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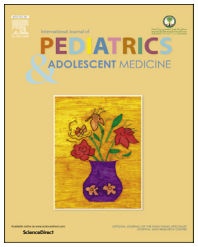

INVITED REVIEW

Building brains, forging futures: the pediatrician's role

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Abstract Recent leaps in the understanding of early brain growth and child development provide us with scientific underpinnings for strategies to improve child health outcomes. Genetic, environmental, and behavioral factors impact the growing child and have a profound impact on lifelong health and function. Recent advances in knowledge concerning the biologic underpinnings of brain development provide a better understanding upon which to base interventions. All growing children experience stress. However, if children are stressed in a manner that exceeds their coping capability, the stress is considered toxic. Toxic stress can impede the cognitive and social emotional growth of the developing brain. Pediatricians have the opportunity to intervene through screening for families at risk, supporting optimal parenting, and linking in a team fashion with other providers of care for young children to support development.

1. Introduction

Enhancing the optimal development of the growing child has always been a focus for the profession of pediatrics. In 1967, former American Surgeon General Dr. Julius Richmond defined child development as "the basic science of pediatrics" [1]. The study of the acquisition of language, movement, and cognition differentiates pediatrics from all other medical specialties. The role of the pediatrician in guiding families to shape development, especially early in brain development, continues to be essential. This charge to promote optimal development broadens a pediatrician's attention to factors outside the traditional boundaries of medicine, as development is determined by a child's genetics, environment, family strengths and challenges, and both formal and informal social capital.

Development is an evolutionary process that begins with genetic endowment of the developing fetus and then is

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influenced by a broad range of environmental factors. Beginning prenatally, continuing through infancy, and extending into childhood and beyond, development is driven by an ongoing interaction between biology (genetic predispositions) and ecology (the social and physical environment). Factors that either promote or undermine early human development have been identified and reveal the interaction of genetic and environmental factors in building brain architecture. Brain development can be impeded by many factors, including war, socioeconomic distress, parental dysfunction, exposure to domestic violence, and media exposure in young children. The dynamic process of brain development sets the life-course trajectory for an individual; in turn, everything from that child's education achievement to economic stability to health behaviors to chronic disease stems from this "dance" of genetics and experience.

2. A collective responsibility

The American Academy of Pediatrics (AAP) has long recognized the importance of a focus on brain development. Health equity is a key theme in the strategic plan of the AAP. All children, regardless of family, nationality, socioeconomic status, or other variables, should be given the opportunity for optimal development. Written in to the American Academy of Pediatrics strategic plan [2] in 2010 is a specific focus on the role we pediatricians play, through our patient contact, advocacy, and program development, on enhancing early brain and child development for children everywhere. The pediatrician as a child advocate has a strong role to play in working with other professional, government, and social groups. It is known that interventions early in life are more cost effective. Noted health economist James Heckman has developed his famous equation suggesting that investing in educational and developmental resources for disadvantaged families, promoting cognitive and social skills in preschool children, and sustaining these early efforts with effective education results in more capable and productive citizens that pay dividends to society for generations to come [3].

3. Point of service opportunities

Pediatric visits are opportunities for developmental enhancement. Screening and surveillance, family engagement, anticipatory guidance, and the creation of therapeutic alliances with families are part of the traditional pediatric encounter. Unfortunately, within the context of busy pediatric patient encounters, opportunities for developmental promotion and surveillance are often missed. Pediatricians have a role in the identification of those children at high risk for poor development, providing positive parenting support for all families to assist them with development, and providing referrals for additional support when necessary. However, too often child health professionals are not succeeding. In many societies, including developed ones, far too many children are left behind. In some areas in America up to 30 percent of youngsters are not succeeding in school by the 3rd grade. High school completion rates are unacceptable and the behavioral health consequences, oppositional behaviors, and mental health consequences as well as the long term impact on worker productivity result in significant losses of potential and increased long term financial costs to society.

4. Plasticity

Brain growth begins with a tremendous proliferation of neuronal connections, connections that are each little experiments with the environment. As the infant grows and matures, pruning of these connections begins as the cerebrum sorts out which connections are useful and which are not. The ability to change the physical structure of the brain in response to need early in life is referred to as plasticity as the brain is plastic and able to respond to the surrounding environment. The propensity for plasticity in the brain is not permanent; it changes over time and is related to the age and development of the child. Windows of opportunities that open and close for development exist in the evolving organism. Without the appropriate stimulation at the right time, the developing cerebrum is impeded in engendering the appropriate connections for success in the future.

We know the developing brain responds to stress. Some types of stress lead to healthy routines such as learning right from wrong and building resilience. Toxic stress is defined as prolonged exposure to adversity (for example neglect, food insecurity, and violence) that causes lasting damage to the developing brain.

Stress of all sorts is essential to the growth and development of the infant human organism. Our immune systems develop as they are exposed to stresses in the microbial environment. Our gastrointestinal systems learn to eat and digest the foods of our cultures, and the developing child learns to accommodate and manage the psychological and intellectual milieu in which they exist. Similar stress and response activities occur in the brain. Children sometimes recognize new situations as stressful, and reach out to those around them to help them learn to accommodate. Caring caregivers provide the emotional support, and the modeling that is essential to the development of coping skills in the face of new adversities. However, in situations in which there is no capable caregiver, no one who is able to provide the needed comfort and guidance, or when the stress is of such magnitude, such as exposure to excessive violence, trauma, or catastrophes, all sorts long lasting developmental consequences occur. In these situations the stress becomes toxic [4]. Toxic stress is the result of overwhelming adversity that exceeds the ability of the growing infant's brain to cope and learn. It has a negative impact on cerebral architecture through the disruption of the neuronal architecture. It adversely effects the development of regulatory functions and can lead to permanent cognitive and social-emotional disability. These changes potentially impact future behavior, both internalizing and externalizing, and result in physiologic disruptions with life-long impacts on the health of the developing individual. The lifelong consequences are substantial and lead to higher levels of chronic disease. The impact of toxic stress on the long term function of the developing child underlies the cost effectiveness of intervening earlier in life [5].