context of heart rate variability, High Frequency is an indicator of parasympathetic activity. In other words, preterm infants have reduced parasympathetic activity, which is responsible of regulating restorative states. Even when evaluated at what would be their full term age if they had not been born prematurely, preterm infants were not able to achieve the levels obtained by full term infants. This suggests that, even as premature babies aged, there was still a development difference compared to full term infants at the age they were supposed to achieve similar parasympathetic activity levels.

The autonomic nervous system immaturity has a direct effect on the effectiveness of the parasympathetic system due to prematurity and the lack of time for continued development. This immaturity has significant health risks for preterm infants, specifically those related to the functions of the autonomic nervous system.

Cardiorespiratory instability is also a major concern in premature infants due to their immature autonomic nervous system, as a result of their condition it leads to a reduced heart variability. This reduced variability means that the heart is less able to respond to the constant needs of the body, increasing the risk of events such as apnea (temporary suspension of breath) leading to oxygen desaturation, and bradycardia (slow heart rate, fewer than sixty beats per minute), which results in reduced blood flow and oxygen supply to the vital organs. These types of events lead to potential health complications and neurodevelopmental disorders (Porta-García et al., 2023).

Another physiological measure that can be compromised in preterm infants is thermoregulation, the ability to control the body temperature. The normal human temperature range is between 36.5°C to 37.5°C. Not having a fully developed autonomic nervous system can result in ineffective thermoregulation, causing an

increase of temperature above 38°C, defined as hyperthermia, or a decrease of temperature below 36.4°C, defined as hypothermia. The WHO (1997) has established three categories for hypothermia, based on the severity: Severe for less than 32°C; Moderate for temperature between 32°C and 35.9°C; and Mild for temperature between 36°C and 36.4°C. Based on a study by Vermont Oxford Network (<https://public.vtoxford.org>) from 2009 to 2016, almost half a million very low birth weight infants had the temperature measure before arriving at the NICU. The results showed that 4 out of 10 infants arrived with hypothermia, which can be an increasing factor for mortality and morbidity (European Foundation for the Care of Newborn Infants, 2020). Infant healthcare organizations recommend using thermal blankets, radiant warmers, and incubators, to control the thermoregulation in premature babies, in order to reduce risks.

Due to the immaturity that preterm infants present in the autonomic nervous system, physiological functions become challenges for their condition, these challenges increase the risk of developing a health complication. In order to manage these risks, there is a need for constant monitoring and interventions when the preterm infants stay at the NICU.

Measurements of Autonomic Regulation in Preterm Infants

One of the methods to measure autonomic nervous system regulation in preterm infants is the heart rate variability. This method provides information about the two branches of the autonomic nervous, sympathetic and parasympathetic. Two important characteristics is that it is a non-invasive method, and it allows continuous monitoring

in real-time, this characteristic is important for the changes in premature infants. The information that this method provides is by the result of a range of different metrics, such as R-R intervals, High Frequency activity (associated with parasympathetic activity, Low Frequency (associated with sympathetic activity and parasympathetic activity). From Kokkinaki et al. (2023), heart rate variability metrics were compared between full term and premature infants, the information was obtained from periods of rest state to an interaction with a parent, after a rest state, continuing with another interaction with the other parent, measures to premature infants were done at their theoretical term age. The findings from Kokkinaki et al. (2023) support the existing literature, which indicates a significant decrease of High Frequency activity, which reflects parasympathetic system function, in preterm infants when compared to full term infants. This highlights the importance of heart rate variability for monitoring preterm infants in real time, and also for research purposes, to address the differences between a full term infant and a preterm infant.

Respiratory Sinus Arrhythmia is an specific indicator of heart rate variability, is in synchrony with breathing. It reflects parasympathetic nervous system activity through the vagus nerve. The heart rate increases when breathing in, and heart rate decreases when breathing out. In research it has been used as a marker related to behavioral, affective and cognitive outcomes in preterm infants (Hofheimer et al., 1995). According to Porges (2007), the level of Respiratory Sinus Arrhythmia is associated with different outcomes across life, during childhood higher emotion expression is associated with higher Respiratory Sinus Arrhythmia. In adolescence, higher Respiratory Sinus Arrhythmia reduces the risk of social related problems, and in adulthood, a decreased Respiratory Sinus Arrhythmia regulation is associated with anxiety.

Interventions that target the regulation of the autonomic nervous system should use these parameters as information for the effectivity, in the literature short term and long term studies exist to support this idea, as the one's previously mentioned.

Chapter 3. Developmental Care and Family-Centered Care in the NICU

Neonatal care has seen important advances in the last decades, particularly in the care of infants with the introduction of frameworks like Developmental Care and Family-Centered Care. These approaches have completely revolutionized the definition of how healthcare professionals interact with prematurity and with the individuals involved, focusing on individualized, comprehensive care that seeks to enhance the wellbeing of both infants and the family. Developmental care, introduced by Dr. Heidelise Als in the late 1980's, emphasized the importance of creating a supportive environment similar to the womb, reducing the stressors, and enhancing the physiological regulation of preterm infants. This approach has introduced improvement, from hospital stays, neurodevelopmental outcomes and an increased parent-infant relationship. Family-Centered Care, emerged from the need of a change in the clinical approach in the NICUs, this framework seeks to promote the active role of families in the care of their infant, through collaborative work with healthcare professionals during the planning and implementation of the individualized plan of care. This introduction sets the base for a deeper exploration of how these care practices and the outcomes for the premature infants, families, and healthcare professionals.

Description and History of Developmental Care

The care for an infant at birth hasn't always been like we now know it. Initially, mothers would deliver their babies at home, with the help and care of midwives,

minimum participation of medical doctors was required, as was left to the care of mostly female figures in the family. There have been many changes in the history of neonatal care, one of them is the event of mothers delivering their babies at a hospital facility. Having mothers left without the company of loved ones, and after birth, without their newborn, left to the care of nurses, depriving small infants from the care and nurture of their mother (Gooding et al., 2011).

Across time, the participation of parents inside a neonatal care environment has changed in beneficial ways, incorporating the parental figure even in situations of prematurity, recognizing the beneficial role in the well being and development for preterm infants (Gooding et al., 2011). It was in 1978 when a novel model of care for premature and low birthweight babies arrived from Bogota, Colombia. This model consisted of placing the newborn vertically in the mothers chest from the moment of birth, and breastfeeding as the main source of nutrition, these principles offered beneficial physiological results for the preterm infants (Whitelaw & Sleath, 1985, Boundy et al., 2016), such as body temperature regulation and body weight improvement, reduced stress and enhanced mother-infant interactions and bonding (Charpak et al., 2005). This practice highlights the importance of a nurturing and caring environment that premature infants need in neonatal care, to look after the sensory, emotional and physiological needs of the infants during critical early life stages.

Developmental care offers valuable insights into interventions in the context of prematurity, and research in this topic has expanded significantly in the recent decades. Developmental Care is a framework designed to enhance the care experience for infants, families, and healthcare professionals by emphasizing individualized interventions based on the needs of the infant, to provide a suitable environment for their wellbeing. Active participation of family members is encouraged inside the NICU,

allowing an active role in the care of their child. The main objectives of this framework is to reduce stressful situations, promote physiological regulation, and use behaviors and physiological feedback to better comprehend the needs of each infant (Als, 1998). Understanding the benefits of this framework is important for this study in the context of prematurity. Therefore, discussing the roots of Developmental Care and the impact on the progression of premature infants is crucial.

The importance of Developmental Care has grown substantially in the context of prematurity, offering new insights into the outcomes of interventions based on this practice. Developmental Care is a comprehensive framework that includes actions designed to better manage the care experience of infants, families and healthcare professionals. This framework puts light on establishing individualized practices for premature infants and optimizing the environment in which the infant is being cared for, all based on the personal needs of each premature infant (Kaye, 2016).

The first hospital dedicated to the treatment of infants was L'Hôpital Des Enfants Malades in Paris, France, founded in 1802 (Lomax, 1996). It was the first pediatric hospital that cared for the cure of patients below 15 years old. In the middle of the 20th century, NICUs were established to provide a controlled and safe environment for preterm and critically ill infants to continue developing (Lussky et al., 2005), this was a major advance in neonatal care. Not only the environment changed but also the parent-figure was added to the landscape, healthcare staff sharing the responsibility of care to parents. In the late 1980's, Dr. Heidelise Als made significant contributions to this field through her research on the behaviors of premature infants and high-risk infants. Her work was based on the belief that earlier sensory interactions outside the womb and environment stressors could significantly impact the development of the premature infants. She developed a theoretical model and a practical program,

emphasizing the importance of individualized and supportive care for these infants (Als, 1986). This program, known as the Newborn Individualized Developmental Care and Assessment Program (NIDCAP), has served as the foundation for several other programs developed for NICU settings; which will be discussed in further chapters.

This approach to neonatal care not only includes practices targeting the immediate medical needs of the preterm infant but also takes into consideration broader social and physical aspects of the NICU experience. Developmental Care includes the active involvement of families and health staff. The aim of this framework is to take into account the premature infant's strengths and vulnerabilities, manage stressors, and promote physiological regulation and development. According to Als (1998), the physiological and behavioral state of the infant should be for their caretakers a key source of information that provides insights into the current condition of the infant, their developmental level, and the capacity for progression.

Components of Developmental Care

Interventions within the Developmental Care approach are created to modify the environment experience to create a more like-womb, to decrease the stress exposure for premature infants. In order to adequately address the needs of every premature infant, it is necessary to include a previous assessment of the premature infant. Dr. Als (1984) outlined physiological and behavioral indicators that can be observed and be a statement of the health and wellbeing of the preterm infant. These indicators include respiratory functions (regular, irregular, slow or fast, and with pauses), skin color (yellowish appearance, pink, pale, visible surface blood vessels forming a web, red, purple, or blue), autonomic instability as motor patterns (tremors, startle, twitching), visceral and

respiratory responses (gagging, spitting up, burping, hiccuping, bowel movements grunting, vocal discharges, in-and-exhaling, gasping), motor system behaviors (extremities flaccidity, flexed or tucked extremities, smoothness of extremities movement, arching, extension of legs, tongue extension, hands on face, smiles, open mouth, suck search, mouthing), state-related behaviors (deep or light sleep, semi-awake, alert, hypoalert, aroused, agitated, upset, crying), and attention-related behaviors (fussing, yawning, sneezing, face open, semi-open eye with movement, frowning, ooh face, locking to object or point, cooing sounds, tongue and lips move in a speech-like rhythm). By monitoring these behaviors and reactions of the interactions of the infant, healthcare staff are able to identify the opportunities to promote an individualized intervention to promote the development of the preterm infant and self-regulation.

Strategies include noise and light reduction, gentle handling of the infant and how it is positioned or swaddled, and longer periods of resting (Symington & Pinelli, 2006). By controlling these environmental factors, preterm infants can continue to experience a more supportive environment that positively affects their development. These interventions aim to enhance the stability of the infant. Observing and understanding how an infant reacts behaviorally and physiologically to the environment and to the care is a crucial step (Als, 1998). According to Stanford Medicine - Children's Health (www.stanfordchildrens.org), Developmental Care interventions include modifying the light room in order to obtain normal day and night cycles and lower the noise and stress sources, adding comfort to where the preterm infant rest, and using cues provided by the infant to use the easy and awake time to do the care needed, instead of waking him or her up and be a source of stress.

Over the last few decades, the role of family members inside the NICU has gained recognition. Active involvement of family members is now promoted, as they are considered the primary and consistent carers of preterm infants (Als, 1984).

The University of Notre Dame (<https://nicudesign.nd.edu/nicu-care-standards/>) proposed the Developmental Care Standards for Infants in Intensive Care, a list of practical standards and recommendations for the benefit of infants, families and healthcare professionals at intensive care units, based on the framework seen in this chapter. Here is a simplified version of the recommendations, with a description of the core of the standard. The recommendations for best practices are:

- System Thinking. This section is directed to health organizations, to ensure professional practices and holistic attention to infants, parents and families.
- Positioning and Touch: Physiological care of the infant by parents and healthstaff, interventions based on the individual needs for positioning, touch and head shaping and support.
- Sleep and Arousal: Highlights the importance of sleep and awake cycles in infants, as well as optimizing the physical environment. Participation of family during care sessions and sharing with parents the presentations of basic information of infants during rounds.
- Reducing and Managing Pain and Stress in the Newborns and Families: Education to parents on behavioral cues of infants, and engagement of interaction with newborn, different interventions to enhance regulation and decrease stressful events.
- Feeding, Eating and Nutrition Delivery: Importance of infant readiness and various options for feeding without risking infant health, education and

promotion among mothers breastfeeding or donating human milk, and monitoring of weight and growth of infants.

Developmental Care has significantly contributed to the neonatal care for premature infants, putting light on the importance of individualized practices and the optimized environment. Frameworks have been developed to enhance the importance of supportive, tailored interventions and have an active participation of family members. Aiming to reduce stress and promote physiological regulation among preterm infants, Developmental Care aims for the growth and wellbeing of preterm infants. Research data supports this framework's effectiveness.

Description and History of Family-Centered Care

Family-Centered Care is a collaborative approach that aims for a meaningful partnership between healthcare providers, families and patients. This approach is developed to promote a bilateral beneficial relationship that sets as the main goal the wellbeing of the patient and the family (Kuo et al., 2011, Abukari & Schmollgruber, 2023). Family's active participation is valuable during the care process and decision-making to develop a plan of care that best fits to the needs of the patient and that supports the family. The Institute for Patient - And Family-Centered Care (IPFFC) (www.ipfcc.org) has four core concepts for this approach: respect and dignity, information sharing, participation and collaboration. This chapter explores these various attributes, providing a comprehensive understanding of Family-Centered Care.

This approach to healthcare was developed after the mid-twentieth century as a consequence of the care culture in the pediatric population, at that moment the idea of

care was heavily focused on physiological care and technical abilities of healthcare professionals. During this time, emotions were set aside, often disregarded, and parents were considered as potential obstacles for the recovery journey of their children (Festini, 2014). In the context of premature or sick newborns, this approach led to infants being removed from their families, separating mother and child from the beginning, in the first hours of life. These infants were treated away from their parents, often for months or years, with minimum parental visitation allowed. This often resulted in higher emotional states on both the infant and the family. Although the well intention of curing or saving a child, missed the recognition of the potential role that parental involvement has in the healing and development of a newborn.

Recognizing the need for change led to the creation of this philosophy of family-centered care. This new approach to care sought to acknowledge, understand, and provide the means for the evolution of the roles that parents and families can have in the care of their children within a medical environment (Bruce & Ritchie, 1997).

At the beginning of the 1990's, this approach gained further attention with the creation of the Institute of Family-Centered Care founded by Beverly Johnson, with the aim to institutionalize the core principles of family-centered care among health settings. This institute, later changed name to Institute for Patient - And Family-Centered Care. The main goal of this institute was to promote collaboration among the different parts that play a role in the care of children; re-defining the relationship with healthcare, by enhancing partnership between patients, families and the medical team. This model of perspective in care *"redefines the relationships in health care by placing an emphasis on collaborating with people of all ages, at all levels of care, and in all health care settings"* (www.ipfcc.org). The work from the institute was to spread the principles of

family-centered care across health settings, to provide voice to infants, parents and families and transform the healthcare landscape.

Helen Harrison, a figure that also played an important role in shaping this philosophy towards the movement of family-centered care. As the author of the *The Premature Baby Book*, Harrison received an overwhelming response by receiving many letters and phone calls for over the course of a decade after the publication of her book from parents who had experienced the difficulties of neonatal care in NICUs, whose children were treated in the NICU. Parents expressed their perception of the experience of having their child inside a NICU, mentioning many of the concerns and situations, such as the way they and their infants were treated by healthcare professionals. They highlighted the difficulties regarding communication when trying to obtain information about the health state of their child; facing exclusion from medical staff even when decisions had to be taken; management of infants' pain; and the limited opportunities for parents to engage in nursing and caring for their infants. In addition, parents communicated their frustration over the follow-up procedures for those infants who were discharged from the NICU. After these events, and moved by these stories, Helen took action and sent these letters to the editor of *Pediatrics*, the leading journal of pediatric research. Her brave move concluded in a proposal by Dr. Lucey, a gathering of parents and medical professionals to discuss these issues, leading to the introduction of the principles of family-centered care to NICUs (Gooding et al., 2011). This bold move set a turning point in neonatal care, bringing voice to parents and infants, laying a foundation for more collaborative, inclusive and compassionate care practices from healthcare settings.

The evolution of Family-Centered Care was influenced by the research and discoveries on attachment theories. These theories emphasized the impact of emotional

bond between parents and their children, providing a scientific groundbase for the new philosophy to care. Making an impact on the implementation of health and care policies with the aim of transforming the health members staff mindset to a more integrated collaboration with parents and families (Ramezani et al., 2014). Important to mention that Dr. Als contributions to neonatal care played a key part in the evolution of this approach.

This shift in approach, with the groundbase from the evolving attachment theories and increased understanding of emotionality and psychological needs of children and families, made a positive change in the healthcare practices. This shift not only represented a change in procedures; it represented a change in the mindset and culture of healthcare settings. To move from the line of clinical approach to another line that puts light on the importance of emotional support that humans need, by involving parents and family. Healthcare systems continue to develop and evolve, the concept of family-centered care makes a statement of the collaborative approach in healthcare environments between patients, caregivers and families, recognizing the importance of making partnership with families in the process of healing instead of thinking only as a transitory visitor.

Family-Centered Care is defined as a comprehensive approach to healthcare that was developed to re-define the rapport between healthcare professionals and families, letting families be the center of the care process (Kuo et al., 2011). This innovative model of care recognizes the crucial role of the parents and family in the recovery process and well being of patients (Ramezani et al., 2014), not taking parents or families the role of merely visitors or passive recipients of information but an active role and crucial participants in the healthcare journey of an individual. The involvement of families, as stated earlier, does not limit to occasional updates or superficial

participation but it actually comprehends every care aspect, including during the process of decision making (Kuo et al., 2011). In this way, family-centered care becomes a more holistic approach, aligned with those frustrations expressed by parents to Harrison, back in the 1990's.

Bertoncelli (2022) concludes that Family-Centered Care is “*based on mutual collaboration between staff and parents, respect, the dignity of individuals, participation, and sharing*”. This reflects the change in the paradigm of healthcare, from this sentence we can understand that partnership among both parties are taken into consideration and respected. The terms, according to Kuo et al. (2011), that are linked to Family-Centered Care are: “partnership”, “collaborations”, and “experts” referring to families because recognizing the abilities at care delivery. The traditional model of healthcare viewed families as peripheral to medical procedures, in the Family-Centered Care approach, families are considered integral to the system that collaborates to healing, recovery and well being of the child. A philosophy of care that places a voice to the needs of families.

Components of Family-Centered Care

Ramezani et al. (2014) in their study to conceptualize Family-Centered Care in NICUs, they proposed these attributes that contribute to the effectiveness of this care model. The attributes include family care-taking, equal family participation, collaboration, family's respect and dignity, and knowledge transformation. Family care-taking considers important an assessment of the needs of the family and the availability of those resources and support to meet their needs. Healthstaff not only

seeks to resolve the needs of the infant but also the family members, this can contribute positively by decreasing the stress, and increasing satisfaction from the resources provided.

Equal family participation seeks to include the family actively in all aspects of care, that means from planning to the moment of decision-making in the daily progress of care. Families are included in actions such as medical rounds, emergencies, special procedures, and nursing reports. The purpose of this action is to recognize that family members are able to provide valuable insights and knowledge about the infant and collaborate to the treatment and recovery, and because they are involved with the medical team at the time of making a decision, they are able to contribute in this process.

Collaboration is related to the close partnership between healthcare professionals and the families, this includes a range of professionals and families to participate in the care planifications, to be executed according to family's preferences and values. This attribute includes the participation of family members in policy development, educational programs, to facilitate the expansion of the approach.

Respect for family dignity involves the recognition of the families' differences (Kuo et al., 2011). From communication to decision-making processes, Family-Centered Care seeks to consider the preferences, tendencies and characteristics of every unique family, not by creating a catalog of policies and general planning of care but to actually individualize each of these aspects according to the infants and their families cultural, social and individual differences.

Knowledge transformation, a bilateral process of complete sharing of information openly, objectively and unbiased (Kuo et al., 2011), between medical professionals and families. The presentation of the information to parents must be

adapted to the way each family is able to better understand it, so that they can be fully informed for further decisions, based on a clear understanding of the panorama of their infant.

These attributes are in line with the core principles of the Institute of Patient-And Family-Centered Care, and provide a deeper explanation of the base of this approach. Family-Centered Care made a significant contribution to the evolution of healthcare, specifically for neonatal care, with the idea of placing the family at the center of the care process, recognizing the importance of the company of the family and the tools that they have to enhance the recovery and well being of a child. By implementing this collaboration in care, infants are not the only ones who are benefited, families are emotionally and psychologically supported by this model (Festini, 2014; Abukari & Schmollgruber, 2023).

Importance of Developmental Care and Family-Centered Care in the NICU

Developmental Care in NICU settings was established after observations of neonatal care specialists that recognized that infants needed more than medical attention, and by adjusting the environment and care approach of healthcare staff and inclusion of family members in the medical care, a significant improvement of the wellbeing of the premature children has been studied. Nowadays, the NICUs have the structure to potentially cover the needs of a preterm infant to continue their growing progress, and with the description of Developmental Care and Family-Centered Care, a more holistic approach was added to the neonatal care and to the lives of families.

In several aspects these approaches can be beneficial, as mentioned before, the interventions intend to promote self-regulation of the preterm infant through the

modification of the environment and care practices, by the integration as a result of these practices the infant can be capable of regulating their stress system.

Developmental Care and Family-Centered care practices have brought benefits to the families and healthcare systems but more specifically for preterm infants. There have been short and long term benefits from interventions based on these approaches. Some of these benefits include shorter hospital stays, less health complications, increase of weight, better feeding, better parent-infant relationship, better sleep cycle, and pain management.

In a study made in Canada by Peters et al. (2009) a total of one hundred and twenty very low weight infants were assigned to an intervention program or standard care. Healthcare staff were educated on the program and behavioral observations were done on infants. The results obtained were reduction of length stay by ten days for infants in the developmental care program, as well as reduction of incidence of chronic lung disease. These outcomes can be linked to a more stable physiological state in the infants, suggesting enhanced parasympathetic regulation. And, at eighteen months old (adjusted age) were found to have less mental delay than those in the control group. Short and long term improvements were found for very low weight infants in the intervention program. Positive results for length of stay in the NICU and in the total hospital stay were found also in a study made by Melnyk et al. (2006), results found were a significant difference of 3.8 and 3.9 day difference to the control group, although this intervention was targeting education and behavior to parents, results were found to have an effect on their infants. These results can be linked to a reduction of stress in parents due to the knowledge they acquired that likely led to a calmer environment for the infants, and in this way parasympathetic activity was enhanced, supporting growth to the preterm infants.

In another study, Pavlyshyn et al. (2023) show in their results that there were several short-term outcomes among the preterm infants that received developmental care different from those who received traditional care. Results establish significant benefits for developmental care over traditional care, as late onset sepsis was observed less frequently in developmental care groups, feeding intolerance was less common along with increased breastfeeding rates, periventricular leukomalacia incidence was lower, severe retinopathy of prematurity was observed less frequently for the same group. In this specific study, developmental care groups had early results in preterm infants, decreasing the incidence of morbidity, increasing the physiological development, and enhancing breastfeeding rates. It can be concluded that developmental care practices improved the digestive function and immune response, controlled by the parasympathetic regulation.

In the line of clinical outcomes and growth metrics for very low weight preterm infants, in a randomized controlled trial in Sweden (Westrup et al., 2000), research on the effect of developmental care program was evaluated and compared to standard care. Aspects measured were ventilation assistance, growth and hospitalization length. Infants born between the year 1994 and 1997 with less than thirty-two weeks and in need of ventilatory assistance after 24 hours of birth were assigned to the standard care group and the intervention group. Results of this study were positive for mechanical ventilation, with lower mean for the intervention group, removal of supplementary oxygen earlier for the intervention group, among other results found the mean of weight gain until their thirty-fifth week of postconceptional age was higher for the intervention group, positive head circumference growth, and a difference between means of 2,7 weeks for hospital discharge, for the intervention group the mean of age of infants was 38,3 and for the standard care 41,0 weeks of post congenital age. These results suggest

better respiratory stability, an overall physiological stability, linked to parasympathetic activity.

Other results were found in a systematic review by Soleimani et al. (2020), where effects of developmental care on the neurodevelopment of premature infants was measured, the results showed a significant effect for mental and motor development in premature infants, this is enhanced in their first year of life. Same effect on neurodevelopmental outcomes was reported by Symington & Pinelly (2006) in their review of thirty-six controlled trials.

Martha G. Welch and colleagues (2014) conducted a trial in a NICU, and one hundred and thirty four preterm infants between twenty-six to thirty-four weeks of gestation, had sessions with their mothers that promoted regulation and communication of affect during their time at the NICU. With an encephalography during sleep of infants thirty five and forty weeks of postmenstrual age, it was reflected in enhanced activity in the frontal region for those infants in the intervention group. These results are positive for the long term health of preterm infants and their brain function, and the result can be linked to the close interaction with the mothers that likely gave a calming effect to infants, promoting in this way the parasympathetic regulation.

On the other hand, when there is a negative effect of the environment on the preterm infant it can be seen in their physiological parameters, as increased heart rate and decreased oxygen saturation, and by an increase in energy expenditure, as a result growth is minimum, Symington & Pinelli (2006) mentions that effects of stressful environment could have short and long term effect on the neurobehavioral development of the premature infants.

The results obtained after implementing a special care system or the inclusion of parents in the process of care in different health situations for infants, demonstrating the

capacity of effect of individualized care and optimized environments on the development and wellbeing of a premature infant. This approach laid the foundation for other researchers to continue studying the interventions that best support preterm infants. As a result, other frameworks were developed, providing emphasis on different aspects of care. The following chapter contains more detailed information, placing light on the potential effect of the collaboration in care of parents and healthcare staff. I would like to illustrate this next chapter with an example: let's think about the benefits that a child can obtain from a type of therapy that lasts one hour, only the therapist and the child. The benefit is big for the child's development, but how is it magnified when caretakers, parents and family members are introduced, educated and actively participate in the therapy along with the child, in that hour the benefits have multiplied. A variety of developmental care and family-centered care programs developed to be executed in hospitals, specifically in NICU settings, will further be commented on in the next section.

Chapter 4. Family Intervention Programs in NICU Settings

The Family Intervention programs in the NICUs are developed to include and integrate parents and caregivers in the care and nurture of the preterm infants. These programs recognized the important role of the parents and family of the presence and active participation in the care process and development process of infants. The main objective is to lessen the stress and difficulties that are associated with the NICU, promoting a nurturing environment for the well being of both infants, parents and caregivers. For this it is important to review the particularities of the programs included in this study, to deepen more into the details of their structure and the results obtained through the years.

Concept and Fundamentals of Family Intervention Programs

Programs such as Kangaroo Mother Care (KMC), Newborn Individualized Developmental Care Program (NIDCAP), Family and Infant Neurodevelopmental Education (FINE), Close Collaboration with Parents, Family Nurture Intervention (FNI), and Family Integrated Care (FICare) were developed to support the development of preterm infants and infants with a medical complication in need of support in a NICU, researchers also mention the active participation of families, that is now recognized to be crucial for the development and growth of the infants.

Each of the programs reviewed in this chapter have a unique approach, although there are key aspects shared across this family of intervention models. These aspects include active family participation during the care of the infant, like during skin-to-skin

contact and decision-making collaboration with the medical team about the plan or progress of the infant. Individualized care is another of the key aspects, promoting interventions that are thought to meet a specific need for that particular infant and the family. Diverse types of assistance is provided to the families, such as education, psychosocial support, and tools that are useful for the care of their infant during the NICU and after the discharge at home.

The common goals of family intervention programs in the NICU are to overall enhance the health and development of preterm infants. These goals are achieved through promoting family-infant bonding, early and active parental participation in the care of the infant, and stress reduction in the infant and the parents due to the experience of the NICU stay. These programs also have as a goal bringing to parents the support needed for their well being, as well as educating them on the preterm care, to empower them in the care of their infants, which contributes to the long-term results of both the infant and the complete family.

The next sections will provide a comprehensive analysis of each of the programs mentioned above that have been implemented in NICU environments. The analysis will also explore the benefits of these programs, and the effectiveness based on empirical evidence provided by several authors, to be able to understand the impact of implementing these programs in neonatal care.

Kangaroo Mother Care

The origins of the Kangaroo Mother Care date from 1979 in Bogota, Colombia, when doctors Héctor Martínez and Edgar Rey Sanabria. Due to an overcrowding problem with incubators, the doctors sought for an alternative to cover the need for preterm and low birth weight infants care (Rey & Martinez, 1983). Using the parent's body warmth to help the infant regulate its body temperature, additionally infants were breastfeed frequently. This results in better developmental outcomes for the premature and low birth weight infants (Rey & Martinez, 1983).

Infants with a weight below 2,000 grams and clinical assessment were to be admitted to the protocol, often preterm infants, taking the child directly to the mother to begin with the procedure of skin-to-skin. If the infant was not stable enough to leave the hospital, mothers obtained a permit to enter and spend as much time as possible, leaving bottled breastmilk to feed the baby. Parents were well educated on the needs of temperature and feeding of the infants.

According to the WHO (2003), the core practices of this modality of care consist of: direct skin-to-skin contact: after the infant is born, is prepared to be placed in the chest of the mother, both are covered with a blanket and ideally left together after the first feed (UNICEF UK, 2023). The original position for this practice is a upright position of the infant against the chest of the person, this position prevents bronchoaspiration (Rey & Martinez, 1983) and to keep the temperature of the infant's body regulated (Ruiz-Peláez et al., 2004), often the baby wears only the diaper and a hat. Mothers are ideally only to breastfeed the infants, in the beginning of the development of this approach, no commercial formula was used, only natural ingredients. This practice would usually start in hospital settings, but it continues at

home. Infants who do not need medical assistance would be discharged early. And, after discharge families receive support, guidance that enables them to assist their infant, as well as continuous monitoring from the hospital staff.

This practice can be implemented in maternal units, for the situations where medical staff runs low or special equipment is not available, if infants are not to be transferred to a high level unit, the WHO (2003) recommends discharge early and be cared for at home once the baby is able to eat normally, and body temperature is stable and the infant is gaining weight.

UNICEF from the United Kingdom (2023) mentions various of the benefits of the implementation of this care practice, as the research evidence keeps growing. The benefits for mother and infant from skin-to-skin are:

- Calmness and relaxation for both the mother and the infant;
- Breathing and heart rate regulation,
- Feeding and digestion stimulation;
- Temperature regulation;
- Due to the closeness, the mother's bacteria is shared with the infant, providing protection
- Hormone release in the mother that stimulates breastfeeding.

As for the benefits of skin-to-skin practice in infants:

- Better oxygen saturation;
- Reduction of stress levels (enhanced result after painful procedures);
- Stimulation of feeding behaviors and growth;

- Lower stay at the hospital facility.

Potential benefits of KMC for preterm infants are well documented, as it is important to assess whether these benefits are to be transferred into the real-world. In order to determine the real impact of KMC, it is necessary to view the effectiveness of the application of this program. By analyzing this evidence, it is clear if this program is able to achieve the goals and enhance the lives of this vulnerable population group and their families.

In a study conducted by Yaniv et al. (2021), important results were obtained from a sample of 96 young adults, they were assessed in their infancy, preschool, adolescence and adulthood. Three groups of infants were recruited, full term, preterm infants who received KMC in neonatal period, and preterm infants who received standard neonatal care. One of the aims of this study was to understand the synchrony of the interaction mother-infant across the various life stages. The results indicated that infants born full-term obtained higher levels of synchrony compared to preterm infants who received special care and those who received standard care. However, preterm infants who received special care improved synchrony when compared to those in standard care, but it does not match completely to the synchrony of those born at full term. By adulthood, the differences between infants at full-term and preterm infants that received special care, similar levels of synchrony are observed in this stage of life. Both groups, full-term and preterm infants that received KMC, show higher levels of synchrony than as preterm infants received standard care, physical contact in KMC preterm infants enhanced the positive effect through the years, restoring synchrony by adulthood. These results on physical contact at the early stage of life highlight the

impact of early-maternal interaction on the social development of the infants, and as well in the relationship of mother and infants.

Charpak and colleagues (2017) published a 20 year follow-up study with the participation of some of the infants who participated in a previous trial of the same author. Data from 264 infants that at birth weighed less than 1800 grams was analyzed and compared to the control group in several aspects, using neuroimaging, neurophysiological, and behavioral tests, to observe their health status, neurological, cognitive, and social functioning. The results obtained from this study were that the KMC at 1 year had higher IQ than the traditional care group, authors commented that this can be due to the sensitivity of caregivers, infants had a more stimulating home. This effect remained after 20 years for this group, parents had a protective and nurturing role (Tessier et al., 2003), these results were reflected in lower behavioral and conflictual issues, as less school absenteeism, reduced hyperactivity, aggressiveness, externalization, and socio-deviant conduct in the young group. Social and behavioral longitudinal outcomes were observed in the KMC.

Feldman et al. (2014) conducted a study involving seventy preterm infants who received skin-to-skin contact for 14 days after birth. These infants were compared to infants receiving standard care over seven times of assessment in a period of ten years. These assessments evaluated infants physiological and cognitive development, and parents were as well evaluated on their mental health, and mother-child interactions. Evidence from the study suggests that infants who received KMC for the laps of 14 days after birth obtained better long-term outcomes. In the period after birth, this care enhanced the infants' autonomic regulation, reflected in better respiratory patterns, and improved bonding behaviors from the mothers. From 6 months to 10 years of age, maternal anxiety reduced and enhanced the cognitive development in infants. By

the age of 10, infants who received skin-to-skin contact presented a higher balanced stress response, improved autonomic functioning, more consistent sleep patterns, and better cognitive control. With these strong results, it is understood that infants' physiological regulation and the care provided by the parents have an interactive process, and this has a direct influence on the infants overall developmental outcomes.

Newborn Individualized Developmental Care And Assessment Program

The early origins of this program date back to 1965, when Dr. Heidelise Als became the mother of a child who presented neurological difficulties from birth, this impacted her experience on how to see and observe an infant to better comprehend the needs. During her years in the University of Pennsylvania, she began to observe and study preterm birth infants in special neonatal nurseries, continuing into their childhood, this is when she identified the support for regulation that the infants needed. In the 1980's, the Newborn Individualized Developmental Care and Assessment Program (NIDCAP) was established as an innovative approach to neonatal care, with the aim of enhancing the development of premature infants.

Dr. Als observed that the conventional NICU environment was not meeting the requirements for the development of these infants, because of the multiple sources of stimulation (Als, 1986), often not aligned with the sensory capacity of a preterm infant, as their sensory system is overstimulated, generating stress in their system (Westrup, 2007). For this reason, the aim of this program is to adapt to the newborn's strengths and goals (www.nidcap.org).

As an opportunity to understand the dynamics of the various subsystems (Als, 1982) that coexist within the human body, seeing the naturalness of an infant's development as a process and phase-oriented path, the Synactive Theory of Development was created, posing that the behavior of infants is based on the organization of five different but interrelated subsystems. The subsystems are: the autonomic nervous system, the motor system, the attentional-interactive system, the state organizational system, and the self-regulatory system (Als, 1982). Further

description of each by Dr. Als (1982, 1995), as observational cues that give information about the state of the subsystem:

- Autonomic system: the most basic subsystem, highlights physiological functions such as the heart rate, respiration, color changes, tremulousness, visceral signals (vowel movements, gagging, hiccups, and more).
- Motor system: including preterm's posture, muscle tone, effective extremity movement.
- State-organizational system: the range of regulation of consciousness states.
- Attentional-interactive system: preterm's ability to cognitively and socially interact moments using the environment cues.
- Self-regulatory system: the infant's ability to return to a balanced and relaxed state, involving stress management, self-soothing, self-adjustment.

This theory highlights the importance of how preterm infants interact with the environment and how these interactions have an impact on their development. Each of the subsystems is highly coordinated, and hierarchy organized (Als, 1982). They are influenced by each, in either a positive or negative way. And according to the author (1982), being hierarchically organized means that lower subsystems are necessary for the higher systems, and as they are interdependent, the disruption of one subsystem affects all the other subsystems. This theory does not only apply for NICU settings, but can be understood from the time when the infant is inside the womb, till the moment arrives at home (www.nidcap.org).

The development of this theory served as a base for NIDCAP, founded in 1984, as the information that proposes brings knowledge and guidance for healthcare

professionals and caregivers, in order to understand the behavioral cues when interacting with the infant, using the infant's feedback for incrementing his abilities and decreasing his vulnerabilities (Als, 1986; Als & McAnulty, 2011; Bertocelli et al., 2022), individualizing and adjusting the care strategies for the preterm infant to not overstimulate from the environment, and to contribute to the neurodevelopmental growth (Als & McAnulty, 2011; www.nidcap.org), along with considering the needs from the family, the life-long nurturers (Perapoch, 2020).

NIDCAP can be implemented in NICU settings integrating the four assumptions of the program:

1. *“Detailed observations of infant behavior during daily caregiving interactions provide an important basis for recommendations in how best to minimize stress and optimize an infant's development” (Als & McAnulty, 2011).*

These observations allow caregivers to individualize the approach used to provide the specific needs of each preterm infant, enhancing the supportive environment for their stability and development.

2. *“Parents and their closest supporters, often family members or friends, provide the optimal co-regulatory support and literal twenty-four-hour bed for the immature infant” (Als & McAnulty, 2011).*

Involvement of parents and close family members or friends, provide, not only to the infant but to the family as well, a co-regulatory support system (Porges, 2022).

Their function does not end as the baby is discharged, but continues along the growth of the infant, being implied in their long-term development.

3. *“Caregiving NICU staff benefits from supportive education in implementing the often challenging procedures necessary (e.g. suctioning, extubation, line placements, etc) as well as regularly available emotional support to process their complex feelings and self-doubt about having to give pain while simultaneously understanding the personhood of infant and parent who must trust and rely upon them” (Als & McAnulty, 2011).*

Educational and emotional support is crucial for healthcare staff, as managing the life of a preterm infant can be a non-linear process.

4. *“Resultant re-envisioning of care will lead to better outcomes in infant medical well-being and neurobehavioral functioning, in parent well-being and functioning, and in staff professional and personal development” (Als & McAnulty, 2011).*

This program aims for the development of preterm infants, families, and healthcare staff. An integrative and holistic approach, that considers and supports all the participants involved. Researchers have implemented this approach into their studies, and impressive outcomes have been demonstrated, such as reduction in:

- Ventilator usage in days
- Extra days of oxygen

- Feeding via nasogastric tube in days
- Level of severity of bronchopulmonary dysplasia
- Intraventricular hemorrhage incidence
- Growth progress
- Number of at-hospital stay

And, significant improvements in:

- Neurobehavioral functioning, assessed as early as 2 weeks to 8 years of corrected age in premature infants
- Frontal lobe engagement and white matter development in the same area
- Confidence and competence of parents in the caring of their infant.

In a study from 1986, Dr. Als and colleagues conducted an experimental study to understand there were improvements for implementing individualized behavioral and environmental care for very low birth weight infants with bronchopulmonary dysplasia. Eight in the control group (CON), and eight infants in the experimental group (EXP), these infants weighed under 1,250 grams, and their gestational age was lower than twenty-eight weeks, and were using respirator for over 24 hours in their first 48 hours of life. The method used was behavioral observation, which is one of the main practices from NIDCAP (Als & McAnulty, 2011), stress and relaxation behaviors were classified. Several positive outcomes were found in the experimental group, such as shorter stay on the usage of respirator, earlier normal feeding behavior, and better behavioral regulation at one month and nine months, and cognitive developmental indices at 3, 6, and 9

months. These findings were found positive for individualized behavioral and developmental care for preterm infants during the time of neonatal care.

Kleberg et al. (2002) found interesting results infants born at less than thirty-two weeks of gestation who received NIDCAP care; at twelve months their results in cognitive development were higher than the control group, better outcomes in Mental Developmental Index according to the Bayley Scales of Infant Development (BSID), but no difference between control group for Psychomotor Developmental Indices (PDI), different from other authors who had found positive outcomes for both aspects at nine months corrected age.

Positive outcomes were found in another study by Klein et al. (2021). Two thousand and twenty eight extremely preterm infants were assessed while developmental care strategies were implemented, such as individualized care, based on observations as proposed by NIDCAP (Als, 1986); pain assessment; frequency, duration, and day of initiation of skin-to-skin; and parental involvement. The results found indicated a decrease of painful procedure on preterm infants, mechanical ventilation, and also the time from birth to extubation, less time to remove an endotracheal tube, being the last step in liberating a patient from the mechanical ventilator (Saeed & Lasrado, 2023). On the contrary, higher pain evaluations were done, more individualized observations, skin-to-skin contact, and parental involvement in the care of their infant.

These results suggest that preterm infants can benefit greatly from individualized and developmentally appropriate care. Implementing NIDCAP programs in the context of NICUs and preterm infants provide a reduction of stress and enhance better medical and neurobehavioral outcomes of preterm infants. Re-envisioning NICU

practices (Als & McAnulty, 2011) can lead to promising outcomes, offering a more effective environment for infants, families and healthcare providers.

Family and Infant Neurodevelopmental Education

The Family and Infant Neurodevelopmental Education (FINE) originated in the beginning in the first decade of the 2000's, at the hospital St. Mary's Hospital, London. This hospital hosted the NIDCAP Center of the United Kingdom (UK). The participation of Bliss, a charity interested in giving premature infants the best care to guarantee survival and a quality of life (www.bliss.org.uk), and the Erasmus Medical Centre in Rotterdam, made it possible for this program to develop and gain an audience inside the UK and out of Europe.

This program promotes three main principles, the first one is based on the knowledge that sensitive care benefits the development of the brain by ensuring a protective and supporting environment for the brain's health (Als, 1998; Kaye, 2016), to support and enhance the benefits of a regulated anatomic system. The second principle involves the relationship between infants and caregivers, and caregivers and healthcare professionals, this last one is able to grow as parents are included and actively involved in the care of their premature children. And the last principle constitutes the idea of the importance of individualized care, based on the unique experience of every infant and their medical condition; understanding that this can be assessed through the observation of the infant's behavior, as Dr. Als proposed in 1984.

As stated at the beginning of this special space dedicated to FINE program, one of the characteristics is that education is essential and core to this program, the structure of the available courses are integrated in several levels, from a foundation level with topics that contain information from neuroprotective information to research based on family-centered neurodevelopmental care. A section for promoting practical skills in their context, placing special emphasis on observation, effective communication with

parents and colleagues, and applying the knowledge in an evaluation of a real case (Warren, 2017). The well-established courses of this program can lead to a complete and significant source of information and practice for healthcare professionals or family members who have a newborn. Other interesting additions are a course of basic principles for neonatal context called “Pre-FINE” (Warren, 2017) and FINE Masterclasses to continue updating the knowledge (Warren, 2017). In a lapse of three years, people attended the courses offered by FINE, and 70% of participants stated that improvements have been made regarding care, safety in children, and higher parental active involvement in their health facilities (Warren, 2017).

Warren et al., (2019) conducted a study to assess the impact of FINE program on neonatal care across the UK, using two surveys of neonatal staff that contained information about perceptions of change in the care at neonatal facilities, the parent’s involvement and the experience of the staff from the beginning of the training. The results of the survey positively highlighted that FINE training promotes increasing impact on healthcare individual practice and by neonatal units, not only on infants, but parents and the healthcare professionals. Having professionals that are confident in their knowledge, and are able to share the information with family members and put in practice their developmental care skills is a quality beneficial for all three members of the circle, infants, parents, and medical staff.

The difference of this program to the rest of the existing is the aim to cover the need of more easily accessible information and training for families and healthcare providers (Warren, 2017). The program’s educational courses provide important resources for healthcare professionals and families, enhancing better care practices, stronger caregiver-infant bond, and effective parental involvement.

The effectiveness that FINE program has demonstrated provides a higher level for the standard care within neonatal care units, being of benefit for infants, parents, and healthcare providers.

Close Collaboration with Parents

The Close Collaboration with Parents program dates from 2008, originated during the process of planification of single-family rooms NICU modality at the Turku University Hospital, in Finland. This training program was developed, different from the other types of developmental care or family-centered care programs that exist, to cover the educational needs from healthcare professionals at NICUs on how to support parents during their stay at hospital units; nowadays it is present in twenty one cities and nine countries (Ahlqvist-Björkroth et al., 2024). The Close Collaboration with Parents program does not only cover educational purposes, but healthcare providers are encouraged to actively use the content of the program by doing bedside hands-on teaching, including reflective discussion groups. The figure of the mentors is strong during the process of healthcare providers' hands-on learning experience.

This training program is divided into four phases, according to Ahlqvist-Björkroth et al. (2017):

- Phase One: Observing Preterm Infant Behavior. The main focus of this is to learn how to observe and communicate effectively the behaviors that infants have, to develop detailed observation, with the goal of recognizing the behavioral and personal uniqueness of every infant.
- Phase Two: Join Observation. In this phase the main focus is to develop the receptive listening and joint observation skills, in order to create collaboration, integrating the other colleagues observations of the infant's behavior and needs for contributing to the care plan.

- Phase Three: Understanding the Individual Characteristics of the Family. The main focus of this phase is to become familiar with the history of how parents became parents for that child, this with the aim of understanding and increasing the empathy from staff members for parents' experience, to provide support by listening to them and being interested in their story.
- Phase Four: Family-Centered Transition From Hospital to Home. This phase focuses on learning to use negotiation and shared decision-making between healthcare professionals and parents during the hospitalization, the transition to home, and the follow-up sessions. The aim of this phase is for promoting the participation of parents in the process of decision-making, for them to see and understand that their opinion is valued.

A change of care culture inside the neonatal care units is necessary, and as Guillaume et al. (2013) concluded, the bond between mothers and fathers lays on the base of the relationship between parents and the healthcare staff. Qualities that are promoted in this training conduct to a better overall experience, wellbeing, and connection of preterm infants and parents, as it is stated in the next lines:

“The main goal of the Close Collaboration with Parents™ intervention is to facilitate a change in a unit to help the health care team better support parents' presence and participation during hospitalization and thereby parenting and parent-infant bonding.” (Ahlqvist-Björkroth et al., 2017)

According to Ahlqvist-Björkroth et al. (2024), the aim of this program is to create a stronger partnership between parents and healthcare members, based on

responsibility, continuous shared communication, timely emotional support, and collaboration in decisions-making moments regarding the infant and the parents. The content included to facilitate the aim of this program regards neurobehavioral assessment of newborns, communication and decision-making, bio-psychological bases of bonding, parenthood, parent-infant early relationships, and at-home transition (Ahlqvist-Björkroth et al., 2024). To build on the benefits and effectiveness of this training program, two additional articles provide insights into the results of the implementation in NICU settings.

A study from Itoshima et al. (2024) evaluating the outcomes when implementing Close Collaboration with Parents program in Finland NICUs, effects were found for length of stay, growth, hospitalization visits and readmissions in preterm population. The data was from all preterm births registered from 2006 to 2020, all preterm infants were born under 35 weeks of gestation. Classification of infants was as follows: a total of 2,104 preterm participants in the Full Close Collaboration (Full-CC) for implemented in-hospital and discharge intervention, Partial-CC consisted of 515 preterm infants whose intervention comprised only during in-hospital stay, and 11,621 preterm infants in control group who did not receive any intervention. The results found were positive for the Full-CC group, obtaining 1.8 shorter length of stay when compared to the control group. Meaning that, on average, Full-CC preterm infants stayed in the hospital for a shorter period. Also, infants in the Full-CC group showed a higher gain of weight of about 11.7 grams per week and growth in length of 1.3 millimeters per week when compared to the control group. Additionally, Full-CC infants obtained lower odds of unplanned visits to the doctor after discharged compared to the control group. These positive results for infants in the intervention group can be linked to the efficient care provided by healthcare professionals and parents during their stay in neonatal care.

He et al. (2021) assessed the parent-infant closeness during the NICU stay when implementing the Close Collaboration with Parents program in nine hospitals in Finland. The assessment consisted of before and after intervention daily reports of mothers and fathers' participation of skin-to-skin contact with infants, during the length of their stay in the hospital at the NICU. The results suggested an increase on average from 36 minutes to 182 minutes per day of parent-infant skin-to-skin contact, despite the NICU cultural differences among hospitals this information provides information that if NICUs are available for parents to stay increases the participation of parents in the care of their infant (Raiskila et al., 2017).

With the results of this study it can be concluded that providing educational information to neonatal staff, emphasizing the importance of listening and collaborating with parents can lead to an increased parental participation in the unit and increased levels of skin-to-skin contact between parents and their infant. An environment that promotes partnership between healthcare providers and parents encourages parents active participation, thereby creating a supportive environment for preterm infants development.

Family Nurture Intervention

The New York-Presbyterian's Morgan Stanley Children's Hospital had the opportunity to host the very first clinical trial of the Family Nurture Intervention (FNI). A distinguishing feature of this program, compared to the others previously discussed, is its emphasis on generating opportunities between mothers and infants to emotionally bond (Welch, 2016). These opportunities aim to support the autonomic co-regulation of the infants with the mother, as it was previously highlighted in our discussion on the clinical impact of prematurity on how the immaturity of this system cost in the life of infants. The Family Nurture Intervention aims to facilitate interactions that are biologically significant to enhance the sensory experience of both mother and baby (Welch et al., 2012).

The main goal of this program is to promote the emotional connection between the mother and the preterm infant, as it has been well addressed by researchers, preterm infants autonomic regulation system is underdeveloped and more exposed to stressors, for a preterm infant is difficult to return to a balanced state (Patural et al., 2004; Mulkey et al., 2018). Family Nurture Intervention is the first one to conduct the Calming Cycle methodology, which will be further discussed. The nurturing interactions are activities that involve holding, touching and communicating with the infant, in these activities sensory availability of an infant is being encouraged to use (Welch et al., 2012), all means to enhance the connection with the mother.

And another goal is to enhance the autonomic co-regulation between the mother and the infant. For this, the Calming Cycle Interactions was proposed, it promotes smoother stress regulation between mother and child, it is the central activity of the interaction between mother and child (Welch et al., 2012). This term emerged from a

study of observations of infants who displayed emotional, behavioral and developmental challenges (Welch, 1989).

During the stay of the preterm infant at the NICU, parents are introduced to a Nurture Specialist, an expert in neonatal care that has received FNI training. The interventions consist in three nurturing activities, denominated “calming interactions” (Welch et al., 2012), respecting the availability of the preterm infant to interact with the mother, the time recommended for the mothers is of at least six sessions of one hour each per week. These sessions are registered in activities and duration by research nurses. The path of interaction between mother and infant goes step-by-step, dictated by the availability and maturity of the premature baby.

In the Calming Cycle Intervention, mothers and infants have a structured interaction where they both participate in cycles of discomfort and mutual soothing. These cycles promote moments of shared distress followed by mutual calming, with activities such as moments of eye contact, and physical closeness, until the infant is soothed and the mother as well (Welch et al., 2012). These interactions intend to contribute to the ability of stress and discomfort management, leading to better emotional regulation in the infant. But, how can this intervention be suited for an environment of prematurity?

As Welch et al. (2012) explains, three main practices are part of the intervention specifically costumed for a NICU unit. The first takes part when the preterm baby is in the isolette, Nurture Specialist guide calming interactions with the mother and the premature by exchanging odor cloths, engaging the mother in form and sustained touch. Once out of the isolette, holding and feeding are guided through the Calming Cycle, this is supposed to lead to faster decrease the over discomfort on the mother and the infant (Welch et al., 2012). Finally, family sessions are included to engage and support the

mother, emotional and practical help are needed throughout the journey of a preterm infant in the NICU unit.

The interactions between mother and infant begin by interchanging cloth with odor of the mother to the preterm infant and vice versa, this practice is based on previous finds where mother's odor contributes positively to stress regulation during painful procedures, having a calming effect on preterm infants (Nishitani et al., 2009). This practice is encouraged to continue at home, when a moment of separation happens, it is recommended for mothers to leave a piece of cloth with her odor to the infant, and in moments of regulation the cloth can serve as a soothing item.

During the early fetal development, the exposure to the mother's voice plays an important role in bond formation, and the infant's body reacts to the familiarity within hours of being born (Ockleford et al., 1988). Although, this can be different in the case of premature birth (Therien et al., 2004). This intervention encourages mothers to engage in regular verbal expression with their premature infants, by using their native language to enhance the emotional connection.

Physical contact although in the context of NICU can often be restricted due to medical procedures. Although it has been seen that gentle, therapeutic touch can promote the stabilization of physiological functions of the preterm infant (Livingston et al., 2000). Mothers in this intervention are provided with techniques for calming physical contact with the preterm infant, used particularly after procedures that cause distress, it is done by providing a firm touch and containment to the infant. This activity supports mothers and premature children's emotional and physical wellbeing.

The benefits obtained from an intervention's clinical trial was carried from 2008 to 2014, with the participation of mother's and 150 preterm infants, each assigned to FNI or standard care. The benefits found in this trial were positive for those infants who

were enrolled in the FNI group, suggesting that this program contributes on brain maturation of the frontal region of the brain at term age (Myers et al., 2015), at 18 months multiple neurodevelopmental domains, attention and social connection (Welch et al., 2015).

A study by Welch et al. (2015), explores the effect of the Family Nurture Intervention on the neurodevelopmental and behavioral outcomes of preterm infants. FNI was implemented in a NICU unit to reduce the negative effects of mother-infant separation. The researchers assessed the development of preterm infants at eighteen months corrected age, and compared them to preterm infants who received standard care (SC). The three assessment tools included were Bayley Scales of Infant Development III (Bayley-III), the Child Behavior Checklist (CBCL), and the Modified Checklist for Autism in Toddlers (M-CHAT). The findings were that infants in the FNI group had significant higher cognitive and language scores on the Bayley-III, less attention difficulties on the CBCL, and higher outcomes on the M-CHAT compared to those preterm infants who received standard care, preterm infants enrolled in the FNI group were less likely to fail social-relatedness items on the M-CHAT. From this study, it can be concluded that Family Nurture Intervention promoting emotional bonding between mothers and preterm infants, can significantly increase neurodevelopment, social interaction, and attention.

Porges et al. (2019) investigated the outcomes of the Family Nurture Intervention on the development of autonomic regulation in preterm infants within their time spent at the NICU. Researchers conducted a randomized control trial, preterm infants between 26 and 34 weeks postmenstrual age (PMA) were assessed. Two groups were formed, standard care (SC) and intervention group receiving standard care plus FNI. The study involved monitoring electrocardiograms (ECG) during sleep at 35 and

41 weeks PMA. Data from ECG was used to measure heart rate and respiratory sinus arrhythmia (RSA), both indicators of autonomic function (Porges, 2007). The results found indicated that the preterm infants that received FNI care showed higher improvements in RSA and vagal efficiency. These findings highlight the effect of FNI in promoting the maturation of cardiac functions in preterm infants. Early nurturing of preterm infants can significantly enhance postnatal development, and according to this program, autonomic regulation is important in social bonding, through the calming cycle, interactions with mother emotional bonding between mother and infant and promote autonomic regulation responses. From a longitudinal follow up of Welch et al. (2020), outcomes of FNI in NICU setting from a trial cohort at 4 to 5 years indicate that this program is found to enhance autonomic regulation in mothers and preterm infants. Process believed to be provided by the calming cycle enhancing the socioemotional autonomic co-regulation, impacting neurobehavioral effects in preterm infants.

Family Integrated Care

The Family Integrated Care (FICare) program is an approach of neonatal care that aims to get parents involved in the care of their preterm infants or critically ill infants in the NICU. The program was first developed in Canada, at the Mount Sinai Hospital in Toronto, the program was formed from the collaboration of Dr. O'Brien and Dr. Lee. It was inspired by the experience of a care model in Estonia, where parents had to take care of their infants because of shortage of nurses, back in 1979. The FICare program was developed to address the emotional and psychological needs of both parents and infants, recognizing the importance of parents and family's role in the infant's process of recovery and development.

FICare's purpose is to strengthen the relationship between parents and the healthcare team by supporting and helping develop the role of parents to become a skilled primary caregiver for their children instead of a visitor (O'Brien et al., 2013). This includes training in tasks such as monitoring their baby's health, administering feeds, measuring growth, bathing, positioning of the preterm infant, administering medications, and contributing to medical records. By participating in this, parents gain confidence and skills to be able to assist their infant's daily care responsibilities.

A framework of four pillars was developed in order for NICU units to build from it: staff education and support, parent education, NICU environment, psychosocial support (www.familyintegratedcare.com)

- Staff Education: This pillar highlights the importance of providing the NICU healthcare providers with education to mentor, educate, along with parents in becoming caregivers for their infants during their stay at the NICU. When the

healthcare providers are prepared and confident in their roles, a collaborative environment will be created where healthcare providers are able to facilitate family-centered care. This enhances the quality of care for infants and the partnership between healthcare providers and parents.

- Parent Education: Focusing on empowering parents by providing knowledge and skills to care for their infants in the NICU is a crucial part of this program, through small group education sessions and opportunities for parents to actively participate in medical rounds. This involvement is further supported by individualized bedside learning, allowing parents to gain hand-on experience and guidance, in this way parents feel prepared and capable of being the primary caregiver of their infants during their NICU stay.
- NICU Environment: A space where parental presence is encouraged, and healthcare professionals are open to collaboration with parents, can guarantee a successful implementation of the program, but an alignment of the policies and procedures from the unit to the pillars of the program is necessary as well. And, the physical and social environment has its importance for where the program will be developed, and must be a safe and secure environment for healthcare providers, parents, and infants.
- Psychosocial Support: Providing the emotional and mental support the families need is crucial. For this, the importance of peer-to-peer support is an important part of this program, through the connection between other veteran parents who are able to share emotional support and experience, with the aim of promoting the participation of parents and families in the process of FICare.

The Family Integrated Care program has targeted crucial experiences infants and parents go through when in a NICU environment, the clinical challenges of an infant and the stress of parents facing this scenario. This program has shown important results regarding the reduction of parental stress and positive results for the improvement of newborns. A study conducted by Church et al. (2020) aimed to assess the long-term effects of the FICare program in behavior at 18-21 months corrected age (CA) and the factors mediating this aspect related to parents and infant growth. The tools of assessment were Toddler Social Emotional Assessment (ITSEA), and to assess parents child mediators Nursing Child Assessment Satellite Training (NCAST), and Parenting Stress Index (PSI). In this study, 123 preterm infants of 33 weeks of gestation participated in the FICare trial and 62 preterm infants participated in the standard care group, both groups were then evaluated at 18-21 months CA. The results found were that FICare infants showed better self-regulation, obtaining a lower dysregulation score on the ITSEA, when compared to the control group. In addition, better parent-infant interactions and less parenting stress were found, which can be linked as a mediator of FICare positive effect on child behavior. From these results it can be concluded that FICare promotes long-term effects on self-regulation skills of preterm infants at 18 - 21 CA.

Long-term neurodevelopmental outcomes of FICare program implementation were assessed by Synnes et al. (2022), in this study preterm infants born at less than 29 weeks gestational age were assessed at 18 months corrected age. Results comprehend the comparison of cognitive, language, and motor assessment of preterm infants who received FICare and preterm infants who received standard care. The results found no significant differences in cognitive and language delays between the two groups, but FICare preterm showed higher motor development and higher body mass index, and

FICare preterm infants showed a higher incidence of intraventricular hemorrhage. To conclude, based on these results the FICare program may not be effective on improving cognitive or language outcomes, but it may improve motor development in very preterm infants.

Other short-term positive effects have been found in various aspects when FICare has been implemented, such as oral feeding (Banerjee et al., 2019); length of stay at hospitals (Örtenstrand et al., 2010; Banerjee et al., 2019); and when implemented at the NICU, less time of mechanical ventilation (Hei et al., 2021).

The implementation of a program like FICare, or any other of the ones mentioned above require a series of changes and adaptations from the base of the medical culture and policies, requiring an integration of parents as primary caregivers of the infants ready to learn from the experts of care, for the wellbeing of their newborn. The results obtained from each of the studies researchers have done are promising for the future preterm infants and parents, as well as healthcare providers, and hospitals. A culture of individualized care, collaboration among medical and non-medical caregivers, implementation of family-centered care culture among medical facilities, can positively influence the well being of the future generations born before time.

Chapter 5. Discussion

This section will evaluate the programs selected for this study based on their effectiveness in regulating the parasympathetic system when implemented in a NICU environment. Next, a comparison across the programs will follow, with special focus on the key results related to three key aspects: autonomic regulation, calming behaviors, and the bonding between parents or caregivers and the premature infant. Finally, description of challenges associated with implementing Polyvagal Theory principles into the NICU care will be commented on, in addition to recommendations for program implementation.

Evaluation of Family Intervention Programs in NICU Settings through the Lens of Polyvagal Theory

In this study, five programs were analyzed for their benefits and effectiveness for promoting autonomic regulation in the premature infants in NICU settings. The information discussed regarding the programs is able to tell the effectiveness in the variety of interventions they propose. Each program offers a particular focus, and it brings a unique perspective to the care of premature infants in neonatal care. Even though they have differences, in these programs there are objectives shared in common: enhancing the closeness and bonding between the premature infants and their parents, increasing the skin-to-skin contact with parents and family, promoting a collaborative partnership between health professionals and parents by providing education and

sharing essential caregiving skills, and individualized care based on skilled observation to match the needs of each premature infant and family.

As can be observed in Table 1, there is a column for the aspect that differentiates the program from the others discussed. In the Kangaroo Mother Care, skin-to-skin contact with the mother or the caregiver is the main goal of the intervention, and based on this practice many positive outcomes have been found throughout the years, and has been used as a complementary intervention in other programs.

The main characteristics found for the Newborn Individualized Developmental Care And Assessment Program are based on the legacy of Dr. Als legacy, the capacity to observe and understand the needs of preterm infants, the individualized environments and care interventions are key in this program, and the participation of parents and family is highly valued, as well as education for healthcare professionals to promote the detailed understanding of the preterm infant through their communication in the form of physiological reactions and behaviors.

The leading aspect of the Family and Infant Neurodevelopmental Education program is the structure of the education and practice of skills that has been established in order to make the information and preparation in the field of neonatal care more accessible for healthcare professionals and families. As the NIDCAP Federation International mentions, the FINE program is a base for introducing the foundation and core practices of developmental care in NICU environments (www.nidcap.org).

In the Close Collaboration with Parents program, healthcare professionals are given the knowledge and opportunities to develop their abilities in communication and empathy, as well as acquiring the needed caregiving skills for the prematures, but the main interest is to successfully involve parents in the process of NICU stay and create a

strong partnership between healthcare providers and parents based on continuous support and collaboration, as the name suggests.

An important aspect to highlight from the Family Nurture Intervention that makes this program interesting is the promotion of sensory co-regulation intervention between mother or caregiver and preterm infant. Other programs promote skin-to-skin contact intervention but this program is based on the exceptional work of Martha Welch's theory of calming cycles, which integrates and describes more the human ability to regulate through touch, including the emotional connection.

The FICare program values the participation of parents in the complete care of their preterm infant, promoted through education and integral support, and an aspect that is highly valued is the presence of parents who have been through a similar situation, who serve as an important support as well for those passing through the process of prematurity.

To conclude, each of the programs have an aspect that can directly impact the development of the premature infants, and more importantly for this study, the regulation of the polyvagal system in a newborn. To collaborate with this statement, next the overall comments from the evidence proposed from each program in the previous chapter will be further discussed.

Table 1. Comparison of Family Intervention Programs.

Program Name	Differential Aspect	Autonomic Regulation	Calming Behavior	Bonding
Kangaroo Mother Care (KMC)	Skin-to-skin	Enhanced autonomic regulation, better respiratory patterns and stress regulation (Feldman et al., 2014).	Quicker calm and recovery state after stress (Feldman et al., 2014).	Long-term enhanced synchrony with the mother and attachment (Yaniv et al., 2021; Charpak et al., 2017)
Newborn Individualized Developmental Care And Assessment Program (NIDCAP)	Observation of behaviors of the infant, individualized environment and interventions, based on the infant's needs.	Shorter stay on the usage of respirator, earlier normal feeding behavior (Als, 1986; Als & McAnulty, 2011)	Better behavioral regulation (Als, 1986)	Higher active participation of parents (Klein et al., 2021)
Family and Infant Neurodevelopmental Education (FINE)	Accessible structured education for healthcare professionals and families.			Higher parental presence (Warren, 2017).
Close Collaboration with Parents	Parents and healthcare professionals close partnership.	Although not directly assessed heart or respiration rate, enhanced development supported by the program can be due to enhanced autonomic regulation.	Skin-to-skin increased significantly, enhancing calmness and regulation in preterm infants (He et al., 2021).	Increased parental presence and active participation in caregiving (He et al., 2021; Ahlqvist-Björkroth et al., 2024).
Family Nurture Intervention (FNI)	Sensory nurture, and emotional connection.	Improved autonomic regulation (HRV and RSA) (Porges et al., 2019).	Brain maturation in areas of emotional and attentional regulation (Welch et al., 2015).	Enhanced by nurturing touch and calming cycles interactions (Welch et al., 2012).
Family Integrated Care (FICare)	Active participation and instruction for parents in the integral care of the infant.	Less stress due to parental proximity at one year old, and better self-regulation at two years old (Church et al., 2020).	Lower dysregulation scores on social and emotion assessment (Church et al., 2020).	In fathers, higher participation and bonding (Van Veenendaal et al., 2022); improved parent-infant interactions (O'Brien et al., 2013).

Comparative of Effectiveness of Polyvagal-Informed Outcomes in NICU Family Intervention Programs

The analysis presented previously, in the last chapter, about the existing evidence of the implementation of the selected programs in promoting the parasympathetic system activation, was evaluated, being the effectiveness on promoting the regulation of the autonomic nervous system as its main factor. This assessment focuses on the selected three key aspects that may determine the alignment of the interventions proposed by these programs to the Polyvagal Theory principles. The three aspects are: autonomic regulation in preterm infants, calming behaviors, and parent-premature infant bonding.

Autonomic regulation understanding serves to comprehend how preterm infants depend on their interaction with the environment, particularly when a developmental care program is being implemented. According to the theory developed by Dr. Porges, the parasympathetic nervous system controls the ability of the body to maintain a relaxed, calm, regulated state, the contrary to being in a fight or flight, or freeze response. The programs selected were assessed based on their effectiveness in promoting autonomic regulation by enhancing a physiological state where preterm infants are able to engage with their environment and not presenting stress responses as mentioned above, due to the activation of other autonomic systems.

Establishing a continuous autonomic stability, interventions are able to contribute to positive developmental results, reducing the stress or dysregulation in preterm infants, which can then compromise their growth and overall well being. Autonomic regulation is a critical component in the principles of the Polyvagal Theory,

this aspect then serves as the base for further aspects such as social engagement and bonding.

The capacity of a preterm infant to show calming behaviors is a reflection of the ability to access the parasympathetic system, a system that enables self-soothing and emotional regulation. The calming behaviors can be an indicator that the preterm infants are perceiving as safe the environment they are in, fostering a down-regulated response and entering a relaxed and recovery state. The programs that promote this process correspond with the Polyvagal Theory, addressing preterm infant's neuroception, the perception of safeness in the environment or interactions, allowing the newborn to continue its physiological and emotional development.

According to the Polyvagal Theory, a safe environment is needed in order to socially interact, as this promotes the co-regulation of parents and preterm infants. The programs that enhance the bonding and co-regulation by supportive care practices, promoting a sense of safety between the infant and parent or caregiver demonstrate coherence with the principles of Polyvagal Theory, placing light on the importance of supportive and safety in the early interactions.

In Table 1 are described the three aspects and the source of information from the previous evidence found for each of the programs. As can be interpreted, these programs share, on some level and are based on different practices and interventions, the ability to promote parasympathetic regulation in preterm infants.

From the KMC program, it can be interpreted that the characteristics of this program do promote the parasympathetic regulation of preterm infants, skin-to-skin contact according to various authors enhances respiratory patterns, long-term calm and recovery states after stress and long-term synchrony (Feldman et al., 2014), and

attachment with the mother (Yaniv et al., 2021; Charpak et al., 2017). This is a very well supported program, not only for the years it has but the outcomes identified.

The NIDCAP program promotes regulation as it results as shorter stay on the usage of respirator, and earlier normal feeding behavior (Als, 1986; Als & McAnulty, 2011); better behavioral regulation (Als, 1986); and higher active participation of parents (Klein et al., 2021).

For the FINE program, effects have been found for information regarding staff benefits and parental active involvement (Warren, 2017, Warren et al., 2019), as I did not find more information available to testify for the main aim of this study, one could think that this program tends to enhance the autonomic regulation because of the possible better practices and skills from the healthcare professionals and the participation of parents in the care of the preterm infants, more information may be needed to state this.

Close Collaboration with Parents support the autonomic regulation although not directly assessed, but shown by enhanced growth (Itoshima et al., 2024); skin-to-skin increased significantly, enhancing calmness and regulation in preterm infants (He et al., 2021); and increased parental presence and active participation in caregiving (He et al., 2021; Ahlqvist-Björkroth et al., 2024). Parental active involvement seems to be a key aspect for preterm infants' regulation.

The program FNI has shown parasympathetic regulation outcomes in improved heart rate and respiratory regulation (Porges et al., 2019); calming behaviors as enhanced emotional and attentional regulation (Welch et al., 2015), and bonding through nurturing touch and calming cycles interactions (Welch et al., 2012). The program covers crucial aspects of the Polyvagal Theory, making this program strong on its interventions and outcomes.

Finally, the FICare program can be effective in autonomic regulation by preterm infants showing less stress due to parental proximity at one year old, and better self-regulation at two years old (Church et al., 2020); lower dysregulation scores on social and emotion assessment (Church et al., 2020); and higher parental participation (Van Veenendaal et al., 2022) and improved parent-infant interactions (O'Brien et al., 2013). As mentioned before, parental availability and active participation has been a crucial factor for the regulation of infants.

These results show the various aspects that lead to results in effectiveness of parasympathetic regulation in programs that are developed for neonatal care. The variety of interventions and purposes serve to better choose the fit when encountering a case of prematurity.

Challenges and Recommendations for Integrating Programs with Polyvagal Principles in the NICU

Integrating programs that aim to enhance the parasympathetic regulation within a NICU can present challenges, like a NICU that can be itself a stress-full environment, controlling for all the aspects occurring like sounds, interventions to infants, monitoring their health state, can make it more complicated. A challenge that neonatal units may have is the availability and time for the neonatal care staff to be trained to deliver a specialized care to the preterm infants and the families, can be timewise complicated, or willingness-wise from the staff to go through the process of learning, training, and being evaluated. Another challenge that can be presented in multiple hospital units is the constant presence of parents and the availability of participation in learning new

techniques or acquiring knowledge due to more aspects. A crucial aspect for implementation of interventions in the NICU is the fragility of the health condition in premature infants.

To address these challenges mentioned before, recommendations are to introduce a shift in the care culture in hospitals, specifically in neonatal units, to open the participation of parents and family in the care of preterm infants, by promoting family-centered care. This targets several possible solutions that may contribute to the installment of a new culture inside healthcare, from the material environment of the NICU unit to the treatment of the parents of the infants.

Further, the study of long term outcomes from interventions for preterm infants under different health and parental conditions, including intervention where parental figure is not available. As this can help to deeper understand alternatives of caregivers.

In addition, the usage of pain free technological devices that contribute to the monitoring of their health in real time, and the needs to be covered to interfere as less as possible with the moments of calmness and rest of the preterm infants. Lastly, more accessible information for parents and healthcare providers about the benefits of implementing the family intervention programs is of major importance.

Conclusion

The theory that has been discussed in this study is the Polyvagal Theory, proposed by Dr. Stephen Porges. This theory provides well established insights about the importance of the autonomic nervous system and its crucial role not only physiological regulation but emotional as well, specifically in the context of prematurity. The term prematurity means that infants are born before they reach their full gestational state, they are born early in their developmental process, for this, understanding that that their autonomic nervous system is not fully mature, and in particular their parasympathetic system, which is one of the branches of the autonomic nervous system. The parasympathetic nervous system has the role of regulation of digestion process, respiration, heart rate, and more.

The Polyvagal Theory highlights the role of the vagus nerve in assisting the regulation of these functions mentioned above, and highlights as well another important body ability that Dr. Stephen Porges named neuroception, which is the ability to perceive safety or potential dangerous threats in the environment. Considering a NICU setting, preterm infants are constantly surrounded by stressful stimuli like new sounds, smells, body sensations, painful procedures, and their limited resources to regulate and maintain a homeostatic state are compromised due to their immature parasympathetic system.

Understanding how the vagal pathways function and have an effect on the physiology of preterm infants gives the capability to medical professionals and researchers to find interventions that can enhance autonomic regulation, in order to contribute to the development of the premature infants. This theory is able to clearly

highlight the impact of a proper environment of safety and nurture for preterm infants, to better support the autonomic regulation in this population, and enhance the improvement of short-term and long-term neurodevelopment outcomes and overall well being of preterm infants.

The implementation of Polyvagal Theory principles into NICU-based family intervention programs, based on the results proposed in the last chapter, provides an important opportunity to support the physiological and emotional well being of premature infants. While challenges exist inside a NICU environment, the evidence proposed by these programs clearly demonstrates the importance of individualized interventions that promote parasympathetic regulation, for the positive impact it has in the development process of a premature infant. Each program contributes in their singularity to the understanding of neonatal care, and to the potential of fostering environments that nurture infants and parents.

The progress accomplished in family intervention programs has arrived to the point where it is with its difficulties, and a future where every premature infant is received with the care that not only thrives to regulate their autonomic system but offers neurodevelopmental and emotional long-term outcomes is a possibility. Collaboration among researchers, healthcare institutions, and families will without a doubt contribute to future progress in the neonatal units, to ensure the best care possible for the most vulnerable among.

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