Poverty and Developing Brain

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Evidence continues to mount that the brains of children living in poverty show tangible alterations. Our authors, all part of a team that studies the issue at Washington University School of Medicine, explain the challenges and the necessary steps needed to build a healthier and more productive society.
Numerous studies of children in the US across decades have shown striking correlations between poverty and less-than-optimal physical and mental health and developmental outcomes. Trauma, poor health care, inadequate nutrition, and increased exposures to psychosocial stress and environmental toxins—all of which have significant negative developmental impact—are likely to be involved.

The effects of elevated stress on child-caregiver relationships appear to be particularly detrimental, unsurprising in that nurturing and supportive caregiver relationships are foundational for healthy development in early childhood. For adults whose job options are unconducive to their role as parents (such as working multiple jobs or night shift hours), or for whom family support is unavailable, or for those do not have the material resources they need, the resulting stress may result in sleep disruption, depression, and anxiety—all of which translate to poor developmental trajectories for their children.

Other health and developmental risks often associated with poverty include lead and other pollutants in air and water, poor nutrition (often related to living in “food desert” areas where healthy foods such as fresh fruits and vegetables are scarce), neighborhood violence, and trauma. “Toxic stress” that exceeds a child’s ability to adapt can occur when the burden of stressful life experience overwhelms the brain’s regulatory capacity, or when the compensatory abilities of brain and body are compromised. A lack of cognitive stimulation (due to such factors as the absence of books and educational materials in the home, poor immersion in language, and a lack of after school or other enrichment activities) or disruption of sleep and circadian rhythms (by neighborhood noise or parents’ irregular work schedules) is likely to impact brain development and emotional and behavioral regulation when these systems are rapidly developing.

**How the Environment Shapes the Developing Brain**

Building on a robust body of literature in the behavioral sciences, developmental neuroscientists have begun to investigate whether tangible effects of poverty and adversity can be detected in the structure and function of the developing brain. A growing body of evidence demonstrates quantifiable relationships between adverse environmental exposures and alterations in neurodevelopment visible in brain scans.

Work in animal models has shown that environmental exposures influence the sculpting of neural circuits, particularly during early developmental “sensitive” periods when the brain is uniquely malleable. This sculpting occurs through processes such as neurogenesis (the sprouting of new brain cells), synaptogenesis (the growing of new connections between brain cells), and synaptic pruning (the elimination of less-used connections between brain cells to enhance efficiency of communication among neurons and in brain circuits). The environmental influence on this shaping process is thought to prepare the organism for adaptation to experiences and challenges it is likely to encounter in the future.

In human studies during childhood, developmental neuroscientists have used tools such as electroencephalography (EEG) and both structural and functional magnetic resonance neuroimaging (sMRI/fMRI) to show an association between early exposure to poverty and
changes in brain structures critical for emotion regulation and cognitive function. For example, research has linked early poverty to a reduction in the size of the hippocampus, a brain region critical for healthy stress response and memory function. Further, studies using both EEG and fMRI have shown different patterns of brain activation in response to stimuli that evoke emotion or the need for emotional regulation. Children growing up in poverty showed greater amygdala activity in response to threatening stimuli. Researchers have also found an association between early poverty and alterations in brain circuits that are important for experiencing emotions, generating adaptive behavior patterns, and learning. These changes include reduction in the connections between the hippocampus and other brain regions, such as the prefrontal cortex and the anterior cingulate, that support cognition.

As environmental shaping helps prepare an organism for its expected future, such stress-related differences in brain structure and function might be adopted to help a child manage uncertainty or respond to difficult circumstances later on. Over time or in response to chronic exposure to stress, however, adversity may also contribute to enduring disruptions in physical and mental health or in cognitive and emotional function.

There is evidence suggesting that the link between early poverty and later psychopathology is mediated through some of the alterations in brain structure and function described above. Findings of this nature have re-ignited public health attention to the problem of child poverty; their insights into the mechanistic pathways of poverty’s deleterious effects on the brain pave the way to more directed targets for prevention and early intervention.

**Studies of Mechanisms**

As with brain development, while the association between exposure to poverty and negative developmental child outcomes have been apparent for many decades, the underlying cellular-level and psychosocial processes are more elusive. Numerous mechanisms appear to be involved. For example, work in both humans and animals has shown that early exposure to enriched versus depleted environments, as well as variations in maternal care, can change the expression of key genes (i.e., turning on and off the production of proteins encoded by each gene) that are involved in brain development and function.

Such epigenetic mechanisms represent an interface at which nature and nurture interact. For example: A healthy response to stress requires activation of a brain system called the hypothalamic pituitary adrenal axis (HPA axis); it regulates the release of the brain hormone cortisol, which helps prepare the body for adaptive coping. Excessive or prolonged HPA activation (such as the chronic stress that commonly accompanies poverty), generates too much cortisol, and can change gene expression in a way that causes lasting disruptions in hippocampal structure and function.

A similar process has been described in immune system reactivity, where chronic exposure to poverty and related stresses results in a “pro-inflammatory” state where the immune system remains activated, even without microbial threats. This chronic low level of elevated inflammation poses long-term health risks.
In addition, living in poverty is associated with disruptions in the sleep-wake cycle; noise and light and patterns of household function that accompany challenging work hours (e.g., late shift work) can reduce the amount of sleep for children as well as adults. These disruptions have their own impact on brain circuits, interfering with neural restorative processes that accompany regular sleep and are critical for learning and emotion.

As noted above, poverty is frequently associated with exposure to environmental toxins known to harm brain development, such as lead, polycyclic aromatic hydrocarbons (produced when oil, gas, and tobacco are burned), and nitrogen dioxide (present in air pollution). All too frequently, poverty also means reduced access to adequate nutrition, green space, and health care, all of which can directly and indirectly impact brain and overall development.

Understanding the mechanisms of risk is complicated by the fact that poverty typically brings many risks at once, making it difficult to determine which risk factor drives which specific negative outcome (e.g., emotion dysregulation, failure to achieve potential), or whether multiple exposures have synergistic effects. And while causality may be suggested by association, it can be clearly established only with experimental designs that measure key outcomes before and after exposure to risk factors. Such studies are very rare but have been possible in the face of an environmental change (e.g., income increases brought out by an economic boon to a community, a pandemic, or policy change, or natural or man-made disasters that bring about social adversity in a previously well-resourced community).

Knowledge gaps notwithstanding, the robust evidence for a connection between poverty and poor physical and developmental outcomes, and the high proportion of US children born into poverty, argue an ethical imperative to determine whether ensuring economic equity would bring benefits comparable to avoidance of toxic exposures and iron deficiency, which is now the standard of care and practice. Further enhancing income may also be a first step towards ameliorating other negative social forces such as environmental and racial injustices associated with low SES. Studies that provide income transfers to young families living in poverty have provided some promising initial results, but most have not followed children long enough to show the enduring neural and mental health benefits.

Understanding the pathways and mechanisms of poverty’s negative effects on the developing child is essential if we are to understand the importance of alleviation of risks associated with poverty and develop more cost-effective and targeted preventions and early interventions. That the direct consequences of economic insufficiency on brain development are entirely avoidable in the US, given its wealth as a nation, underscores the importance of these scientific endeavors.

**Interventions to Protect Developing Children**

Despite the growing knowledge base, there has been surprisingly little sustained public interest or investment in supporting robust programs to interrupt poverty’s deleterious impact on children. A notable exception is the “War on Poverty” with its federal programs for children living
below the poverty line, initiated by President Lyndon Johnson in 1964 and still operational in all 50 states.

Temporary Assistance for Needy Families (TANF) and the annual Child Tax Credit, contemporary mechanisms for direct cash transfers to impoverished families, evolved from the War on Poverty. Other federal programs have focused on consequences of poverty that damage the development of children, including nutritional support (the Women, Infants, and Children program WIC); educational and psychosocial support of parents during their children’s first years of life (Early Head Start and Healthy Families America); and educational support of preschoolers (Head Start). Each program has overwhelmingly demonstrated incremental improvements in the average outcomes of the children such as overall achievement and lower rates of psychopathology. But they have not been nearly enough to close the developmental and mental health gap between children who grow up in underprivileged environments and those who do not.

**Interventions** designed to enhance the parent-child relationship and reduce the likelihood of severe adverse experiences, such as child abuse and neglect, have proven a feasible and effective next-line-of-defense in the roster of federal programs for children in poverty. Ranging from home-visiting programs to live coaching during parent-child interactions, they aim to enhance emotional connection and warmth between parent and child and teach caregivers how to set nurturing but firm limits. These strategies have shown strong efficacy in buffering the negative emotional impact of poverty.

Such interventions may be delivered in clinical settings or in the home or, more recently, by video conferencing. Extending them through community settings such as school or primary care sites will facilitate access to high-risk populations. There are now a number of empirically tested (and proven effective) models of this type of preventive intervention whose low cost makes them feasible for broad delivery with minimal social investment (through taxpayer dollars into social programs) and a high return on that investment. The question becomes: How to emphasize the importance of these interventions and their effectiveness to administrators responsible for child health and well-being?

**Science Policy Gap**

In regard to the above question, the gap between scientific advances and changes in social policy and healthcare practices is well-known. The field of implementation science was developed to address it by identifying barriers to the uptake of advances in medicine, social science, and psychology by practitioners and healthcare systems. This gap can be even more daunting in the area of public policy, where political perspectives and agendas can obstruct the integration of scientific findings.

In the area of poverty and child development, the science-policy gap is strongly influenced by political philosophies and belief systems about the merits and liabilities of social safety nets. Even tangible economic benefits—compelling data that early interventions for children living in poverty result in a high return on investment and significant savings in tax-payer dollars over the long-term when they are used to fund these social programs—often fail to influence policy in a logical manner.
Changing Social Attitudes

More generally, stereotypes about poverty continue to thwart progress in this area. The idea that people live in poverty because they are unmotivated to work, or fail to take responsibility for themselves, or are genetically destined to fail, often drives social investment or lack thereof, even when it affects the well-being of young children. The commonly held misconception that people living in poverty are predominantly racial/ethnic minorities in cities may fuel beliefs based on implicit or explicit bias. In fact, the majority of people in poverty in the US are white and live in rural areas. This is because even though the percentage of racial and ethnic minorities living in poverty is higher than the percentage of white individuals, there are a larger number of white individuals in the US. For example, in 2020, 15.6 percent of white non-Hispanic households were living on $24,999 or less a year, with 29.7 percent of household identifying as black were living at or below the same income levels. However, in terms of numbers of households, this reflects 13.3 million households identifying as white non-Hispanic and 5.2 million households identifying as Black. This is not to suggest that we should only care about poverty if it happens to majority culture individuals, but simply to point out that poverty affects people of all racial and ethnic identities in our society.

We need to develop interventions that support people facing poverty across all racial, ethnic, geographic, and other identity lines. Greater attention to the forces that drive individuals into poverty, such as a lack of inter-generational transmission of wealth, systemic racism and discrimination, social rejection, drug and alcohol abuse, and limitations in opportunity, is of paramount importance when addressing this problem on a larger scale.

Otherwise, the unacceptably high proportion of young children—the next generation of adults—growing up in poverty represents our future. An understanding of how powerfully early life experiences shape the development of their minds and brains provides compelling evidence of what can and needs to be protected, and points to a great opportunity for building a healthier and more productive society. The public needs to know.

Bios:

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