Collaboration to Improve Neuroprotection and Neuropromotion in the NICU: Team Education and Family Engagement

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Abstract

The number of babies born extremely low birth weight surviving to be discharged home after experiencing the NICU continues to improve. Unfortunately, early sensory development for these babies occurs in an environment vastly different from the intended in-utero environment and places them at high risk of long-term neurodevelopmental and neurocognitive challenges. Our goal in the NICU must transition from simply discharge home to supporting the neurosensory development necessary for a thriving lifetime. To accomplish a goal of thriving families and thriving babies, it is clear the NICU interprofessional team must share an understanding of neurosensory development, the neuroprotective strategies safeguarding development, the neuropromotive strategies supporting intended maturational development, and the essential nature of family integration in these processes. We share the educational endeavors of 11 center collaboratives in establishing the foundational knowledge necessary to support preterm babies and their families.

Keywords: neuroprotection; neuropromotion; family-centered; quality improvement; team

While NICUs have seen great technological and medical advances over the past several decades, allowing survival at lower gestational ages, neurodevelopmental outcomes have not improved.[1] Developmental challenges, which may continue even into adulthood, remain prevalent for extremely premature infants.[2–4] The delicate balance of appropriate timing, intensity, amount, and frequency of sensory exposure to protect the brain while promoting development has been increasingly reviewed,[5] but little is published about standards for implementation in the NICU.[6,7] Current evidence emphasizes the vital role parents have in improving neurodevelopmental outcomes,[8–12] therefore, NICU care standards should include parent integration as a key element to help infants survive and thrive.

In this initial paper, we describe staff education regarding neuroprotection and

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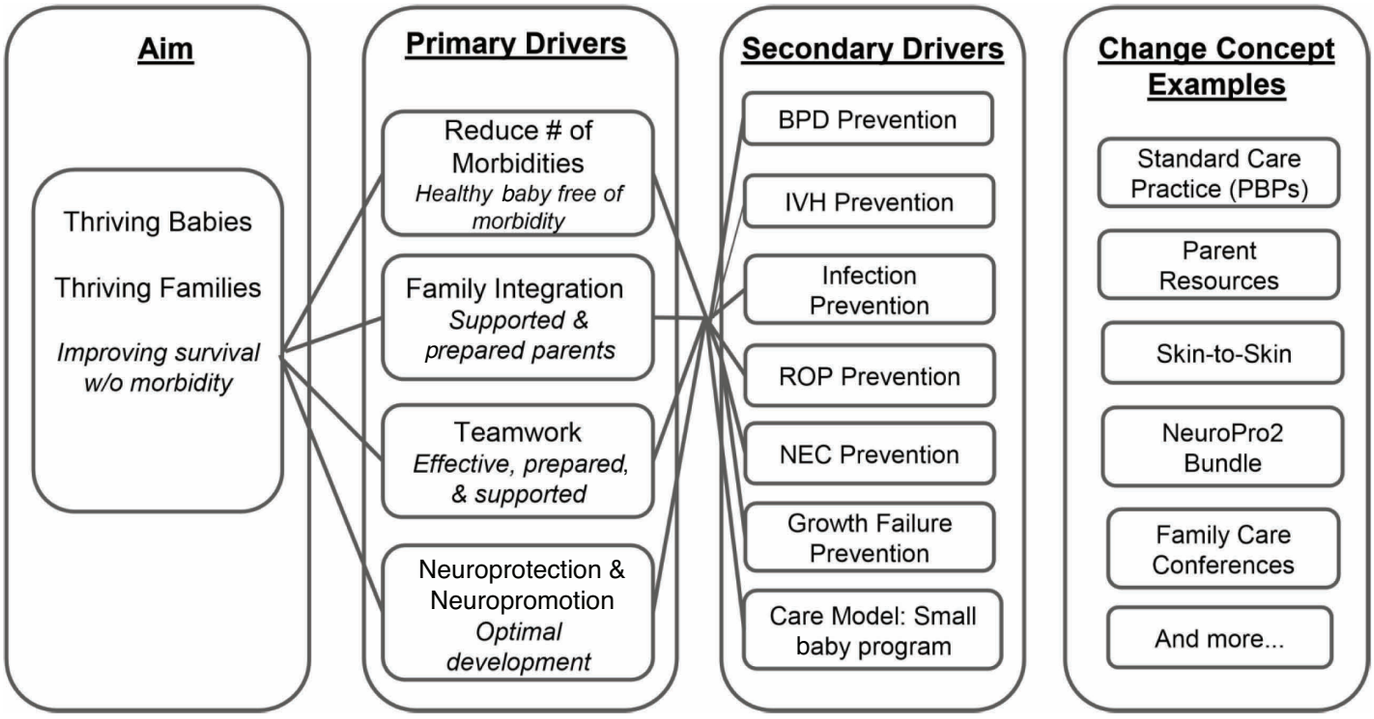
FIGURE 1 ■ Driver diagram.



Abbreviations: BPD = bronchopulmonary dysplasia; IVH = intraventricular hemorrhage; ROP = retinopathy of prematurity; NEC = necrotizing enterocolitis; PBPs = potentially better practices.

neuropromotion as well as family integration in these practices. This education was disseminated within the Micropremature POD, a Vermont Oxford Network (VON) collaborative group of NICUs. A second manuscript, entitled *Collaboration to Improve Neuroprotection and Neuropromotion in the NICU: A Quality Improvement Initiative*, will further describe the improvement work within this POD. In these papers, neuroprotection refers to safeguarding the brain as it develops and neuropromotion refers to encouraging typical brain development in the extrauterine environment.

QUALITY IMPROVEMENT COLLABORATIVE

The Vermont Oxford Network VON is a nonprofit, worldwide collaborative of more than 1,300 hospitals dedicated to improving the quality, safety, and value of neonatal care through small-group collaboration. The VON Micropremature POD's 11 teams of NICU professionals and parents from the United States and Canada have shown a proven ability to achieve better outcomes through collaborative quality improvement efforts via the sharing and comparing of specific care practices and subsequent outcomes.[13]

To meet the challenge of supporting families, promoting neurodevelopment, and protecting the brains of extremely premature infants, the POD made thriving babies and thriving families the goal of their 2018–2019 collaborative (Figure 1). This work was spearheaded by an interprofessional work group of center members, including 2 VON faculty members (an NNP/CNS and a mother of former NICU infants) and 5 certified neonatal therapists (3 physical therapists and 2 occupational therapists). Neonatal therapists were chosen to lead these efforts based on their expertise in neurodevelopment, role in supporting developmental care, and provision of parent and staff education in their respective NICUs.[14,15]

MICROPREMATURE POD EDUCATION

The work group desired to provide all NICUs in the POD with the same level of knowledge regarding neuroprotection, neuropromotion, and family involvement in order to coordinate quality improvement efforts. A preeducation survey was distributed to establish baseline developmental care practices in each unit and to inform the education provided by the work group. Education was initiated at an in-person POD meeting held at the VON Quality Congress in October 2018 and continued throughout 2019 via 6 online webinars, which were recorded and made available to all staff from each of the NICUs via the VON Learning Management System. The education concluded one year later at the 2019 VON Quality Congress. Family participants from each of the member NICUs were included in all these educational sessions, and specific strategies for family involvement were described within each webinar. This collaborative approach to learning has been shown to improve team effectiveness and outcomes.[16,17]

The initial presentation at the 2018 VON Quality Congress introduced sensory development along with initial neuroprotective and neuropromotive care activities that could be provided by staff and parents. The remainder of the webinars, summarized below, provided information on the development of each sensory system, in order of gestational maturation (Figure 2), as well as evidence-based neuroprotective and neuropromotive strategies for each system. A bedside tool (Table 1) was also provided to encourage consistent implementation of recommended strategies by families and health care providers. Each webinar started with a family story, similar to the one presented here, to highlight parent participation and leadership in developmental care practices.

FAMILY STORY

When Ginny became pregnant after struggling with fertility, all she wanted was to be a stay-at-home mom. After delivering 23-week twins via emergency cesarean section, their lives changed more than she and her husband ever could have imagined. So started their journey into the world of the NICU, where they quickly learned about so many things they never knew existed. Most of all, they learned how to just sit and stare at 2 tiny, fragile human beings whom they loved with all their hearts.

Ginny and her husband, Justin, found their NICU course to be excruciating. They watched their twins go through intubations, surgeries, skin concerns, and brain bleeds. After they made the agonizing decision to remove life support from their son, who was incapable of recovering from necrotizing enterocolitis, they were unable to pause and grieve as they had to continue to be present for their daughter. Ventilated just over 6 weeks, she would spend 99 days in the NICU, undergo heart and eye surgeries, experience difficulties with growth, and go home on oxygen. Discharge was an equally joyous and terrifying day as their hearts were full of love and hope for their tiny, 4-pound, little girl.

Their journey with prematurity continued as they aggressively engaged in follow-up therapy for their daughter from 6 months until age 3, at which time they were told she was "completely caught up." They were then shocked to find their daughter diagnosed with autism just before her 12th birthday. Continuing an already long journey of testing came a new list of diagnoses, including brain dysfunction, severe anxiety disorder, dysgraphia, autism spectrum disorder, ADHD comorbid with developmental delay, social emotional disorder, depression, sound and sensory sensitivities, post-traumatic stress disorder, and specific developmental disorder of motor functioning. The daily challenges for Ginny and her family with these disorders, as well as their daughter's diabetes, have turned out to be even more difficult than the early diagnoses of retinopathy of prematurity (ROP) and bronchopulmonary dysplasia (BPD) and those days in the NICU.

When Ginny had the opportunity to participate in quality improvement work for micropremature infants as a parent advisor for the NICU in which her children had been patients, she was excited to support improvements to ease the trauma for future babies and parents. This unexpected career opportunity has added much value and satisfaction to her life and allowed her to give back to the community that helped her become a mother.

PAIN AND STRESS

The impact of pain and stress on preterm neurodevelopment and interventions to mitigate these effects were the topic of the first educational session. While historically it was thought preterm infants did not experience pain, more recent evidence demonstrates preterm infants experience pain more intensely and for longer duration than term infants because ascending nerve fibers develop prior to inhibitory descending nerve fibers.[18–21] One study reported an average of 23 acute painful or stressful procedures per day in the first week for infants in the NICU.[21] Although the frequency of such procedures decreases over the length of NICU stay, pain experienced earlier in gestation is more impactful on neurodevelopment.[22] The brain of the preterm infant is particularly vulnerable to change in response to this experience as it is undergoing rapid development;[23] therefore, pain not only causes acute changes in the infant's physiologic stability, it also causes changes to brain structure, including decreased size, cortical thickness, and white matter.[22,24–27] Repeated painful experiences can also alter the response of the neuroendocrine system and compromise long-term development.[21,25,28,29]

In recognition of the impact of early pain experiences, there has been a call for standardized approaches to reduce and address pain for the preterm infant.[30,31] Efforts to decrease pain exposure by minimizing skin-breaking procedures are essential.[32–34] When painful procedures are necessary, recommended nonpharmacologic supports including sucking, facilitated tucking, and provision of breast milk should be encouraged.[26,35–37]

Preterm infants also benefit from attention to stressful experiences. Stress experienced by neonates includes environmental differences from the womb and separation from parents.[38,39] While not often appreciated as painful, the stress involved with daily care can have a negative impact on the immature autonomic system as the preterm infant is unable to self-regulate, causing change in the stress response long term.[40–42] Consequently, the immature brain experiences cumulative changes in response to stress and pain which affect long-term development.[25]

To minimize neonatal stress experiences and optimize development, it is important to provide predictable, cue-based care,[43,44] including environmental modification and pain management,[45] and to minimize changes made in a given period of time as well as stress over time.[25,42] Parent presence increases the effectiveness of pain control strategies and buffers the stress response, making parents a powerful component of any pain and stress management strategy.[39,46–48]

FIGURE 2 ■ Sensory system development.

<table>
<tr><th>Gestational Age in weeks</th><th>12</th><th>14</th><th>16</th><th>18</th><th>20</th><th>22</th><th>24</th><th>26</th><th>28</th><th>30</th><th>32</th><th>34</th><th>36</th><th>38</th><th>40+</th></tr>
<tr><td>Touch</td><td>nerve endings in place & functional</td><td colspan="6"></td><td>primitive tactile reflexes present</td><td></td><td>skin developed & ready for massage</td><td colspan="3"></td></tr>
<tr><td>Proprioception & Kinesthesia</td><td colspan="5"></td><td>vestibular system functional</td><td></td><td colspan="8" rowspan="2">systems mature & functional</td></tr>
<tr><td>Taste & Smell</td><td colspan="3"></td><td>smell functional</td><td colspan="2"></td><td>taste buds functional</td><td></td><td>recognition of familiar scents</td><td colspan="6">systems mature & functional</td></tr>
<tr><td>Vision</td><td colspan="2"></td><td>neuronal connections forming</td><td colspan="3"></td><td></td><td>visual ganglion cells begin to fire</td><td colspan="2">initiation of cycled lighting</td><td>ganglion firing more coordinated with brain centers</td><td></td><td colspan="2">ready for typical newborn visual experiences</td></tr>
<tr><td>Hearing</td><td colspan="2"></td><td>cochlea formed</td><td colspan="2"></td><td>synchronous firing of ganglion cells</td><td></td><td colspan="7">auditory system functional,
tuning of hair cells begins and continues past term age</td><td>feedback loop mature</td></tr>
<tr><td>Sleep</td><td colspan="4"></td><td colspan="4">indeterminate & irregular sleep patterns</td><td colspan="3">REM & non-REM maturing, increased quiet periods</td><td colspan="2">continuous sleep/wake cycles maturing</td><td>equal REM & non-REM</td></tr>
</table>

TABLE 1 ■ Bedside Tool

Sense	Neuroprotection	Neuropromotion
Touch	Avoid	Provide
	Adhesive contact	**Positive touch**
	Medical equipment touching skin	**Hand swaddling, "hand hugs"**
	Pulling on skin from leads & lines	**Skin-to-skin holding**
	Painful procedures	**Neonatal massage (after 32 weeks' gestation)**
	Shear/friction on skin	**Nonnutritive sucking (NNS) *in response to root***
	Loose items in bed/creases in linens	**Position with flexion, containment, alignment, comfort**
	Provide	**2-person caregiving**
	Gentle removal of adhesives	
	Gently pat skin to clean vs. rubbing	
	Swaddling	
Movement and Body Awareness	Avoid	Provide
	Quick turning/movement of infant	**Talk before touch, touch before moving**
	Neck extension to prevent startle response	**Slow movement in different planes**
	Restraint (contain don't restrain)	**Side-lying or prone for all transfers and movement**
	Flailing extremities or malalignment	**Contain head and limbs in alignment**
	Abnormal movement patterns	**2-person caregiving**
	Traction on limbs—support weight of leads and lines	**Spontaneous movement within a small space**
		Skin-to-skin holding with wrap
		Neonatal massage
		Tummy time
		Facilitated tucking
Sleep	Avoid	Provide
	Sleep interruption	Cluster cares
		Skin-to-skin
Taste and Smell	Avoid	Provide
	Negative experiences (suctioning)	**Drops of breast milk as early and consistently as possible**
	Noxious tastes and smells	**Pacifier & drops in response to rooting**
	Maintain scent-free environment	**Scent cloths**
	Open wipes away from infant and do not leave in bed	**Skin-to-skin for exposure to parent's scent**
	Wait for hands to dry after sanitizing	
	Provide	
	Scent-free environment	
Hearing	Avoid	Provide
	Setting items on top of incubator	**Talk, read, or sing quietly to infant (<45 db), per infant cues**
	Sudden changes to the auditory environment	**Support REM sleep with skin-to-skin** and clustered cue-based care
	Provide	
	Background noise <45 dB, 1 second maximum <70 dB	
	Quiet voices	
	Silence alarms (consider adjusting alarm levels)	
Vision	Avoid	Provide
	Bright or direct light	**Support REM sleep with skin-to-skin** and clustered cue-based care
	Provide	
	Lights off/low and keep cover over bed or over eyes to avoid bright lights (< 10 lux)	Cycled lighting starting at 28–32 weeks ~200 lux during day, <10 lux during night
	Cover eyes during cares and procedures	**Offer visual experiences >37 weeks, per cues**
Stress/Pain Management	Avoid	Provide
	Too many changes in one day	**Predictable (routine) cares with 2 people**
	Provide	**Holistic sensory support**
	Breast milk with pacifier or nuzzling at breast for pain management	**Responsiveness to infant cues**
	Nonnutritive sucking and facilitated tucking	

Note. Items in bold can be done by parents.

TOUCH AND MOVEMENT

Touch and the movement senses, vestibular, proprioception, and kinesthesia, are the first of the fetal sensory systems to develop, and therefore were the topic of the first webinar. Touch is critical for human attachment, formation of family bonds, cognition, communication, and emotional regulation throughout infancy and life.[49–51] Affective touch, also known as social touch, allows unmyelinated, peripheral afferent C-Touch (CT) fibers to serve as a bridge between external stimulation and internal perception, thereby associating an emotional response to touch experiences.[51] These CT fibers respond preferentially to gentle, slow stroking at a temperature near human skin, which helps explain why massage or skin-to-skin holding can cause oxytocin release and increase attachment.[51–54]

While protection from unnecessary medical touch is warranted for extremely premature infants because of their vulnerable skin and physiologic response to touch, infants who are deprived of social touch demonstrate increased sensory processing problems and increased avoidance of social touch, which is a predictor of autism spectrum disorder.[55–57] In the NICU, 95 percent of touch is not intentionally comforting;[58] therefore, provision of positive, social, human touch in the NICU should be prioritized by health care professionals and parents. Literature supports shorter length of stay, improved weight gain, and improved neurodevelopment for infants, along with decreased stress, anxiety, and depression for parents when massage and skin-to-skin holding are provided.[59,60]

The vestibular system is developed and functional by the age of viability and is tied to equilibrium, spatial awareness, and movement and interacts continuously with the visual, proprioceptive, and tactile senses.[51] An infant's responses to rocking, swaying, and bouncing are thought to be from early tactile and vestibular movement in utero,[51] which preterm infants tend not to experience, leading to exaggerated responses to movement in this population. Caregivers, including parents, should therefore provide infants with slow, supported, contained, and gentle movements to diminish negative tactile and vestibular responses during routine care and handling.

Kinesthesia, referred to as muscle memory, is awareness of where the body is in space, and includes receptor neurons located in joints, muscles, and tendons.[61] Proprioception is related to awareness of movement; receptors include muscle spindles and skin-stretch receptors.[61] Neuroimaging indicates the cerebellum and parietal cortex are both involved in movement based on past experiences as well as a forward model of comparison, which is the idea that the baby's experiences can inform their future movements.[62]

Positioning and handling techniques, including flexion, containment, alignment, and comfort, can affect tactile, vestibular, proprioceptive, and kinesthetic input.[63] Staff and parents in the NICU must be skilled with proper handling techniques to minimize system-wide stress and reduce iatrogenic positioning deformities.[63] Two-person caregiving, with attention to flexion, containment, alignment, and comfort, supports an infant's integration of sensory information during care times and has been shown to decrease stress and result in quicker return to physiologic baseline with medical procedures.[64]

TASTE AND SMELL

The next topic presented was chemosensory (smell and taste) development, which operates as a single sensory system in utero.[65,66] Though taste and smell begin to develop later than touch, they become the first fully functioning sensory systems in the fetus.[65,66] At 8 weeks' gestation, chemoreceptors for taste and smell begin to form, with taste buds developing at the end of the first trimester, and smell and taste are functional at 17 and 24 weeks, respectively. By 28 weeks, neonates can recognize familiar scents such as breast milk, which is akin to the taste of amniotic fluid.[65,66]

The long-term effects of noxious taste and smell exposures in the preterm period are not well understood, but likely have adverse effects on feeding skills and contribute to aversive behaviors. In caring for preterm infants, exposure to noxious scents such as alcohol in hand sanitizers or chemicals in cleaning wipes should be minimized by allowing their scents to dissipate outside of the incubator or away from the bed space.[67]

Olfactory centers in the brain are closely aligned with the limbic system and amygdala, which explains why aromas are tied to emotion and memory.[68] Exposure to the smell of breast milk has been shown to increase breastfeeding and decrease crying among preterm infants,[69–74] and early oral administration of breast milk has been linked to earlier achievement of oral feeding and improved immunity.[74–76] The use of cloths or dolls which have absorbed maternal scent has been shown to support bonding, prefeeding behaviors, and physiologic stability.[69,77–79] Oral provision of breast milk via syringe or cotton swab has been shown to decrease pain and support acquisition of nonnutritive sucking leading to breastfeeding.[26,80] These interventions should be incorporated into NICU care and are an opportunity for parents to directly support their preterm infant.

HEARING AND VISION

The auditory system starts to develop with cochlea formation as early as 15 weeks.[81] Neural connections develop through endogenous, spontaneous stimulation. The endogenous, irregular firing of ganglion cells transitions to synchronous firing around 22 weeks, which is important to promote axonal growth connecting the inner hairs cells of the ear to the brainstem, midbrain, and temporal lobe.[81] The auditory system becomes functional between 25 and 29 weeks, and the connections from the inner ear to centers in the brain allow for reception, recognition, and reaction to meaningful and harmful environmental sounds.[81,82] Therefore, it is common to see physiologic changes such as

heart rate variability and desaturations when sound levels in the preterm infant's bed space are increased.[82] Additionally, the auditory feedback loop is not functional until closer to term, which makes modulation of auditory signals difficult for preterm infants.[81,82]

Another component of auditory development includes tuning of the inner hair cells which begins as early as 28 weeks and continues post term.[81] In utero, the auditory experience is limited to lower frequency sounds and protected from higher frequency and intense extrauterine sounds which allows for finer, more precise tuning between adjacent hair cells.[81,82]

Protection of the developing auditory system in the NICU requires adhering to recommended maximum background noise levels of 45 dB.[83] In the absence of unit redesign, practical means to achieve this include: silencing alarms, paying close attention to caregiver contributions to noise levels, avoiding abrupt changes to the auditory environment, and limiting short-duration loud noises to a 1-second maximum of 70 dB.[83] Inner hair cells lose their sensitivity to pitch when background sound levels are intense and exceed 60 dB, and the greater the intensity of the auditory signal, the less sensitivity there is for tuning.[81]

While excessive sound levels in NICUs can cause issues with auditory development,[84] the absence of human sound can impair auditory and motor development.[82] From roughly 28 weeks to term-equivalency, the auditory system requires intentional stimulation.[81,82] Many sensory connections take place during REM sleep, so promotion of auditory development includes prioritizing sleep by clustering care tasks, supporting positive sleep experiences, and encouraging skin-to-skin holding. When the infant is awake or in a quiet sleep followed by REM sleep, it is important to talk, read, or quietly sing to the infant based on their cues.[81,82] Ensuring background noise levels are less than 45dB, without loud spikes, allows infants to better discriminate meaningful interactions and supports optimal tuning of hair cells.[82,83] Encouraging parent vocalizations with their infant is essential to establishing infant–parent attachment.

The visual system is the last sense to develop during fetal life. Neuronal connections between ganglion cells and visual nuclei are formed as early as 15 weeks, but endogenous stimulation of the ganglion cells primarily takes place in the last 12–14 weeks of fetal life and extends into the first months after term birth.[85] As sleep cycles mature, the firing of the ganglion cells is more coordinated with spontaneous waves from the pons and hippocampus.[85] When infants are born preterm, their visual systems are exposed to stimuli not intended to be experienced until term. Animal studies reveal that earlier than normal visual input may modify the developing auditory system,[86] which emphasizes the need for protection of the visual system. It is recommended that low light levels be maintained for younger gestational ages,[85] and it is important to be aware that even small changes in light levels can wake preterm infants.[87] An incubator cover can be used to block light from the environment and the eyes of preterm infants should be shielded when direct lighting is needed for caregiving or assessment.[85]

Endogenous activity in the developing visual system takes place mainly during REM sleep, so it is critical sleep is protected to promote optimal visual development.[85] As infants mature, it is appropriate to offer cycled lighting within recommended levels (200 lux during day, <10 lux at night) to assist with entrainment of 24-hour circadian rhythm.[88] The recommended age for initiation of cycled lighting ranges from 28 to 36 weeks' gestation and should be based on infant cues and maturation, not solely on postmenstrual age.[89] With cycled lighting, the infant's responses should be monitored and lighting levels adjusted based on the infant's behavior.[85,89] Once the infant is >37 weeks, typical infant visual experiences can be offered based on the infant's tolerance, but direct lighting should still be avoided to minimize stress to the developing visual system.[85]

SLEEP

Sleep was the next educational topic because of its importance in neuroprotection and neuropromotion. Sleep is an endogenous process heavily influenced by external factors in the neonatal environment. Identified stages or states include awake (drowsy, active, quiet), rapid eye movement (REM) sleep, and non-REM sleep (drowsy, light, deep/quiet).[90,91] Neonatal sleep cycles generally last 30–70 minutes.[91] Between 20 and 28 weeks' gestation, sleep cycles are indeterminate, irregular, and lack meaningful patterns or cycling. Preterm infants at these ages may rapidly shift between various alert and sleep stages, but by 30 weeks' gestation, REM and non-REM stages start to mature, with increased quiet periods.[90] Continuous sleep/wake cycles are seen by 36–38 weeks' gestation. While the majority of the preterm infant's sleep cycle is in REM stage, term age infants spend equal time in REM and non-REM sleep, with increased periods of alertness and social engagement beyond feeding times.

Critical neuronal growth, connectivity, and pruning happen during the last trimester, but only during REM sleep. Systems requiring REM sleep for development include the somatosensory, proprioceptive, chemosensory, visual, auditory, limbic, social learning, and memory. The functional implications of this are seen in preterm infants who scored lower in cognition, social-emotional competence, language, and motor development at age 2 than peers born at term.[92]

Sleep behaviors are predictive of attention orientation skills, distractibility, and self-regulation in later childhood and adolescence.[93,94] Adult studies and surveys have explored the relationship between sleep, attachment, and the interplay of maladaptive sleep behaviors with genetics, environment, and timing on mood disorders.[95,96]

Sleep is an essential aspect of the growth and well-being of the neonate, and there are many ways for NICUs to both

protect and promote sleep. Protection measures include maintaining low sound levels (soft voices, decreasing alarm volumes, keeping items off incubator), minimizing noxious smells, and positioning infants to be flexed, aligned, and contained for comfort. Nutrition and digestive comfort can be optimized to reduce reflux or stooling concerns which may disrupt sleep. Supportive measures to promote neonatal sleep include clustering cares and assessments, encouraging skin-to-skin holding, providing cycled lighting, and training caregivers, including parents, to recognize infant cues and behaviors.

THRIVING BABIES AND FAMILIES

The final webinar presentation examined the overarching aim of thriving babies and thriving families and included a review of each of the sensory systems and developmentally supportive practices with an emphasis in parent provision of these practices. Evidence reinforces parent engagement is needed for babies to thrive and to improve neonatal brain structure and function.[8,97] Simply being present in the NICU and holding more frequently and for longer duration improve long-term developmental outcomes,[82,98] as do programs which combine nurturing interventions and interaction between parents and their infant.[11,99] Parental responsiveness seems especially crucial to optimizing development,[9,12] and researchers have investigated the mechanisms in parent-infant interaction as well as how improved maternal care mitigates the adverse effects of pain and stress.[100] This webinar focused on parent caregiving, responsiveness, and nurturing engagement while recognizing potential stress and trauma of the NICU environment for both infants and parents.

SENSORY INTEGRATION

The coordination of the sensory systems within the preterm infant is also affected as their early development occurs in the NICU rather than in utero, allowing sensory exposure which premature infants are not yet able to integrate.[101] Exposure to intense sensory and nocioceptive stimuli in the NICU during a critical period of brain development can interfere with motor, neurologic, and sensory processing.[22,102–106] Sensory processing disorder, also known as sensory integration dysfunction, involves difficulties interpreting and using sensory information from the environment for regulation, movement, and social interaction.[107–110] Approximately 39–52 percent of preterm infants have symptoms of sensory integration dysfunction, as compared with 5–17 percent of the general population, with those born prior to 32 weeks having the greatest risk.[111–113]

Regardless of how sensory processing disorder manifests, it can negatively impact the child's participation in everyday activities, making simple routine activities much more complex and impacting family dynamics.[114] There is essential need for appropriately timed and graded sensory exposure for premature infants in order to support them in the NICU and throughout their life span. The bedside tool (Table 1) was developed to ease implementation of these practices and make them accessible to parents and staff. The adaptation of the NICU sensory environment by health care providers, and the education of parents to do likewise, is foundational for neuroprotective and neuropromotive care and has the potential to improve long-term outcomes for these fragile, rapidly developing infants.

PARENT FEEDBACK AND FUTURE OPPORTUNITY

An in-person presentation in conjunction with the 2019 VON Quality Congress rounded out the year of education by allowing increased input from POD family members and discussion regarding use of the bedside tool (Table 1). Parents were asked to share their NICU experiences about neuroprotective and neuropromotive strategies, and opportunities for improvement in each participating NICU were identified. The Micropremature POD teams have embraced a culture of recognizing families as active partners in NICU quality improvement.[115] The parent handbook developed by Pineda et al. in 2017 was also discussed as another venue for supporting the sensory development of small babies.[116] The POD group was then encouraged to specifically focus on the opportunity of increasing the occurrence and frequency of skin-to-skin holding, since it has been shown to support all of the neuroprotective and neuropromotive strategies.[48,97]

CONCLUSION

To achieve the goal of thriving babies and thriving families, it is clear the NICU interprofessional team must share an understanding of neurosensory development, neuroprotective and neuropromotive strategies, and the essential nature of family integration into these practices. The interdisciplinary approach utilized among a group of 11 NICUs in a VON Quality Improvement Collaborative provided an opportunity for teams to share expertise, education, and strategies. The experience of the POD's collaborative quality improvement efforts can be reviewed in the second manuscript, entitled *Collaboration to Improve Neuroprotection and Neuropromotion in the NICU: A Quality Improvement Initiative.*

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About the Authors

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Ginny McGill, PT, DPT, CNT, NTMTC, CLWT, is supervisor of the neonatal therapy program at The Children's Hospital at Providence in Anchorage, AK. She holds several specialty certification to better serve her NICU patients and families.

Kara Ann Waitzman, OTR/L, CNT, NTMTC, is a neonatal occupational therapist who works as a developmental specialist for Miami Valley Hospital in Dayton, OH. She is the founder of Neonatal Touch and Massage Certification and president of Creative Therapy Consultants. Kara Ann is also co-developer of the Infant-Driven Feeding Scales.

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Ginny Shaffer is a NICU graduate parent who serves as NICU Family-Centered Care Program Coordinator and Parent Navigator for The Children's Hospital at Providence in Anchorage, AK. She is also a Family Partner and Faculty Member of the Vermont Oxford Network.

Mindy Morris, DNP, NNP-BC, CNS, C-ELBW, is an experienced clinical nurse specialist, neonatal nurse practitioner, and consultant. She is a quality improvement collaborative faculty member of the Vermont Oxford Network. Mindy is the co-owner of EngageGrowThrive, LLC and co-developer of the Small Baby Care Specialist Program.

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