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The Use of Sensory Integration to Mitigate the Traumatic Environment of the NICU: A Critically Appraised Topic (CAT)

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The Use of Sensory Integration to Mitigate the Traumatic Environment of the NICU: A Critically Appraised Topic (CAT)

PICO

P: Preterm infants in the NICU

I: Sensory integration

C: Preterm infants that receive OT services (sensory integration) in the NICU compared to those preterm infants who do not receive services

O: Decreasing the traumatic impact of the NICU environment

Focused Question

To what degree do sensory integration (SI) interventions for premature infants within the scope of occupational therapy (OT) practice mitigate the traumatic environment of the neonatal intensive care unit (NICU)?

Clinical Scenario

In 2018, one in 10 infants were born premature in the United States, which is classified as being born prior to 37 weeks gestation (Centers for Disease Control [CDC], 2019). This includes an average of 7,303 babies each week (March of Dimes, 2020). The final months and weeks in utero are shown to be critical to typical development (CDC, 2019). The organs associated with the sensory system begin to develop within utero around eight weeks and the development of the senses continues well into childhood and adolescence (Mayo Clinic, 2020). Hearing and vision are the last two sensory systems to develop, thus are particularly immature in the preterm infant (Blackburn, 1998). As a result, those born premature are more likely to develop sensory processing disorder (SPD), vision and hearing problems, attention deficit hyperactivity disorder

(ADHD), anxiety or developmental disability (CDC, 2019; March of Dimes, 2020). In one prospective longitudinal study of preterm infants in the neonatal intensive care unit (NICU), it was found that half of preterm infants born less than 30 weeks developed SPD by ages four to six years old (Ryckman, Hilton, Rogers & Pineda, 2017).

In past literature, trauma has been defined as "painful, unforgettable, physical and emotional, and unexpected" (D'Agata, Coughlin, & Sanders, 2018, p. 1163). One of the earliest environments that has been shown to be traumatic and stressful for the premature infant is that of the NICU (Eliades, 2018). In order to further describe the infant's experience in the NICU, the term Infant Medical Trauma (IMTN) was coined to explain how the physical and sensory environment of the NICU impacted the infant's development (D'Agata et al., 2017). One study found that premature infants in the NICU were exposed to various atypical procedures and sensory experiences, which resulted in differences in the way these infants responded to sensory stimuli (Ryckman et al., 2017). Long term developmental effects may be created from a "mismatch between brain expectancy and environmental input in the preterm infant, which can lead to overwhelming sensory load and stress" (Blackburn, 1998, p. 281).

Overall, sensory exposure in the NICU has been shown to influence brain development (Pineda et al., 2014; Pineda, Raney & Smith, 2019). In addition, infants' exposure to high stress experiences in the NICU resulted in structural and functional changes in the brain, which created the potential to influence neurodevelopmental outcomes (Smith et. al., 2011). At the same time, neonatal stress may alter "healing and recovery processes and growth" (Blackburn, 1998, p. 281). Pineda et al. (2014) further described the link between private NICU rooms and an increase in sensory deprivation, which was visibly observed through brain structure changes associated

with language development, compared to those infants in an open ward environment. It was additionally concluded that early determination of a sensory need and Ayres Sensory Integration (ASI) intervention based on this need enhanced sensory, motor and communicative development, while lack of ASI intervention caused a decline in developmental progress (Lecuona, Van Jaarsveld, Raubenheimer, & Van Heerden, 2017). Pekçetin, Akı, Üstünyurt and Kayıhan (2016) additionally explored the relationship between prematurity, SPD, and the use of sensory integration (SI) as an intervention. It was found that not only were premature infants at an increased risk for developing SPD, but it was further found that SI intervention was an effective treatment to increase positive outcomes for those with SPD (Pekçetin et al., 2016). Thus, understanding early sensory needs and having a multifaceted intervention approach was critical to preterm infant outcomes.

Occupational therapists (OTs) bring a holistic and unique approach to client care and are a fundamental part of the NICU care team (Craig, Carroll, Ludwig, Sturdivant & Boop, 2018). According to Craig et al. (2018), OT's support of early occupations in the NICU were impactful on the development of an individual from infancy into adulthood. OT's specific knowledge base and ability to recognize environmental conditions that are stressful or bring imbalance to infants is what makes their role within the NICU unique. Not only does an OT have specific knowledge about infant development and can be trained in SI, they also have the ability to focus on factors of the physical environment as well as the sensory organization of the infant (Craig et al., 2018). SI is an intervention used by occupational therapists to help those of all ages and diagnoses, including infants, organize how their body processes and integrates the sensory input from their environment (Sensory Integration Education, 2020). OT is a profession that can provide positive

sensory experiences through SI intervention, thus also making it a profession that has the potential to assist in mitigating the traumatic environment of the NICU.

Purpose

The purpose of this review is to assist occupational therapy practitioners in making evidence-based decisions for using sensory integration interventions to mitigate the traumatic environment of the NICU.

Summary of Key Findings

Overview of Level I, II & IV Studies

Of the 40 articles reviewed from PubMed, CINAHL, American Occupational Therapy Association (AOTA) & Google Scholar, five research studies were specifically chosen to be critically reviewed. These five studies met this review's inclusion criteria of premature infants in the NICU and the use of SI intervention and/or the NICU's environmental impact on brain development. These five studies included a level IB2c, randomized control trial design **(**Lecuona et al., 2017), a level IIA2c, quasi-experimental design (Pekçetin et al., 2016), and three level IVA2c studies, which included a prospective longitudinal design (Ryckman et al., 2017) a prospective longitudinal cohort design (Pineda et al., 2014) and a prospective observational cohort design (Smith et al., 2011).

Level I study. Lecuona et al. (2017) explored the effect of ASI intervention on premature infants in a NICU in Africa who were less than 12 months old, had a low birth weight and were from low socioeconomic status. The infants for the study were randomly selected based on age and gender but researchers did not further discuss if they were randomly assigned. The main inclusion criteria for this study was premature infants from low socioeconomic status. The

exclusion criteria for this study included infants that previously received sensory integration (SI) intervention and those with neurological abnormalities. This study was a pre-test, post-test experimental design in which the 24 premature infants were divided into an experimental and control group. The experimental group received 10 weekly 45 minute sessions of ASI intervention with recommendations provided to parents after each session. An OT who was experienced and trained in ASI conducted the ASI intervention as well as the Bayley III Scales of Infant and Toddler Development (BIII), the Test of Sensory Functions in Infants (TSFI) and the Infant/ Toddler Sensory Profile (ITSP) to determine development status (Lecuona et al., 2017).

Level II study. Pekçetin et al. (2016) explored the use of SI intervention to increase sensory functioning of premature infants. This study included an intervention group and a control group, both of which consisted of 34 preterm infants. The infants in the intervention group were assessed at a corrected age of seven months. The exclusion criteria for this study included "infants with major congenital anomalies, systemic diseases, neurological problems, physical or mental developmental delays," or those "with no caregiver signed informed consent" (Pekçetin et al., 2016, p. 414). SI intervention was conducted by a PhD OT student in a maternity hospital in Turkey. The preterm infants in the experimental group who were determined to be at risk or had predetermined sensory processing difficulties underwent individualized SI intervention. Frequency of SI intervention was one session per week, each session lasting 45 minutes, for a total of eight weeks. After these sessions, the TSFI was used by the PhD OT student to determine SI intervention outcomes. The PhD OT student was not blinded regarding which infants were born term and which were born preterm (Pekçetin et al., 2016).

Level IV studies. Ryckman et al. (2017) described the prevalence of SPD in children four to six years of age who were born premature, factors that contributed to SPD and evaluated for early signs of SPD in preterm infants. Preterm infants who were born less than or equal to 30 weeks gestation were enrolled within the first three days of life at the St. Louis Children's Hospital NICU. Half of the bed spaces were open ward and half were private rooms. Infants were excluded from the study if they had a "congenital anomaly" or were "not expected to live" (Ryckman et al., 2017, p. 19). Prior to NICU discharge, each infant completed the NICU Network Neurobehavioral Scale (NNNS) and at four to six years chronological age, participants completed four hours of motor, cognitive and language assessments, although these specific assessments were not named. Following these assessments, infants were assessed for SPD using the Sensory Processing Assessment for Young Children (SPA) by a trained research team member. The researchers mentioned that OT intervention occurred during the infant's NICU stay, but did not further discuss OT's role or the frequency of intervention. Of the 136 preterm infants that were initially enrolled in the study, 104 remained in the cohort through discharge, 84 received developmental testing at four to six years old while 26 infants "received both sensory testing at age 4-6 and neurobehavioral testing at term equivalent age" (Ryckman et al., 2017, p. 20).

Pineda et al. (2014) compared NICU room type to structural brain changes and developmental outcomes in two-year olds who were born less than 30 weeks gestation. For this study, 136 preterm infants were recruited within the first three days of life from a NICU in the midwestern United States. The NICU contained "39 open ward beds and 36 private rooms" and bedspace assignment was determined by a blinded charge nurse (Pineda et al., 2014,

p. 53). Infants remained in these locations throughout their hospitalization and were excluded if they had a congenital anomaly. Assessment measures the researchers used during the study included the Premie Neuro test, the NNNS, Dubowitz Neurological Exam, the Neonatal Oral Motor Assessment Scale, the McMaster Family Assessment Device (FAD), the Modified Checklist for Autism in Toddlers (M-CHAT) and the Infant Toddler Social Emotional Assessment (ITSEA) and the BIII. Specific brain measures were also taken throughout the course of the study, including an amplitude integrated electroencephalography (aEEG), magnetic resonance imaging (MRI), brain metrics, functional magnetic resonance imaging (fMRI) and surface-based morphometry. At the two-year developmental testing follow up, 86 infants participated, including 47% from the open ward environment and 53% from the private room environment (Pineda et al., 2014).

Smith et al. (2011) explored the impact of preterm infants' exposure to stress using an MRI and two neurobehavioral evaluations at term equivalent age. Of the 65 preterm infants who were initially eligible for the study, 55 preterm infants were recruited within one day of birth. Infants were excluded from the study if they were greater than 30 weeks gestation or were determined to be terminally ill. The NNNS and the Dubowitz exam were the neurobehavioral tests that were performed on the infants, whereas the Neonatal Infant Stressor Scale (NISS) was used to measure infant stress. Nurses were trained to record specific stressors of the infant from enrollment in the study until the infant reached term equivalent postmenstrual age (PMA) or was discharged. At 36-44 weeks PMA, brain metrics as well as "MRI brain scans were performed" (Smith et al., 2011, p. 542). The NISS, NNNS and MRI results were compared to examine correlations (Smith et al., 2011).

Analysis of Study Results

Two research studies used SI intervention with preterm infants to evaluate for developmental outcomes (Lecuona et al., 2017; Pekçetin et al., 2016). Pekçetin et al. (2016) specifically evaluated sensory processing outcomes of SI intervention while Ryckman et al. (2017) described early neurobehavioral indicators of infant development of SPD later in childhood. Two other research studies also evaluated early neurobehavior in combination with brain development and the NICU environment's impact on this development (Pineda et al., 2014; Smith et al., 2011). Two studies specifically mentioned NICU environment room type as a significant factor in development (Pineda et al., 2014; Ryckman et al., 2017). All five studies were conducted over time, ranging from eight weeks (Pekçetin et al., 2016) to six years (Ryckman et al., 2017).

Differences were noted between the experimental group and the control group following 10 weeks of ASI intervention (Lecuona et al., 2017) and eight weeks of SI intervention (Pekçetin et al., 2016). Infants in the experimental group who received ASI intervention were more likely to employ self-soothing strategies, including finger and dummy sucking or using a soft taglet (Lecuona et al., 2017). It was concluded through the research that stressors in the NICU may be mitigated using ASI intervention, which encouraged infants to employ self-soothing methods to help them better integrate NICU sensory information (Lecuona et al., 2017). In addition, the data from the ITSP found that the experimental group and control group both showed increased awareness of their environment and became more "sensory seeking" (Lecuona et al., 2017, p. 980). The experimental group specifically demonstrated improvements in "registration, sensory sensitivity, sensory avoiding [as well as] threshold behaviours" (Lecuona et al., 2017, p. 980).

The experimental group also demonstrated improvements in motor function, cognition, communication and socioemotional development (Lecuona et al., 2017). It was demonstrated that ASI intervention had a positive influence on the experimental group's development (Lecuona et al., 2017), thus allowing this group to more purposefully and meaningfully respond to their sensory experiences (Lecuona et al., 2017). Both Lecuona et al. (2017) and Pekçetin et al. (2016) used the TSFI as a baseline measure and as a post-intervention measure of sensory processing skills to determine the effectiveness of ASI and SI intervention. In addition, the TSFI and ASI or SI intervention were completed by an OT, which demonstrates the specific role OT has related to assessment of and intervention with preterm infants (Lecuona et al., 2017; Pekçetin et al., 2016).

Individualized ASI intervention has been determined to be effective in improving sensory processing and mitigating development of SPD in premature infants (Pekçetin et al., 2016). It has been recognized that prematurity increases the risk of developing SPD (Pekçetin et al., 2016; Ryckman et al., 2017). Ryckman et al. (2017) posited that there were early signs of SPD that were detectable in premature infants. According to the NNNS, these early signs of SPD included "signs of stress" and "suboptimal reflexes" (Ryckman et al., 2017, p.18). Smith et al. (2011) also used the NNNS and found that preterm infants exposed to excessive stress displayed increased nonoptimal reflexes and abnormal patterns of movement. One study specifically explored the prevalence of SPD in infants born less than or equal to 30 weeks gestation and found that half of the infants demonstrated SPD (Ryckman et al., 2017). If these signs of stress, reflexes (Ryckman et al., 2017; Smith et al., 2011) and patterns of movement (Smith et al., 2011) are recognized early, SI intervention may be effective in mitigating infant development of SPD (Pekçetin et al.,

2016). Therapy interventions targeted to address sensory processing difficulties are most beneficial when addressed in early stages of development (Pekçetin et al., 2016; Ryckman et al., 2017).

Unlike the previous articles, Pineda et al. (2014) used the NNNS to compare open ward NICU environments to private rooms. Pineda et al. (2014) first found that preterm infants in the private room had higher arousal levels (i.e. irritability and motor movement) in comparison to those in the open ward. In addition, through evaluation of aEEG scores at two weeks, 20 weeks, 34 weeks and term equivalency, it was found that preterm infants in private rooms also demonstrated "a trend toward lower cerebral maturation" (Pineda et al., 2014, p. 56). Smith et al. (2011) found that stress impacted asymmetry of the frontal and parietal lobes and found a correlation between stress and decreased brain matter connectivity in the temporal lobe. Similarly, Pineda et al. (2014) also found a relationship between the private room environment and asymmetry in the temporal lobe, a region known for language function. Therefore, both the private NICU room environment and stressful exposures may impact temporal lobe development (Pineda et al., 2014; Smith et al., 2011). This increased stress (Smith et al., 2011) may be mitigated through use of ASI intervention to encourage employment of self-soothing methods (Lecuona et al., 2017), especially for those preterm infants in the private NICU room environment (Pineda et al., 2014). Pineda et al. (2014) also found that preterm infants in private room environments were more likely to be hyperactive and aggressive. Further it was found that infants in private rooms had overall lower language scores and decreasing motor scores during follow up at age two (Pineda et al., 2014). ASI intervention has been previously shown to increase motor abilities (Lecuona et al., 2017), which is another reason why it may be an appropriate early intervention for preterm infants.

In critically evaluating threats to internal validity, it was significantly noted that all five studies were limited due to maturation, which is a normal component given the population of preterm infants in the NICU environment (Lecuona et al., 2017; Pekçetin et al., 2016; Pineda et al., 2014; Ryckman et al., 2017; Smith et al., 2011). Additionally, four of the five research studies evaluated had limited external validity due to the subjects' accessibility to the study, as these studies were each conducted fully within one hospital setting (Lecuona et al., 2017; Pekçetin et al., 2016; Pineda et al., 2014; Ryckman et al., 2017). External treatment interactions were also a possible limitation for four of the five articles, such as additional NICU OT services, potential lack of parent follow through in intervention treatment plans, severe illness and the potential that additional services could have been provided between NICU discharge and follow up assessment, all of which may have impacted individual study outcomes (Lecuona et al., 2017; Pineda et al., 2014; Ryckman et al., 2017; Smith et al., 2011). Operational definitions could have been enhanced in three of the five articles to improve external validity (Lecuona et al., 2017; Ryckman et al., 2017; Smith et al., 2011). One study was limited due to an employment of a contrived environment as opposed to a natural setting (Pekçetin et al., 2016), while an additional study was limited due to excessive testing within a short period of time (Ryckman et al., 2017), both of which implied a possible realism effect. Last, one study was externally limited due to the possibility of a Rosenthal effect, as the examiner was not blinded to groups while administering the SI intervention (Pekçetin et al., 2016).

Overall, Lecuona et al. (2017) and Pekçetin et al. (2016) stated the importance of early sensory integration intervention for preterm infants. Further research is needed to explore NICU environmental stress (Smith et al., 2011) and the "optimal NICU environment" (Pineda et al.,

2014, p. 59) in order to better help preterm infants appropriately "respond to their environments and participate in occupations later in life" (Ryckman et al., 2017, p. 20).

Clinical Bottom Line

Through research, it has been determined that ASI or SI interventions are effective in helping infants appropriately respond to sensory stimuli. There is also strong evidence that preterm infants in the NICU experience significant amounts of stress, which impacts brain development and increases the likelihood of development of SPD. It has been shown through research that there is a correlation between NICU room type, stressful exposures and their impacts on motor and language development in preterm infants. When identified early, sensory integration can be used to reduce the impact of these external factors. What is still inconclusive is the effect of ASI or SI interventions in mitigating the traumatic environment itself without taking into consideration the individual preterm infant. There is insufficient evidence not only related to use of ASI or SI interventions with preterm infants in the NICU, but there is also a lack of higher-level evidence linking NICU environmental stressors to developmental outcomes. There have been no previous research studies that have evaluated the relationship between ASI or SI interventions, the traumatic environment of the NICU and infant developmental outcomes. In addition to the lack of evidence, this review has been written under the assumption that all NICU environments are traumatic and that SI intervention is an appropriate and feasible tool to use in the NICU setting. This is an emerging area of research in which ASI and SI intervention continues to require additional validation to determine effectiveness in practice. Another important consideration is that some cultures may view the sensory environment and the importance of sensory intervention differently. OTs must take these biases and lack of evidence

into consideration when choosing to use these interventions in practice, especially with preterm infants.

OTs may focus on using SI intervention to help promote sensory development of premature infants and should consider the impact of the NICU environment on this development when intervening. One cannot separate the infant from their environment, thus making SI an important consideration for intervention in the NICU setting. OTs interested in implementing SI intervention in their NICU practice should first pursue SI certification. In addition, OTs should continue to critically examine current research and evolving SI literature in order to stay up to date with current SI intervention practices. Further research should be explored to examine the NICU sensory environment and the impact it has on preterm infant development. In addition to having a solid understanding of infant development, it is also critical for OTs to be able to specifically identify infant stress and abnormal reflexes in order to intervene at the most appropriate time. The NICU interdisciplinary team plays a significant role in the care of infants. Not only are OTs capable of being certified in SI interventions, OTs are also specialized in understanding infant development. This makes OTs a critical asset to the NICU team in order to help identify early signs of sensory processing difficulties. OTs can intervene at the most critical time in an infant's development to help the infant positively integrate their sensory environment. At the same time, OTs are able to recognize how the environment supports or inhibits development, in order to find the most optimal fit between the preterm infant and the NICU environment.

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