Published in final edited form as:

New Dir Child Adolesc Dev. 2017 December ; 2017(158): 69–79. doi:10.1002/cad.20220.

Poverty's Impact on Children's Executive Functions: Global Considerations

Stephanie L. Haft[1] and **Fumiko Hoeft, M.D., Ph.D.**[1,2,3,4,5]

[1]UCSF, Department of Psychiatry and Weill Institute for Neurosciences, San Francisco, USA

[2]UCSF Dyslexia Center, San Francisco, USA

[3]University of California Multi-Campus Precision Learning Center, San Francisco, USA

[4]Haskins Laboratories, New Haven, CT

[5]Keio University School of Medicine Tokyo, Japan

Abstract

Poverty detrimentally impacts child executive function (EF), a subset of cognitive abilities implicated in reading and other achievement outcomes. Consequently, research has focused on understanding explanatory and mediating mechanisms in this association. This research, however, has mainly involved populations from Western, high-income countries. Children from low- and middle- income countries comprise a significant proportion of the world's population, and are at additional risk for poor EF as a result of a more disadvantaged context. The present review examines global work on poverty and EF, to highlight important cross-national similarities and differences. Findings suggest a global association between poverty and EF, and point to cognitive stimulation and environmental enrichment as common mediating variables that may also be moderators and targets for intervention. However, findings also underscore the need to consider the socio-cultural context of countries when examining impacts of parenting, schooling, and other metrics. Research and intervention implications are discussed.

Background

Childhood poverty is associated with a range of negative developmental, behavioral, and emotional sequelae that can further perpetuate inequalities in income, achievement, and health. One such outcome is impaired development of executive function (EF), a collection of goal-oriented cognitive abilities including domains of working memory, cognitive flexibility, inhibitory control, and planning. Research from developed and developing countries, including Western and non-Western societies, shows a strong relationship between socio-economic status (SES), a metric of poverty, and childhood EF (e.g. Lia CH Fernald, Weber, Galasso, & Ratsifandrihamanana, 2011; Hackman, Gallop, Evans, & Farah, 2015). Considering poor EF can lead to impairments in academic achievement, emotional functioning, and occupational outcome (Alloway & Alloway, 2010; Miller, Nevado-

Corresponding author: Fumiko Hoeft MD PhD, 401 Parnassus Ave., San Francisco, CA 94143; 415-476-9861, Fumiko.Hoeft@ucsf.edu.

Montenegro, & Hinshaw, 2012; Snyder, 2013), this relationship means that children in poverty worldwide are at risk for further negative life outcomes by virtue of EF disparities.

Despite the strong links between poverty and EF, children living in poverty exhibit individual variability in EF. Accordingly, efforts have increased to investigate potential mediators and moderators of the SES-EF association and identify targets for interventions and programs. However, this literature has focused disproportionately on children from high-income countries (HICs) in Western societies, largely neglecting children living in lower-middle income countries (LMICs). The effects of poverty on EF are likely to be influenced by cultural practices and environments that vary across countries, suggesting mediation analyses conducted in HICs may not be applicable in LMICs. Additionally, gradients and severity of poverty may be more extreme in LMICs in the context of less governmental resources – over 200 million young children in LMICs do not reach the full cognitive potential they would attain in a more nurturing environment (Grantham-McGregor et al., 2007). Thus, EF research that informs interventions to be implemented in LMICs is crucial (The World Bank, 2015), especially for those children who reside in more disadvantaged contexts.

Accordingly, we review research on poverty and EF in a global context, focused primarily on research from HICs on why poverty is linked to poorer EF, potential global influences on these pathways, cross-national variability in mediators, confounds and challenges involved in global research on EF and poverty; we suggest future research with implications for interventions seeking global impact. Given the salience of EF in a range of achievement outcomes, our goal is to contribute to knowledge aimed at lifting all children in all countries out of the vicious cycle of poverty and inequality.

Pathways Linking Poverty to Inequalities in EF Development

In the past decade, research focused on elucidating why poverty detrimentally impacts EF highlights poverty's stressful impact on neuroendocrine and brain function. Children living in poverty are exposed to a range of psychological, environmental, and biological stressors which may impact EF directly, and/or lead to elevated levels of cortisol, a stress response hormone regulated by the hypothalamic-pituitary-adrenocorticol (HPA) axis. Stress hormones in turn regulate synaptic and neural activity particularly in the prefrontal cortex (PFC), the home of EF (see Blair & Raver, 2016; Johnson, Riis, & Noble, 2016) for reviews). As a result of neuroendocrine changes related to stress, children in poverty may experience damaging structural changes in the PFC, leading to poorer EF. Although globally, the explanatory power of these stressors may vary in strength and/or with the presence of additional factors related to living in an LMIC, research confirms an association between poverty and additional stressors regardless of culture or country.

Mediators and Moderators of the Poverty-EF Link: Similarities and Differences across Countries

Further explaining how poverty impacts EF and potential ways to mitigate these effects, research from HICs has converged on candidate mediators involving parental caregiving, the provision of a cognitively enriching environment, and biological and neural differences. We examine this literature including the limited work on this topic from LMICs, to highlight similarities and differences between contexts.

Parenting

Multiple studies within HICs have reported a positive association between aspects of parenting and child EF performance (e.g., Bernier, Carlson, & Whipple, 2010; Hammond, Müller, Carpendale, Bibok, & Liebermann-Finestone, 2012). Specific attention has been lent to scaffolding, parental autonomy support in guiding a child's goal-directed activities, and parental sensitivity in promoting EF development (Hammond et al., 2012). Concurring with this, research on mediators of the poverty-EF relationship has highlighted the role of parenting. Parental responsivity (Sarsour et al., 2011) and maternal sensitivity in early childhood (Hackman et al., 2015) mediated the association between family SES and EF in US children from diverse SES backgrounds, affecting children's cortisol levels, a proxy for stress (Blair et al., 2011). Together, these results echo work on the impact of economic stress on caregiving practices, and they also suggest parenting's role as a moderator with buffering effects. In other words, positive parenting can regulate a child's stress response in the face of poverty, thereby countering the negative impact of stress physiology on child cognition and EF.

The ability of parents in LMICs to intervene in their child's EF development may be more limited. Poverty in LMICs can be more extreme; additional stressors (e.g., infectious diseases, environmental toxins, food scarcity) lessen capacity for parents to invest in scaffolding their children's cognition (Walker et al., 2011). Sometimes parents may not be present at all – as with street children (youth who reside or work on the streets for an extended period of time without adult supervision), who comprise a proportion of the population in many developing countries (de Benitez & Hiddleston, 2011). Two studies of street children in LMICs have confirmed the poverty-EF link found in Western literature (Dahlman, Bäckström, Bohlin, & Frans, 2013; Pluck, Banda-Cruz, Andrade-Guimaraes, & Trueba, 2017). However, researchers studying boys in Bolivia found that street children scored significantly higher on an EF flexibility and planning task than housed counterparts of similarly low SES (Dahlman et al., 2013). Similarly, a study of children in Ecuador found that the street children had surprisingly preserved EF (Pluck et al., 2017). Within these countries' social and cultural contexts, exercising EF in navigating street life may confer a slight advantage to some low-SES children.

Though studies of street children who lack parental supervision may seem to be at odds with parenting, poverty, and EF literature in HICs, the results actually support the role of scaffolding in EF development. The LMIC street children's EF was likely attributable to opportunities to independently exercise problem-solving and executive planning rather than to lack of parenting (Dahlman et al., 2013), which agrees with the goal of parental scaffolding – to provide guidance without direction to enable children to generate solutions autonomously. While these studies from LMICs therefore support the role of parents in mitigating effects of poverty on EF, they also suggest that the social and cultural contexts of parenting need to be considered.

Environmental Stimulation and Enrichment

Another determinant of a child's EF development is access to stimulating materials in the home environment (books, computers, etc; Dilworth-Bart, 2012; Hughes & Ensor, 2009). Animal models have shown that cognitive stimulation promotes synaptic changes in the hippocampus and cortex that in turn lead to improved cognitive performance (Hackman, Farah, & Meaney, 2010). Research has found that an enriching home environment does indeed mediate the SES-EF association (Dilworth-Bart, Khurshid, & Vandell, 2007; Sarsour et al., 2011), even after adjusting for correlation with other candidate mediators (Hackman et al., 2015). Studies from LMICs (Zambia and Argentina) also show the mediating effect of early cognitive stimulation in the home (McCoy, Zuilkowski, & Fink, 2015), specifically literacy and computer resources. The traditional definition of cognitive stimulation, typically access to literacy resources, may need to be reexamined across cultures where caregivers may stimulate their children in other ways (McCoy et al., 2015). However, the existing results suggest that the model in which a stimulating home environment mediates between SES and EF holds true across countries.

Families in poverty have fewer financial resources to invest in enriching materials, resulting in inequalities in EF development across SES (family investment model; Conger & Donnellan, 2007); this may be exacerbated by "book deserts" observed in low-income US neighborhoods (Neuman & Moland, 2016), or reduced access to print in LMICs with many remote areas (Spaull & Taylor, 2014). However, these findings suggest an EF intervention target for low-SES communities; an intervention program to offset the effects of poverty by providing cognitively stimulating environments has demonstrated positive effects on EF in children in Pakistan (Obradović, Yousafzai, Finch, & Rasheed, 2016). Such interventions can be applicable worldwide.

Biological Mediators

Stress physiology has received attention in poverty and EF research. It is negatively affected by poverty, ultimately having a deleterious effect on a child's EF. However, following a model of differential susceptibility (Pluess, Stevens, & Belsky, 2013), not all children exposed to the stressors of poverty will be equally reactive. Research in the US has confirmed that biological indicators of stress such as salivary cortisol (Blair et al., 2011) and allostatic load (Evans & Schamberg, 2009) mediate between SES and EF, and that behaviorally, observed child temperament reactivity moderates the SES-EF link (Raver, Blair, & Willoughby, 2013); children more biologically reactive to adversity may be particularly at risk for low EF in the face of poverty, whereas less reactive children may be somewhat protected (Obradović, 2016).

A relationship between economic background and cortisol response has been observed in Dominica (Flinn & England, 1997), rural Mexico (Lia CH Fernald & Gunnar, 2009), and Nepal (Worthman & Panter-Brick, 2008), yet these studies have not included EF outcomes or mediation analyses. Examining the relationship between stress physiology and EF outcome in LMICs is a future research direction, but may be confounded by nutrition: child stress physiology varies as a result of stunting in low-SES samples (Dobrova-Krol, van IJzendoorn, Bakermans-Kranenburg, Cyr, & Juffer, 2008; L. C. Fernald, Grantham-

McGregor, Manandhar, & Costello, 2003; Nyberg et al., 2012). Stunting (delayed height-for-age), resulting from chronic malnutrition and affecting ~165 million children in developing countries (De Onis, Blössner, & Borghi, 2012), negatively impacts general cognitive development (Ajayi et al., 2017). These, together with its impact on stress physiology, should be considered an important player in EF outcome in LMICs.

In a study of EF in low-income Zambian children (McCoy et al., 2015), stunting explained the SES-EF relationship and predicted EF above and beyond early learning experiences. While height-for-age may not be an appropriate research variable in HICs where severe malnutrition is rare, these findings underscore the importance of including anthropometric data in EF mediation research in LMICs. This research is an indirect but promising way of supporting child EF in LMICs, as targeted interventions can reduce stunting (Rockers et al., 2016). Work on biological stress reactivity and EF in LMICs, therefore, should include the impact of stunting both on stress and on EF.

Neural Mediators

Many studies link SES to individual brain differences, underscoring the role of brain development in the poverty-to-EF pathway (see review by Blair & Raver, 2016). These studies demonstrate that poverty impacts neuroanatomy and neurophysiology through biologic and epigenetic mechanisms, and thus has a detrimental effect on EF development (Johnson et al., 2016). Only one study has replicated work on neural correlates of EF in an LMIC population. Tarullo et al. (2017) examined the relation of EF to gamma activity in a disadvantaged population of rural Pakistan, showing that gamma power was indeed a “neural marker” for EF performance in LMIC as is the case in HICs (Benasich, Gou, Choudhury, & Harris, 2008; Brito, Fifer, Myers, Elliott, & Noble, 2016), suggesting cross-national relevance of the metric (Tarullo et al., 2017). Despite the lack of mediation analyses, this result supports HIC findings pointing to brain development as an SES-EF mediator and suggests that neural measures may be an important, unbiased indicator of EF that is valid across countries and contexts, in contrast to many existing behavioral measures. Although the limited portability and affordability of neuroimaging tools makes implementing research on brain correlates of EF in LMICs challenging, identifying neural correlates and mediators can be valuable in understanding the pathways from poverty to outcome for at-risk children. Future work might also investigate the impact of other neural patterns affecting the SES-EF link as moderators or confounds, for example, developmental differences in temporal or hippocampal regions (Hair et al., 2015).

Additional Considerations in Scaling Poverty-EF Work Globally

In scaling work on poverty, EF, and their mediators to LMICs countries, several confounding variables that affect child development need to be considered: nutrition, infections, toxins, learning opportunities, exposure to violence, and general cultural and geographic considerations vary widely (for review, see Walker et al., 2011). In general, the poverty cofactors and associated stressors that explain inequalities in EF development in HICs are the same but exacerbated in LMICs. A lack of learning materials, poor housing quality, prevalence of maternal depression, and childhood trauma exposure are all negatively associated with country gross domestic product (Bradley and Putnick, 2012), and all of these risks affect child EF directly or through their detrimental impact on epigenetic or neuroanatomical systems (Hackman et al., 2010; Schapkin et al., 2006; DePrince et al., 2009). Therefore, research on EF in LMICs may need to place an emphasis on controlling for the many impactful cofactors of poverty.

Metrics involved in this area of research also need to be carefully chosen and operationalized – for example, despite recent work on developing culturally sensitive assessments, EF tasks may still be impacted by cultural norms, e.g., the importance of speed in certain cultures (Armengol, 2000). Additionally, the income- and needs- based frameworks that define SES in HICs may not be applicable to LMICs - recommendations for improving the measurement of poverty in child development and EF research thus include incorporating cultural contexts as well as cognitive and neural indicators or outcomes of poverty (Duncan & Magnuson, 2012; Lipina, Simonds, & Segretin, 2011). Cultural tendencies may also impact cognitive processes – for example, East Asian children tend to score higher on EF tasks than their Western counterparts (Oh & Lewis, 2008), and authors suggest the disparity may be attributed to cultural differences in context sensitivity.

Conclusion and Implications

The research reviewed here highlights commonalities and key contextual differences across countries in regards to poverty and EF research. Poverty cofactors that contribute to EF discrepancies in HICs exist in LMICs, but to a larger extent and alongside additional stressors. Cognitive stimulation appears to be a mediating variable globally. Parental caregiving practices play an important role in promoting EF, but may vary culturally, and the relevance of intervention targets may vary by culture or country. For example, interventions for stunting, although it mediates poverty and EF outcome, is only relevant where stunting occurs, and parent-based EF or poverty programs are less impactful where parental involvement or capacity is low.

Overall, the findings highlight the need for increased mediation and moderation analyses as well as work on neural correlates in LMICs as directions of future research. In the pathway from poverty to child EF outcome, there are multiple entry points for targeted interventions, all of which may be impacted by global variations. Because research on poverty cofactors and mediating variables informs such interventions, it is important that findings are applicable to all children. A large body of literature associates child EF with a range of achievement outcomes, including reading and mathematics (Cragg & Gilmore, 2014; Guajardo & Cartwright, 2016). Thus, protecting against poverty’s detrimental impact on EF is important in promoting academic success in children worldwide, enabling them to break out of the vicious cycle of inequality and health disparities

References

Ajayi OR, Matthews GB, Taylor M, Kvalsvig JD, Davidson L, Kauchali S, Mellins C. Structural equation modeling of the effects of family, preschool, and stunting on the cognitive development of school children. Frontiers in Nutrition. 2017; 4

Alloway TP, Alloway RG. Investigating the predictive roles of working memory and IQ in academic attainment. Journal of Experimental Child Psychology. 2010; 106(1):20–29. [PubMed: 20018296]

Armengol C. Developmental and cross-cultural issues in the assessment of attention and executive functions. Revista Española de Neuropsicología. 2000; 2(3):3–20.

Benasich AA, Gou Z, Choudhury N, Harris KD. Early cognitive and language skills are linked to resting frontal gamma power across the first 3 years. Behavioural Brain Research. 2008; 195(2): 215–222. [PubMed: 18831992]

Bernier A, Carlson SM, Whipple N. From external regulation to self-regulation: Early parenting precursors of young children's executive functioning. Child Development. 2010; 81(1):326–339. [PubMed: 20331670]

Blair CB, Raver CC. Poverty, stress, and brain development: New directions for prevention and intervention. Academic Pediatrics. 2016; 16(3):S30–S36. [PubMed: 27044699]

Blair C, Granger DA, Willoughby M, Mills-Koonce R, Cox M, Greenberg MT, … Fortunato CK. Salivary cortisol mediates effects of poverty and parenting on executive functions in early childhood. Child Development. 2011; 82(6):1970–1984. [PubMed: 22026915]

Bradley RH, Putnick DL. Housing quality and access to material and learning resources within the home environment in developing countries. Child Development. 2012; 83(1):76–91. [PubMed: 22277008]

Brito NH, Fifer WP, Myers MM, Elliott AJ, Noble KG. Associations among family socioeconomic status, EEG power at birth, and cognitive skills during infancy. Developmental Cognitive Neuroscience. 2016; 19:144–151. [PubMed: 27003830]

Conger RD, Donnellan MB. An interactionist perspective on the socioeconomic context of human development. Annu Rev Psychol. 2007; 58:175–199. [PubMed: 16903807]

Cragg L, Gilmore C. Skills underlying mathematics: The role of executive function in the development of mathematics proficiency. Trends in Neuroscience and Education. 2014; 3(2):63–68. https://doi.org/10.1016/j.tine.2013.12.001.

Dahlman S, Bäckström P, Bohlin G, Frans Ö. Cognitive abilities of street children: Low-SES Bolivian boys with and without experience of living in the street. Child Neuropsychology. 2013; 19(5):540–556. [PubMed: 23043625]

de Benitez ST, Hiddleston T. Research paper on the promotion and protection of the rights of children working and/or living on the street. 2011

De Onis M, Blössner M, Borghi E. Prevalence and trends of stunting among pre-school children, 1990–2020. Public Health Nutrition. 2012; 15(1):142–148. [PubMed: 21752311]

DePrince AP, Weinzierl KM, Combs MD. Executive function performance and trauma exposure in a community sample of children. Child Abuse & Neglect. 2009; 33(6):353–361. [PubMed: 19477515]

Dilworth-Bart JE. Does executive function mediate SES and home quality associations with academic readiness? Early Childhood Research Quarterly. 2012; 27(3):416–425.

Dilworth-Bart JE, Khurshid A, Vandell DL. Do maternal stress and home environment mediate the relation between early income-to-need and 54-months attentional abilities? Infant and Child Development. 2007; 16(5):525.

Dobrova-Krol NA, van IJzendoorn MH, Bakermans-Kranenburg MJ, Cyr C, Juffer F. Physical growth delays and stress dysregulation in stunted and non-stunted Ukrainian institution-reared children. Infant Behavior and Development. 2008; 31(3):539–553. [PubMed: 18511123]

Duncan GJ, Magnuson K. Socioeconomic status and cognitive functioning: moving from correlation to causation. Wiley Interdisciplinary Reviews: Cognitive Science. 2012; 3(3):377–386. [PubMed: 26301469]

Evans GW, Schamberg MA. Childhood poverty, chronic stress, and adult working memory. Proceedings of the National Academy of Sciences. 2009; 106(16):6545–6549.

Fernald LC, Grantham-McGregor SM, Manandhar DS, Costello A. Salivary cortisol and heart rate in stunted and nonstunted Nepalese school children. European Journal of Clinical Nutrition. 2003; 57(11):1458–1465. [PubMed: 14576759]

Fernald LC, Gunnar MR. Poverty-alleviation program participation and salivary cortisol in very low-income children. Social Science & Medicine. 2009; 68(12):2180–2189. [PubMed: 19406546]

Fernald LC, Weber A, Galasso E, Ratsifandrihamanana L. Socioeconomic gradients and child development in a very low income population: evidence from Madagascar. Developmental Science. 2011; 14(4):832–847. [PubMed: 21676102]

Flinn MV, England BG. Social economics of childhood glucocorticoid stress response and health. American Journal of Physical Anthropology. 1997; 102(1):33–53. [PubMed: 9034037]

Grantham-McGregor S, Cheung YB, Cueto S, Glewwe P, Richter L, Strupp B, Group ICDS. Developmental potential in the first 5 years for children in developing countries. The Lancet. 2007; 369(9555):60–70.

Guajardo NR, Cartwright KB. The contribution of theory of mind, counterfactual reasoning, and executive function to pre-readers' language comprehension and later reading awareness and comprehension in elementary school. Journal of Experimental Child Psychology. 2016; 144:27–45. [PubMed: 26689129]

Hackman DA, Farah MJ, Meaney MJ. Socioeconomic status and the brain: mechanistic insights from human and animal research. Nature Reviews Neuroscience. 2010; 11(9):651–659. [PubMed: 20725096]

Hackman DA, Gallop R, Evans GW, Farah MJ. Socioeconomic status and executive function: developmental trajectories and mediation. Developmental Science. 2015; 18(5):686–702. [PubMed: 25659838]

Hair NL, Hanson JL, Wolfe BL, Pollak SD. Association of child poverty, brain development, and academic achievement. JAMA pediatrics. 2015; 169(9):822–829. [PubMed: 26192216]

Hammond SI, Müller U, Carpendale JI, Bibok MB, Liebermann-Finestone DP. The effects of parental scaffolding on preschoolers' executive function. Developmental Psychology. 2012; 48(1):271. [PubMed: 21928877]

Hughes CH, Ensor RA. How do families help or hinder the emergence of early executive function? New Directions for Child and Adolescent Development. 2009; 2009(123):35–50. [PubMed: 19306273]

Johnson SB, Riis JL, Noble KG. State of the art review: poverty and the developing brain. Pediatrics. 2016; 137(4):2015–3075. peds.

Lipina SJ, Simonds J, Segretin MS. Recognizing the child in child poverty. Vulnerable Children and Youth Studies. 2011; 6(1):8–17.

McCoy DC, Zuilkowski SS, Fink G. Poverty, physical stature, and cognitive skills: Mechanisms underlying children's school enrollment in Zambia. Developmental Psychology. 2015; 51(5):600. [PubMed: 25844851]

Miller M, Nevado-Montenegro AJ, Hinshaw SP. Childhood executive function continues to predict outcomes in young adult females with and without childhood-diagnosed ADHD. Journal of Abnormal Child Psychology. 2012; 40(5):657–668. [PubMed: 22124540]

Neuman, SB., Moland, N. Urban Education. 2016. Book Deserts The Consequences of Income Segregation on Children's Access to Print. 0042085916654525

Nyberg CH, Leonard WR, Tanner S, Mcdade T, Huanca T, Godoy RA. Diurnal cortisol rhythms and child growth: exploring the life history consequences of HPA activation among the Tsimane'. American Journal of Human Biology. 2012; 24(6):730–738. [PubMed: 23042663]

Obradović J. Physiological responsivity and executive functioning: Implications for adaptation and resilience in early childhood. Child Development Perspectives. 2016; 10(1):65–70.

Obradović J, Yousafzai AK, Finch JE, Rasheed MA. Maternal scaffolding and home stimulation: Key mediators of early intervention effects on children's cognitive development. Developmental Psychology. 2016; 52(9):1409. [PubMed: 27505702]

Oh S, Lewis C. Korean preschoolers' advanced inhibitory control and its relation to other executive skills and mental state understanding. Child Development. 2008; 79(1):80–99. [PubMed: 18269510]

Pluck G, Banda-Cruz DR, Andrade-Guimaraes MV, Trueba AF. Socioeconomic deprivation and the development of neuropsychological functions: A study with "street children" in Ecuador. Child Neuropsychology. 2017:1–14.

Pluess, M., Stevens, S., Belsky, J. The Infant Mind: Origins of the Social Brain. 2013. Differential susceptibility: Developmental and evolutionary mechanisms of gene-environment interactions; p. 77-96.

Raver CC, Blair CB, Willoughby M. Poverty as a predictor of 4-year-olds' executive function: New perspectives on models of differential susceptibility. Developmental Psychology. 2013; 49(2):292. [PubMed: 22563675]

Rockers PC, Fink G, Zanolini A, Banda B, Biemba G, Sullivan C, … Hamer DH. Impact of a community-based package of interventions on child development in Zambia: a cluster-randomised controlled trial. BMJ Global Health. 2016; 1(3):e000104.

Sarsour K, Sheridan M, Jutte D, Nuru-Jeter A, Hinshaw S, Boyce WT. Family socioeconomic status and child executive functions: The roles of language, home environment, and single parenthood. Journal of the International Neuropsychological Society. 2011; 17(01):120–132. [PubMed: 21073770]

Schapkin SA, Falkenstein M, Marks A, Griefahn B. Executive brain functions after exposure to nocturnal traffic noise: effects of task difficulty and sleep quality. European Journal of Applied Physiology. 2006; 96(6):693–702. [PubMed: 16421758]

Snyder, HR. Major depressive disorder is associated with broad impairments on neuropsychological measures of executive function: A meta-analysis and review. American Psychological Association; 2013.

Spaull N, Taylor S. Access to what? Creating a composite measure of educational quantity and educational quality for 11 African countries. Comparative Education Review. 2014; 59(1):133–165.

Tarullo AR, Obradović J, Keehn B, Rasheed MA, Siyal S, Nelson CA, Yousafzai AK. Gamma power in rural Pakistani children: Links to executive function and verbal ability. Developmental Cognitive Neuroscience. 2017; 26:1–8. [PubMed: 28436831]

Walker SP, Wachs TD, Grantham-McGregor S, Black MM, Nelson CA, Huffman SL, … Lozoff B. Inequality in early childhood: risk and protective factors for early child development. The Lancet. 2011; 378(9799):1325–1338.

Worthman CM, Panter-Brick C. Homeless street children in Nepal: Use of allostatic load to assess the burden of childhood adversity. Development and Psychopathology. 2008; 20(1):233. [PubMed: 18211736]