

Building a New Biodevelopmental Framework to Guide the Future of Early Childhood Policy

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Four decades of early childhood policy and program development indicate that evidence-based interventions can improve life outcomes, and dramatic advances in the biological and behavioral sciences now provide an opportunity to augment those impacts. The challenge of reducing the gap between what we know and what we do to promote the healthy development of young children is to view current best practices as a starting point and to leverage scientific concepts to inspire fresh thinking. This article offers an integrated, biodevelopmental framework to promote greater understanding of the antecedents and causal pathways that lead to disparities in health, learning, and behavior in order to inform the development of enhanced theories of change to drive innovation in policies and programs.

Dramatic advances in neuroscience, molecular biology, genomics, and the behavioral and social sciences are deepening our understanding of how healthy development happens, how it can be derailed, and what societies can do to keep it on track. We now know that genes provide the initial blueprint for building brain architecture, environmental influences affect how the neural circuitry actually gets wired, and reciprocal interactions among genetic predispositions and early experiences affect the extent to which the foundations of learning, behavior, and both physical and mental health will be strong or weak (Fox, Levitt, & Nelson, 2010; Meaney, 2010). A strong foundation lays the groundwork for responsible citizenship, economic prosperity, healthy communities, and successful parenting of the next generation. A weak foundation can seriously undermine the social and economic vitality of a nation (Knudsen, Heckman, Cameron, & Shonkoff, 2006).

Decades of research in child development have taught us that families and communities play the central role and bear most of the costs of providing the supportive relationships and positive learning experiences that young children need for healthy development (Shonkoff & Phillips, 2000). There also has been considerable documentation of the extent to which public policies and formal services can enhance developmental outcomes for young children living in a wide variety of circumstances (Karoly, Kilburn, & Cannon, 2005). Building on this extensive knowledge base, striking new discoveries in the biological sciences are presenting policy makers and civic leaders with provocative insights into the far-reaching influences of early developmental processes that were not appreciated as recently as a decade ago. The extent to which advances in molecular biology are already beginning to transform the way we diagnose and treat disease illustrates one example of this new world. The challenge before us is to capitalize on the capacity of this scientific revolution to stimulate creative new ways of thinking about how to address a much broader range of societal concerns, including education reform, workforce development, health promotion, prevention of disease and disability, protection of children from the consequences of maltreatment and exploitation, reduction in violent crime, and alleviation of poverty.

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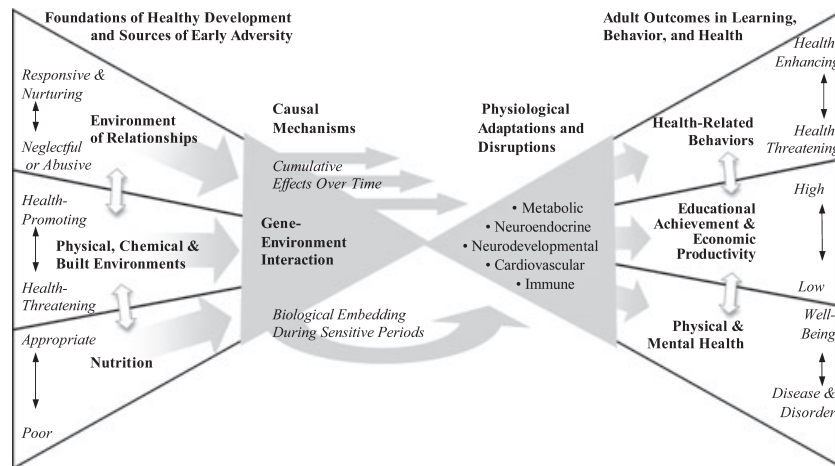


Figure 1. A biodevelopmental framework for understanding the origins of disparities in learning, behavior, and health.

Developmental Frameworks and Theories of Change

Current Models

Early childhood policies and practices over the past several decades have been guided by several theoretical models of human development that have been refined over time. These include the transactional model formulated by Sameroff and Chandler (1975) and later adapted to the challenges of early childhood intervention by Sameroff and Fiese (1990, 2000), the ecological model articulated by Bronfenbrenner (1979), and the concepts of vulnerability and resilience developed by Werner and Smith (1982), Garmezy and Rutter (1983), and Rutter (2000). Together these models underscore the extent to which life outcomes are influenced by a dynamic interplay among the cumulative burden of risk factors and the buffering effects of protective factors that can be identified within the individual, family, community, and broader socioeconomic and cultural contexts. Each of these models also emphasizes the influence of reciprocal child–adult interactions in the developmental process, thereby underscoring the importance of stable and nurturing relationships, as well as the recognition that young children play an active role in their own development. The challenges of applying these multidimensional models, however, lie in their complexity. That is to say, the acknowledgment of numerous, interactive influences on developmental outcomes underscores both the futility of searching for simple solutions to complicated problems and the difficulty in choosing which variables to include and which to omit when one is designing a specific policy, program, or research project.

Building on these broadly supported models of child development, the field of early intervention for children living in disadvantaged circumstances (most typically associated with poverty) in the United States is currently driven by a theory of change that emphasizes the provision of enriched learning opportunities for the children and a combination of parenting education and support services for their families (usually focused exclusively on mothers), in community-based centers and/or the home. Over four decades of program development and evaluation, this basic model has been implemented successfully in a number of flagship demonstration projects, each of which has produced desirable impacts on a range of long-term outcomes, including increased rates of high school graduation and adult earnings, as well as reductions in special education referrals, welfare dependence, and incarceration, among others (Heckman, 2006; Shonkoff & Phillips, 2000).

Building an Enhanced Framework to Inform Innovative Policy

Although the basic principles of development described above have stood up well over time, advances in the biological and social sciences now offer an opportunity to formulate an augmented framework to drive a new generation of early childhood policies and practices. Support for this new framework is underscored by a rich and rapidly growing evidence base that illustrates the extent to which early experiences are biologically embedded in the development of multiple organ systems, with long-term impacts on metabolic regulation and cardiovascular health as well as the mastery of

cognitive, language, and social skills (Hertzman, 2000; Meaney, 2010; Shonkoff, Boyce, & McEwen, 2009). Beyond its potential benefits for policies that affect all young children, the proposed biodevelopmental framework alerts decision makers to the particular importance of addressing the needs of those who are the most disadvantaged at the earliest ages. Equally important, yet potentially more challenging from a policy planning and implementation perspective, new research into individual differences in biological sensitivity to context offers significant promise in helping to explain why some children appear to do well in the face of adversity and why selected interventions appear to be effective for some children and not for others (Obradovic, Bush, Stamperdahl, Adler, & Boyce, 2010; O'Neal et al., 2010).

This new framework for research and policy is informed by a growing body of evidence that the foundations of healthy development and the origins of many impairments can be found among biological "memories" that are created through gene-environment interactions in the early years of life, in some cases beginning as early as the prenatal period (e.g., Barker, 1997; Davis & Sandman, 2010; D'Onofrio et al., 2010). These patterns, often mediated through epigenetic modifications, can be manifested within the circuitry of the developing brain and the physiological systems that influence a variety of biological functions such as stress management, immunological responsiveness, metabolic and neuroendocrine regulation, and cardiovascular integrity. The scientific concepts that explain these phenomena are derived from evolutionary biology, grounded in the assumption that the immature organism "reads" salient environmental characteristics in the service of developing the capacity to adapt to the environment in which it "expects" it will live. When early experiences are nurturing, contingent, stable, and predictable, healthy brain development is promoted, and other organ regulatory systems are facilitated. When early experiences are fraught with threat, uncertainty, neglect, or abuse, stress management systems are overactivated, and the consequences can include disruptions of developing brain circuitry as well as the establishment of a short fuse for subsequent activation of the stress response that leads to greater vulnerability to a host of chronic diseases. Although more research is needed to elucidate the precise nature and full range of causal mechanisms that mediate these effects, there is compelling evidence from recent studies of young children who have been abused or subjected to chronic neglect in institutionalized settings to

support the conclusion that significant adversity early in life can induce physiological responses in the service of short-term survival benefits that come at considerable cost to long-term adaptive capacities as well as both physical and mental health (Cicchetti, Rogosch, Gunnar, & Toth, 2010; Pollak et al., 2010). The relation between low birth weight associated with severe nutritional deficiencies in utero and greater risk of subsequent metabolic syndrome, central body fat distribution, obesity, hypertension, insulin resistance, and cardiovascular disease is another example of this phenomenon (Barker, Osmond, Forsen, Kajantie, & Erikson, 2005).

In an effort to educate policy makers about the biology of adversity and its consequences for both health and development, the National Scientific Council on the Developing Child (2005) proposed a conceptually guided taxonomy based on three categories of stress experience—positive, tolerable, and toxic—to differentiate normative life challenges that are growth promoting from significant threats to long-term health and development that warrant intervention. It is important to note that these three categories refer to the physiological expression of the stress response and not to the specific stressors themselves. Although the underlying biology of these distinctions awaits empirical validation, their conceptual basis is grounded in well-established scientific principles.

Positive stress is characterized by moderate, short-lived increases in heart rate, blood pressure, serum glucose, and circulating levels of stress hormones such as cortisol and inflammatory cytokines such as interleukin-6. Precipitants include the challenges of dealing with frustration, adjusting to a new child-care setting, and other normative experiences. The essential characteristic of positive stress is that it is an important aspect of healthy development that is experienced in the context of stable and supportive relationships that facilitate adaptive responses that restore the stress response system to baseline.

Tolerable stress refers to a physiological state that could potentially disrupt brain architecture (e.g., through cortisol-induced damage of neural circuits in the hippocampus) but is buffered by supportive relationships that facilitate adaptive coping. Precipitants include the death or serious illness of a family member, parental divorce, homelessness, a natural disaster, or community violence. The defining characteristic of tolerable stress is the support provided by invested adults that helps restore the body's stress-response systems to baseline, thereby preventing neuronal disruptions that could lead to

long-term consequences such as posttraumatic stress disorder.

Toxic stress refers to strong, frequent, and/or prolonged activation of the body's stress-response systems in the absence of the buffering protection of stable adult support. Major risk factors include extreme poverty, recurrent physical and/or emotional abuse, chronic neglect, severe maternal depression, parental substance abuse, and family violence. The defining characteristic of toxic stress is that it disrupts brain architecture, adversely affects other organs, and leads to stress management systems that establish relatively lower thresholds for responsiveness that persist throughout life, thereby increasing the risk of stress-related disease or disorder as well as cognitive impairment well into the adult years.

The basic elements of the biodevelopmental framework presented in this article are organized within three sets of target domains: (a) interactions among foundations of healthy development and sources of early adversity, (b) measures of physiological adaptation and disruption, and (c) both positive and negative outcomes in learning, behavior, and health. These domains provide a scaffold for the design of further research into basic developmental processes as well as a roadmap for a new era in early childhood policy focused on specific foundations of health and sources of adversity that offer promising targets for innovative intervention strategies, beginning as early as the prenatal period.

The first target area—the environment of relationships in which a young child develops—requires attention to a continuum from nurturing, responsive caregiving to neglectful or abusive interactions. This includes both family and nonfamily members as important sources of stable and growth-promoting relationships as well as critical buffers against significant threats to healthy development. The second target area—the physical, chemical, and built environments in which the child and family live—requires protection from neurotoxic exposures such as lead, mercury, and organophosphate insecticides; safeguards against injury such as the use of infant seat restraints in automobiles; and availability of safe neighborhoods and the associated social capital that supports families with young children. The third target area for intervention—appropriate versus poor nutrition—requires attention to the availability and affordability of nutritious food; parent knowledge about age-appropriate meal planning for young children that assures adequate intake of both macronutrients (e.g., protein, carbohydrates, and fat) and micronutrients (e.g., vitamins and miner-

als); and effective controls against the growing problem of excess caloric consumption and early obesity.

The second set of domains in the proposed framework includes a variety of physiological responses that present promising opportunities for a new generation of mediating, biological variables whose measurement might inform the effects of a broad range of experiences and interventions. In some cases, these physiological markers may be associated with specific adverse events or experiences that occur during sensitive periods in the development of the brain or other organ systems. The lifelong cognitive deficits and physical impairments associated with first trimester rubella infection or significant prenatal alcohol exposure are two prominent examples of this type of time-sensitive effect. In other circumstances, physiological changes may reflect the cumulative damage or biological “wear and tear” caused by risk factors such as recurrent abuse or chronic neglect that build up over an extended period of time. When early influences have been positive, physiological systems are typically healthy and adaptive. When influences have been adverse, systems may be dysfunctional and lead to impaired learning, maladaptive behavior, illness, disability, and a shortened life span. In both cases, genetic predisposition moderates the effects of environmental influence and differential sensitivity to context can result in differential outcomes (Obradovic et al., 2010). The identification and measurement of these physiological “footprints” offers considerable promise as a potential source of short- and medium-term markers of both resilience and vulnerability in the face of adversity, as well as potential metrics for assessing the impact of early life interventions on mediators of longer term outcomes (such as chronic diseases) that require decades to confirm. Potentially promising biomarkers that appear to be worthy of careful study include measures of oxidative stress, inflammatory cytokines, telomere length, telomerase levels, and epigenetic profiles, among many others.

The third set of target domains includes adult outcomes in educational achievement and economic productivity (high vs. low), health-related behaviors that are enhancing (e.g., nutritious diets, frequent exercise, and use of condoms to prevent sexually transmitted disease) versus those that are threatening (e.g., smoking, alcohol abuse, illicit substance use, unprotected sexual activity, antisocial behavior, and violent crime), and health status (well-being vs. disease or disorder). Although greater details regarding precise causal sequences remain to be elucidated, increasing evidence

supports the conclusion that many aspects of these domains of adult competence and health can be influenced by early life experiences that are amenable to intervention.

The Evolving Context of Early Childhood Policy in the United States

The origins of public support for the notion of intervening in the lives of disadvantaged young children were fueled by four foundational influences in the 1960s—President John Kennedy’s interest in mental retardation, President Lyndon Johnson’s determination to eliminate the intergenerational cycle of poverty, the moral force of the civil rights movement, and emerging scholarship that challenged the prevailing view of genetic determinism and promulgated the novel idea that intelligence could be influenced by experience (Bloom, 1964; Hunt, 1961). When President Johnson called on policy makers and researchers to design a War on Poverty, they created school breakfast programs, neighborhood health centers, and a preschool summer enrichment project named Head Start, among a host of other initiatives. Over the intervening years, randomized controlled trials have demonstrated that a variety of early childhood interventions (including well-studied programs with extended longitudinal follow-up data such as the Perry Preschool Project, Abecedarian Program, and Nurse Family Partnership) can clearly make a positive difference in the development of disadvantaged young children (Campbell & Ramey, 1994; Olds, 2006; Schweinhart, 2005). After more than 40 years of concurrent advances in the science of early childhood development, the challenge facing policy makers at the end of the first decade of the 21st century is clear—it is time to leverage new scientific knowledge in the service of generating new intervention strategies that will produce substantially greater impacts.

We know more now than ever before about how young children learn and about how to facilitate the development of competencies in a variety of domains. We also have greater insights into how significant adversity can produce disruptive physiological effects on the developing brain, cardiovascular system, and immune system that can have lifelong impacts on both educational achievement and health. As the notion of early childhood policy for children and families is attracting the interest of increasing numbers of public and private sector leaders across the political spectrum, these rapidly

moving scientific frontiers offer unprecedented opportunities to stimulate new thinking. With the demand for prudent investment increasing and the pressures on resource allocation growing, three challenges have become increasingly clear.

First, there is marked variability in the quality of implementation of successful programs as they are taken to scale. Demonstration projects tell us what is possible, but their replication on a broader scale has been remarkably uneven. In some cases, failure to achieve comparable impacts has been attributed to the difficulty of reproducing the charismatic leadership and exceptional motivation displayed by those who launch new programs. Others point to the inevitable shortcomings of replication efforts that attempt to serve more children at lower costs by hiring less well-trained staff and burdening them with large caseloads.

Second, increasing evidence indicates that the most effective interventions for children living in poverty produce positive outcomes, but the magnitude of their impacts is typically modest in size. This is perhaps best illustrated in 40-year follow-up data from the most frequently cited early childhood program, the Perry Preschool Project, which reported higher rates of high school graduation (from 45% to 66%) and lower rates of arrest for violent crime (from 48% to 32%) for program participants compared with a randomized control group (Schweinhart, 2005). By any reasonable standard, the magnitude of these intervention impacts would be judged as impressive. However, the fact that one third of the program participants did not graduate high school and another third were arrested indicates the need for more effective intervention strategies. Longitudinal follow-up data on recipients of home visiting services through the Nurse Family Partnership Program support a comparable conclusion (Olds, 2006). Statistically significant impacts on long-term outcomes can be achieved, but effect sizes are often modest and persistent disparities remain to be addressed.

Third, large numbers of young children and families who are at greatest risk, particularly those experiencing toxic stress associated with persistent poverty complicated by child maltreatment, maternal depression, parental substance abuse, and/or interpersonal violence, do not appear to benefit significantly from existing programs. Highly disorganized parents are less likely to seek services and more likely to drop out of programs when they do enroll. When they are successfully engaged, the needs of families facing exceedingly complex social and economic disruptions typically overwhelm conventional early

childhood program staff whose expertise is restricted to child development and parenting education. Consequently, the evaluation literature on interventions for children in highly distressed families, such as programs for children who have been victims of abuse or neglect, reveals relatively limited evidence of success (MacMillan et al., 2007).

Together these three challenges underscore the need for a new era in early childhood policy and practice that is guided by science and driven by leadership that combines a strong sense of civic responsibility, an informed understanding of the positive returns that can be generated by wise investment, and a willingness to explore new ideas. Within this context, the field of early childhood intervention currently requires the concurrent pursuit of two separate, yet complementary, paths. One track leads toward closing the gap between what we know and what we do right now. Its course is well marked—enhanced staff development, increased quality improvement, appropriate measures of accountability, and expanded funding to serve more children and families. The second path heads into less well-charted territory, yet its purpose is deeply compelling—to create a new mind-set that promotes innovation, invites experimentation, and leverages the frontiers of both the biological and social sciences into transformational changes in policy and practice. The first path will bring state-of-the-art services to greater numbers of children and families. The second positions current best practices as a promising starting point, not a final destination. Both courses are essential.

Crafting a Science-Based Transition Into a New Era

In 2000, the National Research Council and Institute of Medicine produced a report entitled, “From Neurons to Neighborhoods: The Science of Early Childhood Development” which proposed three broad sets of research recommendations: (a) integrating child development research, neuroscience, and molecular genetics; (b) integrating the basic science of human development and the applied science of early childhood intervention; and (c) improving evaluations of early childhood interventions (Shonkoff & Phillips, 2000). Striking scientific advances over the ensuing decade now underscore the compelling need for comparable innovation in policy and practice. The following four objectives are offered as promising directions for such efforts:

The need for an expanded definition of evidence that includes well-established scientific concepts as well as benefit-cost data and the results of randomized controlled studies. The growing demand for evidence-based policies and programs is an increasingly powerful force in the early childhood policy arena. Accountability protects the interests of those who rely on services and those who provide them no less than it meets the needs of those who are responsible for funding them. The question is not whether decisions about the allocation of resources should be informed by evidence, but whether the current definition of evidence that guides early childhood investments may be too narrow. There can be no disagreement with the assertion that randomized experiments remain the gold standard for comparing the efficacy and effectiveness of alternative interventions. The value of cost effectiveness and cost-benefit assessments for calculating the monetary returns achieved from selected interventions is also not in question. That said, although these well-established sources of evidence provide useful information about existing services, they offer relatively little guidance for the compelling task of innovation.

Core concepts of development that meet the rigorous criteria of scientific peer review represent an underutilized yet equally important source of evidence for the policy arena. The extensively documented influence of early experience on gene expression is evidence that poor school performance is not an inevitable consequence of growing up in poverty. The disruptive impact of toxic stress on the development of neural circuitry in the immature brain, and the special sensitivity of the hippocampus that contains much of the neural infrastructure for simple memory and early learning, provide compelling evidence of the need for intensive intervention for very young children who have been abused or neglected. The inextricable interactions among neural circuits that subsume cognitive, language, and emotional capacities provide more than enough evidence to indicate that attention to the mental health of children experiencing significant adversity may be as important to their preparation for school success as exposure to experiences rich in language and literacy. Although evidence documenting the adverse effects of exposure to violence on brain development does not tell us anything about the effectiveness of a specific intervention program, it does underscore the need for dramatic rethinking of marginally effective programs for very young children who live in highly threatening environments. Although quantitative

data from cost-benefit studies can help policy makers calculate the financial returns that can be expected from existing services, they offer relatively little guidance for creative agency directors or service providers who are motivated to develop new ideas.

The challenge facing those who seek to reduce the gap between what we know from the biological and behavioral sciences and what we do through policy and practice is to look beyond the program evaluation literature alone and leverage sound scientific concepts to drive innovation. When program evaluation data are presented favorably by advocates and dismissed as methodologically flawed by critics, responsible policy makers can still make informed decisions based on sound scientific principles, followed by ongoing evaluation to determine the impacts of their choices. In short, evidence from randomized experiments and cost-benefit studies is instructive but it simply tells us what we have learned from the past. When these data are augmented by evidence grounded in well-established scientific principles, tempered by a balance of wisdom and creativity, promising new ideas are more likely to emerge.

The need to bring a science-based approach to understanding how early childhood policies and programs can be more responsive to variations in cultural context as well as adversity associated with racial or ethnic discrimination. Acknowledgment of the importance of cultural competence in early childhood policy and practice is common, but scientific investigation of the impact of different childrearing beliefs and practices on early brain development is nonexistent. Moreover, although the need for more behavioral research into the normative development of children who grow up in a variety of cultural contexts is clear, it is essential that such research include more analyses of within-group variability rather than continue to focus primarily on between-group differences. The extent to which advances in the biology of adversity may provide greater insights into the causes of disparities in health and learning outcomes associated with minority group status also awaits further study. Recent findings that children with high neurobiological stress reactivity are more likely to exhibit maladaptive outcomes in the face of significant adversity but better adaptation in the context of low adversity suggests a particularly compelling direction for additional research in this area (Obradovic et al., 2010).

Garcia Coll et al. (1996) proposed an innovative conceptual model for developmental research on minority populations that differed from previous

frameworks by placing constructs related to social position and social stratification at the core of their formulation of child development rather than at the periphery. This approach is based on the assumption that stratifications associated with racism, prejudice, discrimination, and segregation have important effects on the development of minority children, particularly with respect to the impacts of segregation, which can be manifested through various combinations of residential, economic, social, and psychological separation or frank isolation. In a related fashion, the cultural distance between professional staff in early childhood programs who are predominantly representative of the dominant culture and the increasingly diverse population of families with young children they are asked to serve presents a clear challenge that has generated considerable rhetoric, yet relatively little productive action. More empirical data on the developmental consequences of minority group status for young children, separate from the influence of social class, would promote a more constructive approach to this issue.

The need to overcome the persistent fragmentation that typifies health, education, and human services systems by leveraging an integrated, science-based framework rather than negotiating interagency agreements among conceptually disconnected programs. The initial rationale for establishing the National Research Council and Institute of Medicine Committee that produced "From Neurons to Neighborhoods" was a firm belief that the fragmented world of early childhood policy, practice, and research was guided by a single underlying science of early childhood development that needed to be articulated. As our understanding of that unified science base has deepened, the persistent disconnection that typifies the multiple policy streams that address early childhood concerns has become increasingly untenable. The contrast between research-driven attempts by departments of education to provide enriched preschool programs for low-income children and resistance by welfare departments to the establishment of high-quality standards for child care for young children whose mothers face mandated employment regulations is one striking example. Another prominent disconnection is the primary focus on physical safety and the absence of expertise in early childhood mental health within child protective services systems that have responsibility for the well-being of young children who have been abused or neglected. In these and many other circumstances, improved outcomes for children facing significant adversity are most

likely to be achieved through the coordinated application of a unified, science-based framework across agencies and sectors, not through continuing attempts to foster improved interagency cooperation among disparate systems that are guided by divergent, historical traditions rather than convergent, contemporary knowledge.

The need to formulate and test new theories of change to drive more effective interventions. Early childhood policies and practices are likely to advance best within an open environment that engages a broad diversity of values and expertise, promotes intellectual flexibility and creativity, and encourages a willingness to take risks and learn from failure. This is not meant to minimize the continuing importance of efforts that focus on incremental improvements in the quality of existing programs. It is simply intended to underscore the need for dramatic rethinking in the search for more effective intervention strategies.

The biodevelopmental framework described earlier presents an integrated approach for addressing the early childhood roots of disparities in learning, behavior, and health. Advances in neuroscience suggest two currently underaddressed threats to early development that are particularly promising candidates for greater attention. The first and most compelling is the need for more effective intervention strategies to reduce the adverse biological effects of toxic stress on developing brain circuits and other organ systems. As noted above, although the underlying biology is likely to be exceedingly complex and resistant to simple remedies, there is sufficient evidence right now to support substantial new investments in innovative, relationship-based interventions for young children burdened by the stresses of child maltreatment, significant parental mental health impairments (particularly maternal depression and substance abuse), or family violence. Another candidate domain for increased attention, which is closely associated with the immediate consequences of toxic stress, is the disruptive impact of child mental health problems on early learning. In short, the provision of rich, center-based learning experiences for young children is not sufficient to prevent developmental lags if the children are burdened by anxieties or fears as a result of disruptive life circumstances that are not being addressed directly. Similarly, the provision of information on child development and advice on parenting is not sufficient for mothers and fathers with low income and limited education if the parents themselves are having considerable difficulty coping with the stresses of poverty, depression,

substance abuse, food insecurity, homelessness, and/or neighborhood violence.

Stated bluntly, precipitants of toxic stress in the lives of vulnerable children and their families are not currently addressed sufficiently. Although there is a growing evidence base for effective treatment of behavioral and mental health problems in young children, the incorporation of that expertise is extremely limited in the typical early care and education center. The absence of explicit intervention strategies to address the considerable financial burdens experienced by low-income families whose children are enrolled in early childhood programs presents another serious gap, particularly in the face of evidence that the experience of living in poverty between the prenatal period and age 5 appears to have a strong association with subsequent adult earnings and work hours (Duncan, Ziol-Guest, & Kalil, 2010). Finally, the increasing racial and ethnic diversity of the early childhood population and its varied needs demands a deep commitment to the critical task of building, testing, and continually refining more sophisticated and multidimensional theories of change that speak to a broad range of childrearing beliefs and practices.

A Global Perspective on Early Childhood Development

Advances in the natural sciences generate core biological concepts that apply to all animal species. One of the central principles of this growing knowledge base is the critical role of early experiences in shaping the developmental process, whether the subjects of investigation are rodents in laboratory cages, rhesus macaque monkeys in primate research centers, or humans living in a wide variety of social, political, or economic environments. In the wealthiest countries in the world, where economic disparities, racial or ethnic discrimination, and other social challenges are associated with persistent gaps in educational achievement and health status, science can inform the development of innovative policies and practices to mitigate the negative impacts of adversity on young children. In the lowest income countries, which continue to struggle with severe malnutrition, debilitating infection, high child mortality rates, and limited educational achievement, science offers a promising opportunity to augment policies focused exclusively on child survival with a complementary array of investments in early childhood development that will help build the human capital needed to

overcome deeply entrenched poverty and promote a broader social and economic agenda.

Over the past decade, the concept of early childhood development has received increasing attention in several high-profile international documents and reports, including the Education for All Dakar Declaration (UNESCO, 2000), the United Nations Millennium Development Goals (United Nations, 2000), the WHO Commission on Social Determinants of Health (Commission on Social Determinants of Health, 2008), and the 2007 *Lancet* series on child development in low-income countries, which estimated that 200 million children worldwide are not reaching their cognitive potential as a consequence of deep poverty (Grantham-McGregor et al., 2007). Concurrent with this growing global awareness, UNICEF (2009) reported that more than 30 governments have established national early childhood policies and 70 have some type of national mechanism to coordinate programs across ministries or sectors.

Despite these positive trends, however, substantial gaps remain to be closed. More than half of the world's governments do not have any policy or coordination mechanism related to early childhood health and development, and those that have articulated policies are typically guided by statements of intent rather than enforceable or implementable plans. In a parallel fashion, although the first goal articulated in the 2000 Dakar Declaration calls for "expanding and improving comprehensive early childhood care and education," it is the only goal without a quantifiable indicator or specific target by which progress can be measured. Finally, few of the major international donors have identified early childhood as a specific component in their funding strategies and most allocate less than 2% of their development assistance for education at the preprimary school level (UNESCO, 2006).

Generally speaking, global understanding of the science of early childhood development and its implications for framing policy priorities remains limited. This is further complicated by the paucity of available data to determine which interventions have measurable impacts on child well-being in a variety of political and cultural contexts. The need for coordination across policy sectors (i.e., involving ministries in health, education, and finance) as well as among the senior leadership within international agencies adds to the current challenges. Consequently, objectives like enhanced early childhood development are very difficult to achieve and sustain as they tend to be departmentalized, with child survival being the focus of the health sector and

early child care and education that of the education sector. The proposed biodevelopmental model could be used to support a science-based strategy to transcend those barriers.

Concluding Thoughts

After four decades of scientific advances and early childhood program development, we have solid evidence that underscores the role of positive, early experiences in strengthening brain architecture and a growing understanding of how significant adversity damages brain circuits and undermines lifelong learning, behavior, and both physical and mental health. Moreover, neurobiology tells us that the later we wait to invest in children who are at greatest risk, the more difficult the achievement of optimal outcomes is likely to be, particularly for those who experience the early biological disruptions of toxic stress.

Complementing this knowledge base in the biological and developmental sciences, program evaluation data tell us that we can improve the life trajectories of children who face the burdens of poverty and social disadvantage, but the quality of program implementation and the magnitude of measured impacts are highly variable. This evidence base is supported further by the anecdotal reports of early childhood program staff who indicate that they see the positive impacts of their efforts on a daily basis yet are often overwhelmed by the emotional, behavioral, and social problems of many of the children and families they serve. All available information points to the same conclusion—intervention in the early years can make an important difference, and the magnitude of policy and program impacts must be increased.

Science tells us that the early childhood period is a time of both great opportunity and considerable risk, and its influence can extend over a lifetime. The foundational importance of the early years is increasingly appreciated across the political spectrum, and there is growing recognition that families, communities, the workplace, and government each has a shared interest and distinctive, noninterchangeable role to play in assuring the healthy development of all young children. Stated simply, the science of early childhood and brain development is strong and growing, the moral imperative for preventive action is compelling, and the potential social and economic returns on investment are substantial.

The distinguished biologist E. O. Wilson (1998) wrote, "We are drowning in information, while

starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely." The challenge for informed policy making is to focus less attention on competing interpretations of program evaluation data that demonstrate statistically significant but relatively modest impacts and to direct more investment toward generating and testing new ideas about how to improve life outcomes more effectively for those whose needs are not being met. The complementary challenge for the research community is to focus less on fine-tuned measurement of what we already know about the developmental process and more on the formulation, testing, and continuous refinement of new theories of change to address significant threats in the early years of life. An exciting new era in early childhood policy, practice, and research lies at the convergence of these two agendas—an era driven by science, creativity, and pragmatic problem solving in the service of building a more humane present and more promising future for all young children and their families.

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