SPOTLIGHT 2

Poverty hinders biological development and undermines learning

Life outcomes are hugely influenced by a child's development during the early years. Biological systems develop sequentially and cumulatively, so what happens early in life lays the foundation for future development. Between the time of gestation and a child's sixth birthday, the brain matures faster than at any other time of life. This period is also when the brain, along with its supporting systems, is most malleable. This malleability is a double-edged sword: high susceptibility to early environmental influence serves as both a window of opportunity and a source of vulnerability, because it means experiences can shape how development unfolds.[1] The environment children grow up in is a key determinant of their developmental trajectories toward outcomes later in life.

Growing up in poverty usually exposes children to many risk factors. In poor households, low levels of parental education exacerbate material deprivation by undermining investment choices for children's development, in terms of how parents use both their financial resources and their time. Moreover, parents' limited mental bandwidth, as well as the psychological stress imposed by poverty (including working many hours in often precarious conditions to make ends meet), further undermine the time, energy, and care they can give their children.[2] For the child, this often results in poor physical inputs starting in the womb, such as insufficient nutrition or extreme deprivation. It also results in poor social inputs, such as insufficient stimulation (not being held, responded to, talked to, or played with), neglect, abuse, exposure to violence, displacement, or maternal depression.

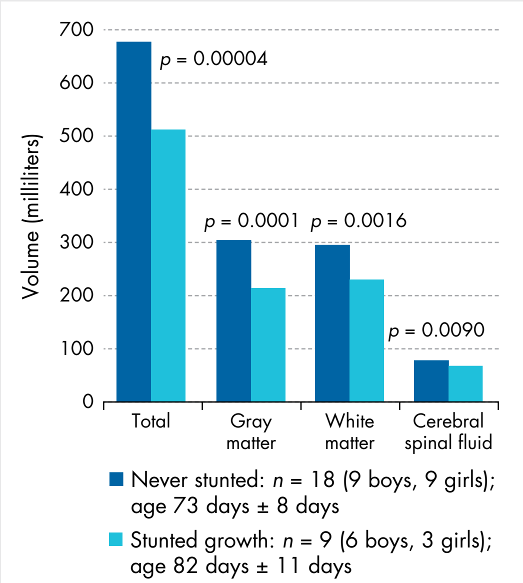
Acute adversity during the early years becomes embedded in children's bodies. In the face of deprivation, disease, or noxious environments, developing systems direct resources toward survival rather than promoting growth—physical or mental. For example, one in four children worldwide is stunted due to chronic malnutrition.[3] Stunting between gestation and a child's second birthday is associated with late school enrollment, lower cognition, poorer executive function, and less school attainment.[4] Some catch-up is possible after a child's second birthday, but previously stunted bodies remain highly sensitive to disease and infection. Children born with low birth weight (suggesting fetal undernutrition) are at higher risk of chronic adult diseases such as hypertension, diabetes, obesity, and coronary artery disease ("metabolic syndrome"). The extent to which the associated earlier cognitive impairment can be reversed is uncertain.

Exposure to multiple risk factors without the buffering support of available, well-informed, responsive caregivers can cause toxic stress.[5] Stress triggers the flight-or-fight response, an intense physiological reaction that puts the body in a state of alertness to deal with potential threats. Continual activation of the flight-or-fight response in early life endangers developing systems, because the brain focuses on addressing the perceived danger to the detriment of further development of biological systems not essential for survival.

Toxic stress in the early years can undermine lifelong health, learning, and behavior. Hormones associated with the flight-or-fight response, such as cortisol, can inhibit physical growth as well as weaken immune systems and metabolic regulatory mechanisms, all of which permanently increase an individual's susceptibility to illness.[6] Moreover, toxic stress during the early years can impair the development of neural connections in parts of the brain that are critical for learning—such as those associated with

Figure S2.1 Severe deprivation affects brain structure and function from early in life

Total white and gray matter in infants, by stunting status



Source: WDR 2018 team, using data from Nelson and others (2017). Data at http://bit.do/WDR2018-Fig_S2-1.

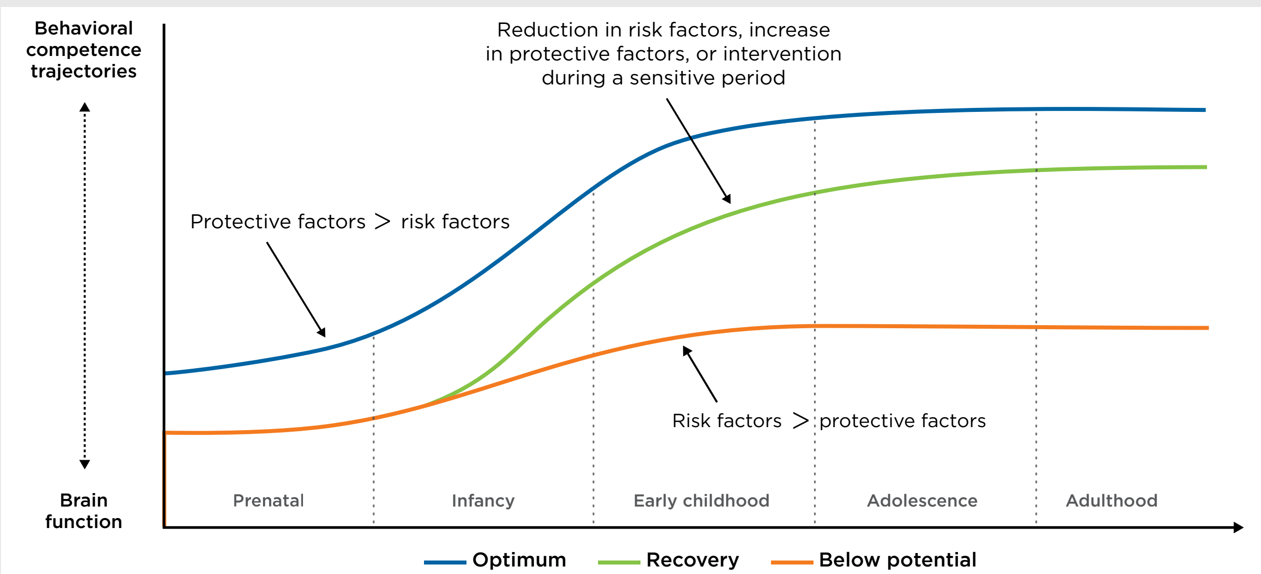
Note: Data obtained from infants 2–3 months old in Dhaka, Bangladesh, using magnetic resonance imaging (MRI). Graph depicts two groups of infants: 18 not stunted (not malnourished) and 9 stunted (malnourished). Graph shows (from left to right) total amount of brain volume; total amount of gray matter, where most neural computations are performed; total amount of white matter, which transmits electrical signals between gray matter and affects brain function and learning (that is, the information pathways of the brain); and cerebral spinal fluid, which protects the brain and spinal cord from injury and infection and is generally involved in many aspects of brain health.

socioemotional outcomes and executive functions, the biological foundations of learning.[7]

Severe deprivation, along with the associated stress, can impair healthy brain development.[8] Neuroimaging data from studies in Bangladesh, The Gambia, Romania, the United Kingdom, and the United States reveal differences in brain development (both structural and functional) linked to socioeconomic status. The studies confirm reduced brain connectivity as well as smaller brain volumes in areas associated with language, memory, executive function, and decision-making skills, on the one hand (figure S2.1),[9] and high activation of regions associated with emotional reactivity, on the other.[10] Such connectivity patterns and associated biological maladaptations are very difficult to reverse.

These biologically embedded responses lead to worse developmental trajectories and impaired learning, hurting foundational skills from the earliest stages of life. Because early childhood development outcomes are interdependent (see spotlight 1), subpar development in any one dimension is likely to affect the others. Children with stunted bodies and brains attempting to compensate for developmental gaps face daunting odds as they start formal schooling because of the sequential nature of development, coupled with the sharp decrease in brain malleability after a child's sixth birthday. Investments in early childhood development enable the normal, timely development of biological systems, shaping children's long-term ability to learn (figure S2.2). Well-designed

Figure S2.2 Risk and protective factors affect developmental trajectories



Source: Walker and others (2011).

early childhood interventions that increase poor children's access to protective factors (nutrition, stimulation, care, protection from stress) can enable those children's normal, timely biological development, thereby strengthening their long-term ability to learn (see chapter 5).

Notes

1. Knudsen (2004).
2. Mullainathan and Shafir (2013).
3. UNICEF, WHO, and World Bank (2016). *Stunting* is defined as a height-for-age z-score of less than two standard deviations below the median of a healthy reference population.
4. Black and others (2013); Christian and others (2014).
5. Center on the Developing Child (2016).
6. McEwen (2007).
7. Evans and Kim (2013); McCoy and Raver (2014).
8. Center on the Developing Child (2016).
9. Bright Project (http:/www.globalfnirs.org/the-bright-project); Nelson and others (2017); Noble and others (2015); Vanderwert and others (2010).
10. Pavlakis and others (2015).

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