

EDITORIAL

The importance of everyday factors in pediatric neurodevelopment

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Seemingly ordinary aspects of daily life—such as sleep, sound, pain, glucose regulation, the surrounding environment, social determinants of health, and overall wellness—can have profound effects on the neurodevelopmental outcomes of infants and children. The manuscripts contained within this review issue delve into the significance of these everyday factors, examining current research, identifying gaps in the literature, and highlighting future directions for improving neurodevelopmental outcomes.

PAIN, SEDATION, ANALGESICS, AND DELIRIUM IN THE SICK CHILD

Despite best efforts to optimize the healing environment in the hospital, many interventions that children experience in the hospital can have adverse effects on pediatric health and development. Providing several examples of this, Selvanathan and Miller¹ review the potential effects of painful exposures during the neonatal period on the developing preterm brain. In an attempt to blunt the negative effects of pain, clinicians may resort to using analgesic and sedative medications; however, these medications may also negatively alter brain maturation and neurodevelopment, necessitating a balance between exposure and management that has not yet been well defined. In the neonatal period and all throughout childhood, these same risk factors of neurodevelopmental disability and administration of deep sedation may also increase risk for intensive care delirium. Diserod, et al.² discuss the limitations in our current understanding of delirium, focusing on the available screening tools to assess for delirium. This same type of challenge to provide rapid and accurate screening can also be seen more generally in the attempt to differentiate the “healthy” from the “sick” child. Roland et al.³ tease out some of the strategies to best identify the not too sick from the not too well, focusing on scoring systems, risk stratification using biomarkers, and cultural shifts in clinical decision-making, ultimately suggesting an algorithm based on early warning systems.

GLUCOSE

Glucose is the primary energy source for the brain, and optimal management of neonatal glucose concentrations are crucial for improving neurodevelopmental outcomes. In their review, Lagacé and Tam⁴ discuss that fluctuations and extremes in blood glucose concentrations are key contributors to adverse outcomes, including seizures, brain injury, and long-term neurologic impairment, particularly in conditions like neonatal encephalopathy. Continuous glucose monitoring (CGM) has

been shown to reduce hypoglycemic events in preterm infants, though challenges remain in tracking and managing glucose concentrations. In children with type 1 diabetes, however, CGM is the standard of care for ambulatory diabetes management, though it continues to lack research and FDA approval for pediatric inpatient use. Morales-Dopico and colleagues⁵ describe that while CGM has improved care and quality of life for children with type 1 diabetes, barriers to inpatient implementation still exist, including cost and lack of data on CGM accuracy and use in pediatric inpatients.

SLEEP AND SOUND

Emerging evidence highlights the critical role of sleep in pre- and post-natal brain development. In this issue, de Groot et al. describe the literature linking brain development to alterations in sleep and sleep-wake cycles. They specifically highlight the roles that cortical activity during sleep plays in supporting neurodevelopment and impacting functional brain connectivity.⁶ Similar neurodevelopmental evidence can also be found for other stimuli inciting brain activity, such as sound. Auditory stimulation plays a crucial role in brain development, beginning prenatally. Preterm infants, for example, are deprived of the protective sound environment of the womb which is replaced by the altered sound environment in the NICU, including non-attenuating sounds. Di Fiore and Liu⁷ review the literature demonstrating the neurodevelopmental effects of the sound environment on brain volume trajectories and discuss potential sound interventions, such as using ear muffs, single-patient rooms, or maternal voice and music therapy, which may reduce infant stress and improve weight gain and brain maturation.

CHILD HEALTH: FROM HOME-ICS TO PLANET-OMICS

Potential adverse exposures are by no means restricted to the hospital environment. Dr. Stein⁸ reviews the definition of child health, providing a framework for the investigation and understanding of the relationships between a child's environment and their health. This requires attention to both the microenvironment of the home and family as well as the macroenvironment encompassing global pandemics and climate change. Aspects of the home environment, including internal and external factors, can significantly contribute to a child's neurodevelopmental outcomes. Christensen, et al.⁹ review this “home-ics” concept of how the home affects biology resulting in altered outcomes, including how clinicians can screen for and address these home factors. On a global scale, children are also especially vulnerable to environmental exposures, antimicrobial resistance, climate change, and other global health issues, as described by O'Reilly, et al.¹⁰ (PR-2024-0158.R2). These large-scale problems require large-scale solutions; some of which are proposed by Haq, et al.¹¹

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in their review that seeks to provide guidance and resources that clinicians can utilize to advocate for changes that could protect global children's health. Children are particularly vulnerable to climate change and child health professionals have an important role in ensuring children are included and prioritized in all policies.¹²

NEUROIMAGING

One of the mechanisms for assessing the effects of early life exposures such as parental stress, pollution, lead, and other toxins is through brain magnetic resonance imaging. Lautarescu, et al.¹³ evaluate the brain structural changes that have been associated with these types of early life exposures and specifically provide a call for future research aiming to characterize the interactions between simultaneous exposures. Claessens, et al.¹⁴ further describe the prognostic ability of brain magnetic resonance biomarkers to provide early prediction of later cognitive developmental delay.

SOCIAL DETERMINANTS OF HEALTH AND PARENTAL IMPACTS ON CHILD HEALTH

Lastly, social determinants of health have a significant impact on pediatric health, including during the neonatal period. Herzberg and colleagues¹⁵ review evidence that socioeconomic and community factors during pregnancy predict neurologic development, linking lower socioeconomic status to smaller brain volumes. It is likely that both maternal stress and environmental exposures are key mechanisms behind these effects. Parental stress is especially elevated during a child's stay in the newborn intensive care unit (NICU). The review by Lizelle van Wyk et al.¹⁶ on parental psychological distress (PD) in the NICU, including anxiety, stress, post-traumatic stress disorder, and depression, and the significant effect on both parent and infant health outcomes. Effective strategies like support therapies, cognitive behavioral therapy, educational programs, and kangaroo care, which have shown mixed success in reducing PD are also addressed. Overall, family-centered care and changes to NICU environments offer potential improvements, but standardized screening for PD and interventions targeting the entire family unit remain underexplored. Due to PD, as well as many other internal and external reasons, parents often face challenges bonding with their infant in the artificial environment of the NICU. In a review by Mann et al.¹⁷ the barriers and facilitators to family presence at the bedside is explored and further highlights the importance for neurodevelopmental outcomes.

Overall, the environment of the everyday can have significant impacts on neonatal and pediatric outcomes. More research is needed, especially on the intersection of poverty, racism, and their systemic effects on social determinants of health. Best practices in this area exist but are not yet uniformly implemented. Future ongoing involvement of parents, families and children in research prioritization and implementation – which are currently supported by organizations such as the Patient-Centered Outcomes Research Institution – is especially crucial in optimizing the “importance of the everyday” in pediatric health care.^{18,19}

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