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An Integrated Scientific Framework for Child Survival and Early Childhood Development

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KEY WORDS

child, child development, child survival, early childhood development, global health, health disparities, poverty, risk factors, social policy

ABBREVIATIONS

ECD—early childhood development
EFA—Education for All
HDI—Human Development Index
MDG—Millennium Development Goals
UNICEF—United Nations Children's Fund
WHO—World Health Organization

As lead author, Dr Shonkoff assumed primary responsibility for conceptualizing the article, assigning the drafting of individual content sections by each of the co-authors, integrating all of the article's sections, and producing a unified manuscript. Drs Shonkoff and Richter originated the idea for the article, and Dr Richter wrote a preliminary draft that Dr Shonkoff built out considerably. Dr Richter contributed to all additions and revisions of the paper. Dr Van der Gaag conceptualized and wrote the section on human capital formation, and Dr Bhutta created and produced the table, in addition to providing content refinement throughout the text.

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abstract

Building a strong foundation for healthy development in the early years of life is a prerequisite for individual well-being, economic productivity, and harmonious societies around the world. Growing scientific evidence also demonstrates that social and physical environments that threaten human development (because of scarcity, stress, or instability) can lead to short-term physiologic and psychological adjustments that are necessary for immediate survival and adaptation, but which may come at a significant cost to long-term outcomes in learning, behavior, health, and longevity. Generally speaking, ministries of health prioritize child survival and physical well-being, ministries of education focus on schooling, ministries of finance promote economic development, and ministries of welfare address breakdowns across multiple domains of function. Advances in the biological and social sciences offer a unifying framework for generating significant societal benefits by catalyzing greater synergy across these policy sectors. This synergy could inform more effective and efficient investments both to increase the survival of children born under adverse circumstances and to improve life outcomes for those who live beyond the early childhood period yet face high risks for diminished life prospects. *Pediatrics* 2012;129:1–13

Building a strong foundation for healthy development during the early years of life is an important prerequisite for lifelong well-being, successful communities, economic productivity, and harmonious civil societies.[1,2] Stated simply, a promising future belongs to those nations that invest wisely in their youngest citizens. Increasing evidence indicates that the lifelong burden of early disadvantages can be difficult to reverse, whereas a good start helps children develop capacities to cope successfully and contribute to the socioeconomic development of the society in which they live. Thus, as progress is made in reducing child mortality, particularly in the poorest countries that carry the greatest burden of unfulfilled human potential, improving the life prospects of those who survive presents an equally compelling priority.[3] To this end, new knowledge in the biological and social sciences can inform innovative strategies to address threats to child survival and well-being, and improve adult outcomes, as well, in ways that did not exist as recently as a decade ago.

Advances in the life sciences have deepened our understanding of the importance of dynamic interactions among environmental influences (including exposure to toxic chemicals), social experiences (including the debilitating effects of poverty, population displacement, unstable relationships, and exposure to violence), nutrition (including the consequences of both inadequate and excessive food intake), and genetic predisposition (including the extent to which experiences can influence gene expression) in affecting both individual and population well-being. New discoveries in molecular biology and epigenetics are explaining how early adversity, as a result of scarcity, stress, or instability, can lead to physiologic disruptions in the developing brain, the cardiovascular system, and other body organs, as well as behavioral adaptations that have lifelong impacts on learning, behavior, and health.[4] Under conditions of extreme disadvantage, short-term physiologic and psychological adjustments that are necessary for immediate survival may come at significant cost to lifelong health and development. Indeed, there is extensive evidence that the long-term consequences of deprivation, neglect, or social disruption can create shocks and ripples that affect generations, not only individuals, and have significant impacts that extend far beyond national boundaries.[5]

CONFRONTING THE HUMAN AND SOCIETAL TOLL OF POVERTY

Severe economic hardship and social adversity impose a cumulative burden of risk on hundreds of millions of children around the world, a burden that undermines multiple dimensions of their lives, including resources, safety, care, and opportunities. Growing up in impoverished or unsafe conditions is associated with significant threats to long-term physical and mental health, cognitive development, educational achievement, emotional well-being, and social adjustment, and these impacts are particularly potent in early childhood.[6–10] Whereas poverty is measured primarily in terms of material assets and purchasing power, associated social and psychological dimensions such as social exclusion, lack of empowerment, and a sense of hopelessness also undermine family dynamics, child-rearing practices, and human development.[11,12]

The undernutrition linked to poverty is estimated to contribute to 35% of all child deaths due to measles, malaria, pneumonia, and diarrhea, as well as to stunted growth for >200 million children worldwide.[13] A recent analysis of longitudinal data from low- and middle-income nations found that poverty and undernutrition in the preschool years accounted for a loss of more than two grades in school and >30% in later adult income.[14] Poverty is also associated with higher levels of exposure to stressful conditions linked to violence, poor infrastructure, and lack of services.[15,16] The longer poor children are exposed to these destabilizing circumstances, the greater the risk that their stress response systems become dysregulated, which leads to increased susceptibility to illness, disability, impaired learning, and social maladjustment in both the short and long term.[17–20]

The failure to address conditions that limit the life prospects of young children seriously undermines the social and economic development sought by all nations.[21–23] Setting priorities for mitigating the adverse impacts of poverty, discrimination, and/or violence on children, however, is not a simple task. The imperative of reducing preventable deaths is fundamental, and the implementation of effective interventions within existing health care systems remains a challenge.[24–34] Equally important, however, is the realization that the campaign to save lives is incomplete if the future prospects of those who survive are constrained by continuing adversity, particularly in the poorest countries. Thus, the time has come to mobilize science to both increase child survival and promote early childhood development.

THE EARLY CHILDHOOD ROOTS OF HUMAN CAPITAL

In 1990, the United Nations Development Program adopted the Human Development Index (HDI), which incorporates a rough assessment of health and education along with income, as an alternative to the Gross Domestic Product per capita as a measure of a country's overall well-being.[34] Ten years later, the international community adopted eight Millennium Development Goals (MDGs),

several of which address child-related aspects of health and education. This perspective was reinforced further in the recent report of the Commission on the Measurement of Economic Performance and Social Progress, which stated that "the time is ripe for our measurement system to shift emphasis from measuring economic production to measuring people's well-being…in a context of sustainability."[35]

The movement toward measures of social and economic development that include dimensions of human well-being (such as nutrition, health, cognitive skills, and social competence), rather than metrics that focus largely on per capita income, underscores the argument for prioritized investment in the early childhood period, when the trajectories of these life outcomes are strongly influenced by early experiences. Indeed, no country that has failed to invest in its young children has experienced rapid development, as measured by the HDI or the so-called capability approach.[36] Furthermore, although some countries (eg, Brazil, China, and India) have achieved relatively rapid economic growth in recent years without substantial investment in early childhood programs, their rising wealth has been accompanied by significant increases in income inequality, with large segments of the population still lacking access to adequate health care, education, and vital social services.

Traditional human capital theory employs a life cycle model that links investment in human capacity, such as education, to increased productivity in the labor market, which, in turn, leads to higher wages and aggregate economic growth.[37,38] Generally speaking, this extensive literature has focused on the development of cognitive skills, based on the assumption that they mediate better school performance, higher levels of educational achievement, increased income, and greater prosperity.[39,40] Recently, some economists have looked beyond cognition alone and emphasized the extent to which emotional and social capacities facilitate cognitive development[41] and ultimate labor market productivity.[42,43] These analysts have also noted that competencies achieved at one stage increase the productivity of human capital investments at a later stage, thus leading to dynamic multiplier effects over time and a strong case for early intervention.[44]

Beyond the importance of attaining skills, health status (including nutrition) is also highly correlated with economic outcomes. An estimated 30% of the growth in per capita income that occurred in Britain between 1790 and 1980 (a period that included the Industrial Revolution) has been explained by the improved gross nutrition of the labor force.[45] The correlation between income and health indicators other than nutrition is also strong, yet the causal direction has been harder to determine. That said, substantial progress has been made in establishing the impact of health on wages and productivity, especially in low-income settings.[46] Moreover, there is considerable evidence documenting the relation between early health status (including birth weight and growth during the first few years) and later health outcomes in adulthood, as well as with educational achievement, family income, household wealth, individual earnings, and labor supply.[47–51]

Both the HDI and the MDGs recognize the importance of health, nutrition, and education as necessary components of well-being that many view as a matter of basic human rights.[52,53] It is also becoming increasingly well understood that these dimensions of human development are important drivers of economic welfare generally and of poverty reduction specifically.[54,55] Consequently, the usual trade-offs between investments to reduce poverty and its correlates (eg, malnutrition, disease, illiteracy) versus investments to stimulate economic growth do not exist (in the long run) for investments in young children, where the net result is synergy, not competition.

The economic literature on human capital development and prosperity has progressed from the static life cycle models of the past, which focused largely on formal education and labor market outcomes, to current dynamic models that recognize the importance of the timing of investments, the relations among cognition, executive function skills (ie, working memory, cognitive flexibility, and inhibitory control), and social competence, as well as interactions among multiple dimensions of human capital such as nutrition, health, and school achievement.[56,57] These contemporary models also reflect greater understanding of the intergenerational nature of human capital formation, particularly in terms of the links among maternal educational attainment, the social status of women, and the healthy development of children.[58,59] Building on these conceptual shifts in economics, advances in neuroscience, genomics, and developmental psychology are shedding new light on the underlying causal mechanisms that link early life experiences to adult human capital, thereby presenting an extraordinary opportunity to reframe policy discourse in development economics.[60,61]

In 2002, the General Assembly of the United Nations endorsed a new agenda entitled *A World Fit for Children*, which included an expanded commitment to early childhood policies to enhance physical, social, emotional, spiritual, and cognitive development.[62] Despite this bold declaration, an estimated 200 million children under age 5 currently fail to meet their developmental potential as a result of poverty and undernutrition.[14] This figure is 20-fold higher than

the number of children who die before their fifth birthday and represents roughly one-third of all children under age 5 in the world.[14] The economic implications of these data are underscored by recent longitudinal analyses that reported significant loss of education and adult earnings attributable to early undernutrition in five low- and middle-income countries.[63]

BUILDING A COORDINATED, SCIENCE-BASED APPROACH TO CHILD SURVIVAL, CHILD DEVELOPMENT, AND LIFELONG HEALTH

Although full elucidation of the underlying causal mechanisms that explain socioeconomic disparities in health and learning awaits further investigation, a rich and growing science of early childhood development is available to inform the design of more effective interventions to both increase survival for children born under conditions of significant disadvantage and improve the life prospects of those who do not die yet face extraordinarily high risks for poor outcomes.[1] To this end, the National Scientific Council on the Developing Child[64] proposed a conceptual framework that draws on the following evidence-based principles:

- The architecture of the brain is constructed through an ongoing process that begins before birth, continues into adulthood, and establishes either a sturdy or a fragile foundation for all the health, learning, and behavior that follow.
- The interaction of genes and experiences literally shapes the circuitry of the developing brain, and is critically influenced by the mutual responsiveness of adult-child relationships, particularly in the early childhood years.
- Skill begets skill as brains are built in a hierarchical fashion from the bottom up, with increasingly complex circuits building on simpler circuits and increasingly complex and adaptive skills emerging over time.
- Cognitive, emotional, and social capacities are inextricably intertwined, and learning, behavior, and both physical and mental health are highly interrelated over the life course.
- Although manageable levels of stress are normative and growth-promoting, toxic stress in the early years (ie, the physiologic disruptions precipitated by significant adversity in the absence of adult protection) can damage the developing brain and other organ systems and lead to lifelong problems in learning and social relationships as well as increased susceptibility to illness.
- Brain plasticity and the ability to change behavior decrease over time, so getting things right the first time is less costly, to society and individuals, than trying to fix them later.
- We have the capacity to measure effectiveness factors that make the difference between interventions that work and those that do not work to support healthy child development.

The link between significant adversity in childhood and increasing risk for later disorders in physical and mental health has been documented extensively.[4,65–67] Low birth weight and poor infant growth, for example, are associated with a range of metabolic disorders.[68] Children who have been neglected, abused, or malnourished are more likely to have heart disease as adults.[69–73] They are also at greater risk for a variety of health-threatening behaviors such as smoking and substance abuse, as well as depression and anxiety disorders.[74–77]

The most widely postulated biological explanation for these well-established associations points to the long-term consequences of short-term adaptations in neuroendocrine, autonomic, immunologic, and neuropsychological systems[78] that are designed to cope with immediate threat, yet become problematic in the face of excessive activation.[4,79] Alterations in electroencephalography tracings and elevated levels of cortisol and norepinephrine in children exposed to repeated trauma and maltreatment are examples of such responses.[65,80] Converging evidence from epidemiology and neuroscience also indicates that a variety of stresses in early life, including adverse intrauterine influences such as nutritional deficiencies, can cause enduring abnormalities in brain organization and structure, as well as in endocrine regulatory processes, that lead to reduced immune competence and higher or less regulated cortisol levels, among other consequences.[63,81,82] Extreme stress and fear in infancy can also result in later patterns of hypervigilance and dysregulated relationships that impair learning, socialization, and productivity.[78]

To fully understand the ways in which survival, growth, learning, and health are interrelated and undermined in comparable ways by significant adversity, it is essential to understand the central role of the brain in interpreting and regulating the body's neuroendocrine, autonomic, and immunologic responses to stressful events. Stated simply, the brain is the body's central control center that influences both physiologic and behavioral responses to threat as well as the development of coping skills in the face of adversity.[83] Moreover, the brain is not only an engine of physiologic change in other organ systems, but it is also itself a target of acute and chronic stress, both physical and psychological, and therefore it

changes both structurally and functionally in response to significant threat.[84]

The biology of adversity and resilience demonstrates that significant stressors, beginning in utero and continuing throughout the early years, can lead to early demise or produce long-lasting impacts on brain architecture and function that are associated with later variations in stress responsiveness, learning, and relationships, as well as with alterations in health and the rate of aging. Stress-induced changes have been well documented in multiple brain regions, with the most extensive work focused on the hippocampus (which specializes in circuits associated with simple memory), the amygdala (which mediates fear and aggression), and the prefrontal cortex (which mediates executive functions such as planning and self-regulation). These changes involve stress-induced remodeling of neuronal structure and connectivity, which can alter a range of behavioral and physiologic responses, including anxiety, aggression, mental flexibility, and memory, among other processes.[84] When stress response systems are overactivated during the early years, they are programmed to adapt to an environment that is "expected" to remain adverse. As a result, the threshold for activation is lower and the "hair trigger" nature of the stress response results in greater risk for overly rigid and often aggressive behavior.

Beyond the impact of stress-induced changes in brain circuitry on behavior, the consequences for lifelong health and well-being are also apparent. For example, functional activation of the prefrontal cortex has been shown to be related to changes in blood pressure, and elevated amygdala activity has been linked to the development of atherosclerosis.[85] Reduced hippocampal volume seen in association with years of chronic stress[86] has also been documented in individuals with diabetes, Cushing's disease, major depression, and posttraumatic stress disorder, as well as in predisease states associated with elevations in circulating inflammatory cytokines.[87,88] Moreover, research based on the "Barker (thrifty phenotype) hypothesis" has produced considerable evidence documenting an association between adverse fetal conditions, as reflected in relatively lower birth weight and the subsequent patterning of growth in the first 2 years of life, and a variety of poor health outcomes in adulthood. These include increased risk of coronary artery disease, hypertension, and stroke,[72] as well as diabetes[89] and obesity,[90] all of which are modified by the speed and patterning of subsequent growth during childhood, also in response to environmental conditions.[91] Relatively larger birth weight, in contrast, has been found to be associated with increased risk of some hormone-related cancers.[92]

The most widely accepted explanation of these findings has been described as "programming," whereby a specific exposure during a sensitive period is hypothesized to exert irreversible, long-term effects through epigenetic mechanisms (with or without parallel psychological adaptations) that "read" the environment in ways that inform subsequent health or developmental processes. In the case of undernutrition, for example, the fetus adapts to a condition of scarcity in the intrauterine environment to improve its immediate chances of survival as a hedge against future food shortages.[93] Such adaptations cause permanent changes in endocrine physiology and metabolic regulation that result in higher rates of obesity in the face of later caloric sufficiency, as well as increased risk for a variety of adult diseases such as diabetes and hypertension. These same physiologic systems can be overwhelmed and result in early death or continue to respond to ongoing adversity during early childhood in ways that ultimately lead to greater risk of impaired health and compromised functionality in the adult years.[94,95]

THE GLOBAL LANDSCAPE FOR CHILD SURVIVAL AND EARLY CHILDHOOD DEVELOPMENT

The systematic tracking of child mortality on a global scale began in the 1960s, and efforts to improve survival rates were accelerated in the early 1980s under the vigorous leadership of the United Nations Children's Fund (UNICEF). The combined impacts of a range of interventions during this period led to a global drop in under-5 mortality from an estimated 121 per thousand in 1980 to 88 per thousand in 1986, saving the lives of some 12 to 25 million children.[96,97] Over the ensuing decades, the application of both traditional public health principles and new biomedical advances have fueled a number of highly effective initiatives, and overall child mortality has continued to decline to an estimated 68 per thousand in 2008.[98]

Despite important progress toward MDG #4, which is focused on the reduction of child mortality, the premature deaths of >8 million children each year remain a formidable challenge. Worldwide, children under 5 are about four times more likely to die than adults between 15 and 59 years of age,[99–101] and 90% of those who die before their fifth birthday live in the poorest 42 countries in sub-Saharan Africa and South Asia.[97,102,103] In 2005, the World Health Assembly passed a resolution putting maternal and child health and survival at the top of their list of priorities, which was followed by substantial budget commitments to extend interventions for child survival.[104–106] A recent report for the period from 2000 to 2010 found that, although overseas development assistance for

maternal, newborn, and child health had increased, funding for this sector accounted for only 31% of all development assistance for health in 2007.[26] In an effort to spur greater progress toward meeting MDG goals in this area, the United Nations launched a Global Strategy for Women's and Children's Health in 2010 with a stated objective of saving 16 million lives by 2015.[107]

The major causes of death under the age of 5 in the wealthiest nations currently include neonatal conditions, congenital anomalies, motor vehicle accidents, and cancer. The most common causes of childhood mortality in the poorest countries are diarrhea, pneumonia, measles, and neonatal conditions, with undernutrition as a major underlying contributing factor. Malaria and HIV add significant additional casualties in vulnerable areas. The current knowledge base driving the child survival agenda is grounded in traditional public health principles and the demonstrated effectiveness of interventions such as the provision of adequate nutrition, clean water, sanitation, and basic medical care; promotion of early and exclusive breastfeeding; immunization, oral rehydration therapy, and vitamin A supplementation; the use of insecticide-treated bed nets to prevent malaria; and prevention and treatment of HIV/AIDS. Table 1 provides a listing of recent reviews of interventions designed to improve maternal, newborn, and child health and nutrition.

While it is clear that continuing biomedical research will advance our ability to further reduce mortality on a global scale, important challenges to child survival in the developing world still remain within the realm of political will and effective delivery of basic nutrition, sanitation, and personal health services. These challenges are manifested in the need for existing health systems to deliver an effective combination of health promotion, disease prevention, and therapeutic interventions. The successful implementation of these services requires competent governance, functional facilities and supply chains, a well-trained and motivated health care work force, and additional resources.[108] Increasing demand through community engagement and mobilization are other critically important factors influencing maternal and newborn care in poor countries.[109]

Equally important, and deserving of increased attention, the biology of adversity suggests that social interventions that reduce or mitigate the physiologic consequences of toxic stress associated with significant material deprivation (with or without the additional burdens of recurrent abuse, chronic neglect, intrafamily and civic violence, and maternal depression) represent a promising enhancement of existing strategies for reducing early childhood mortality. To this end, interventions focused on strengthening the capacities of families to meet their children's needs in the face of destitution or threat suggest two causal pathways to prevent premature death. The first is predicated on more effective utilization of preventive and therapeutic health services. The second is based on the protective influence of parents' ability to promote greater resilience in their children by facilitating effective coping mechanisms in the face of adversity.

Building on these efforts, as child mortality rates continue to fall, the foundational importance of the early childhood period for lifelong health and development suggests that survival alone can no longer be a sufficient goal, especially for the poorest countries. Indeed, the scientific concepts outlined in this article suggest a common underlying vulnerability that leads to a continuum of risk, from early mortality through a broad spectrum of compromised learning as well as impairments in both physical and mental health. Thus, the extent to which persistent scarcity, stress, and social instability pose continuing threats to the life prospects of children must be a focus for more proactive intervention.

As the science of early childhood development (ECD) has received increasing recognition globally, the demand for greater attention to the needs of young children has been incorporated into several high-profile international documents, including the World Declaration on Education for All (EFA)[110] and the Dakar Framework for Action,[111] the Millennium Development Goals, and the Report of the World Health Organization (WHO) Commission on Social Determinants of Health.[112] In 2006, UNICEF reported that >30 low- and middle-income countries had established national ECD policies, and >70 nations had some type of national commission to coordinate ECD programs across ministries and sectors.[113] These calls for greater investment in young children have been buttressed by increasing evidence of the effectiveness of early childhood interventions on a range of health and developmental outcomes in low- and middle-income countries.[29,114,115] Within this increasingly receptive environment, advances in the biology of adversity offer considerable promise as an additional catalyst to help stimulate the design and testing of coordinated strategies to further reduce preventable death and to build a foundation for a lifetime of healthy development.[24,32,63,116–135] When viewed through this broader lens, current medically based interventions that are designed primarily to improve maternal and child survival are also likely to have positive influences on child development, yet these outcomes have not been measured in most evaluations of such programs. For example, antenatal services for women that lead to lower rates of intrauterine growth retardation[24] result

TABLE 1 Reviews of Interventions Focused on Maternal, Newborn, and Child Health and Nutrition

Review	Focus	Scope	Data Sources	Findings/Recommendations
Lancet review of child survival (2003)[32]	Child mortality under age 5	Comprehensive review	23 interventions	Groups of preventive and treatment interventions but no delivery strategies
WHO review of practices that promote child survival, growth, and development (2004)[31]	Children under age 5	Review of evidence for 12 key practices identified by UNICEF and WHO	12 key practices	Underscored importance of linking practices at community level with service availability
Lancet review of neonatal outcomes (2005)[28]	Newborn mortality	Community-based interventions review (few RCTs)	43 interventions	16 newborn interventions packaged into three delivery strategies (community, outreach, and facility levels)
Lancet review of maternal survival (2006)[27]	Maternal mortality and morbidity	Literature and program review (few RCTs)	120 interventions	Recommended facility-based skilled care at childbirth as the core intervention
Review of maternal and perinatal priorities in developing countries (2006)[30]	Maternal care	Literature review and component analysis for cost-effectiveness	84 interventions	5 intervention packages considered (with or without nutritional supplements)
Lancet review of child development programs (2007)[29]	Child and adult cognitive and other developmental outcomes	Literature and program review (few RCTs)	20 programs	Recommendation to integrate early child stimulation and nutrition programs, and evaluate at scale
Lancet review of maternal, newborn, and child care (2007)[33]	Maternal, newborn, and child mortality	Literature and delivery strategy review for interventions across continuum of care	190 interventions	8 packages of interventions targeted at four levels (household and community, outreach, upper and lower level facilities)
Lancet review of undernutrition (2008)[24]	Maternal, newborn, child, and adult mortality and morbidity due to undernutrition	Literature and program review (RCTs and observational studies)	45 interventions	Maternal nutrition and supportive interventions targeted to children during the first 24 months
Lancet review of primary health care (2008)[25]	Interventions relevant to maternal, newborn, and child survival and selected key risk factors	Literature and program review (RCTs & observational studies)	156 interventions	37 key interventions recommended for inclusion in primary care settings
Lancet review of countdown to maternal, newborn, and child survival goals (2010)[26]	Focus on maternal, newborn, and child survival-related interventions and tracking coverage	Review of relevant information from DHS and MICs data sources	22 interventions and respective coverage	Better coverage seen with programmable interventions such as EPI vaccinations, vitamin A supplementation, etc.
Lancet review of stillbirths (2011)[34]	Focus on strategies to influence fetal health and growth affecting stillbirths	Comprehensive review of available information and trial data	35 interventions	10 evidence-based interventions recommended for inclusion in programs in developing countries including expanded antenatal care for prevention of pregnancy induced hypertension, and detection and management of IUGR and diabetes

RCT, randomized controlled trial; DHS, demographic and health survey; MIC, multiple indicator cluster survey; EPI, expanded program on immunization; IUGR, intrauterine growth retardation.

in the birth of babies who are at lower risk biologically for developmental impairments. Another example is provided by interventions that promote breastfeeding to enhance both nutritional status and immunologic competence,[32,119,125] which are also likely to promote early developmental progress by strengthening maternal-infant attachment. In a reciprocal fashion, strategies that focus explicitly on strengthening caregiver-child interactions and expanding early learning opportunities in the face of significant material deprivation are likely to reduce or mitigate the biological impacts of adversity on very young children, thereby enhancing both their survival and their development.

Although the underlying science that supports investment in early childhood development has advanced considerably, and the literature on effective demonstration projects in low-income countries is growing, empirical evidence of the successful scale-up of specific interventions across national and cultural settings is less well developed. Moreover, EFA Goal 1 addresses early childhood objectives, yet it is the only education goal without a quantifiable indicator against which progress can be measured.[136] Similarly, more than half of the world's governments have ECD policies that are statements of intent rather than enforceable mandates. These concerns are compounded by the limited number of major international donors who have identified ECD as a specific focus, the majority of whom allocate <2% of their education funding to the early childhood years.[136]

Over the past several decades, early childhood policies and practices 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[137] and later adapted to the challenges of early childhood intervention by Sameroff and Fiese[138]; the ecological model articulated by Bronfenbrenner[139]; and the concepts of vulnerability and resilience developed by Werner and Smith,[140] Garmezy and Rutter,[141] and Rutter.[142] Together, these frameworks underscore the extent to which life outcomes are influenced by a dynamic interplay between 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 and recognizing the active role that young children play in their own development. The challenges of actually applying this multidimensional framework include both avoiding the lure of simplistic solutions and making strategic decisions about which factors to address and which to omit in designing a specific policy, program, or empirical study.[143]

In response to these challenges, early childhood intervention services typically include nutrition supplements, basic health services, and a combination of nurturing care and enriched learning opportunities for children, linked to a mix of parenting education, emotional support, and social protection and social services for their families. Over four decades of program development and evaluation, this approach has been implemented in demonstration projects around the world that have confirmed the ability to produce significant impacts across a range of outcomes.[144] Although much of the empirical literature has come from the United States, where positive returns on investment have been documented in cost savings from decreased grade retention and referrals for special education as well as lower prevalence of later welfare dependence and incarceration,[1] the evidence base for successful intervention across a broad diversity of nations is growing.

In low- and middle-income countries, model programs that combine nutrition and psychosocial stimulation services have demonstrated the greatest impact on disadvantaged populations.[145] A review of 20 programs that met rigorous scientific criteria found that all but one (which was delivered at a very low level of intensity) had positive effects on children's cognitive development, whereas some also reported gains in social competence, with effect size estimates ranging from 0.3 to1.8.[29] A more recent meta-analysis of evidence from 30 interventions utilizing a variety of approaches in 23 countries in Europe, Asia, Africa, and Latin America also found moderately positive effects across multiple developmental domains.[146] Of the models studied, eight provided early education, five provided child care, five focused on nutrition, four combined nutrition and early education, two linked nutrition and child care, one provided both early education and child care, and six focused primarily on cash transfers. On average, the magnitude of the long-term effects was about one-quarter to one-third of a SD, with cognitive impacts at the higher end (particularly in programs with an explicit education component) and positive effects sustained through adulthood when long-term data were obtained.[114]

Recent modifications of conventional ECD programs have included greater attention to financial and social protection for parents, increasing focus on confronting violence against women and young children, and the promotion of positive engagement of men in addressing family needs. These and other program models have been delivered through a variety of mechanisms including home visiting, primary

health facilities,[146,147] and group sessions with caregivers.[148] In this context, a broader range of social interventions, such as conditional and unconditional cash transfers, microcredit schemes, and voucher programs, are increasingly being adopted to meet the needs of disadvantaged, young children around the world. Conditional cash transfers appear to be a particularly promising strategy to expand ECD impacts, because they improve the immediate, material circumstances of poor families (by providing money), while also enhancing the life prospects of the children by having the "conditions" linked to services that strengthen their health, nutrition, and early educational experiences. Evaluations of these programs have documented positive impacts on children's nutritional status;[149] encouraging evidence of their ability to address critical child needs in resource-poor settings or areas that have been struck by extreme adversity such as internal wars or large-scale epidemics[150,151]; and promising reports of their implementation in sub-Saharan Africa.[152,153] For societies that are burdened by the highest levels of material deprivation and political instability, the need for more innovative approaches that go beyond the provision of conventional health care and early childhood programs clearly remains a particularly compelling challenge. In such circumstances, an integrated science of early childhood health and development offers a powerful framework within which creative new strategies can be formulated, tested, and refined over time.

CONCLUDING COMMENTS

Extensive documentation of the value of investing in healthy development beginning at birth (and indeed, prenatally) stands in stark contrast to current policies regarding human capital formation in virtually every nation in the world. A recent study of child well-being in 28 countries in the Organization for Economic Cooperation and Development (OECD) estimated per capita expenditures on children in the first 18 years of life at $126 000, with an average of only 24% spent during the period from birth to age 5, compared with 36% spent from age 6 to 11 and 41% from age 12 to 17.[154] Comparable data on human capital investment in developing countries are not available, yet the gaps between human needs and available resources are known to be considerable at all age levels. This situation is most severe in sub-Saharan Africa, where the absolute poverty rate for children is the highest in the world, the rate of growth stunting exceeds 30%, and only 12% of children are enrolled in preschool compared with an average rate globally of 32% in developing countries and 74% for developed nations.[155] In 21 of the 48 countries in the region, infant mortality is well above 100 per thousand. In the realm of education, gross primary enrollment rates approach 100% in many countries, but primary grade completion remains below 50% in one-third of them and preprimary enrollment is typically in the single digit range or nonexistent.[155]

Science tells us that the foundations of lifelong health and learning are built in the earliest years of life. Therefore, the time has come to match continuing progress in the global reduction of child mortality with greater investment in the universal promotion of early childhood development, particularly in the poorest nations. Sustainable gains in child survival have been generated by social interventions and health care initiatives that focus on improving the physical and mental health of mothers, promoting the stability and security of families, supporting child nutrition, ensuring child protection against significant adversity, securing basic health services of good quality, and building culturally compatible bridges between service programs and homes. A systematic analysis of these core strategies for reducing mortality reveals a remarkable overlap with many of the key characteristics of interventions that are effective in promoting healthy development, which typically add the essential element of enriched learning opportunities in the early years of life. Central to both objectives is the importance of preventing, reducing, or mitigating the adverse physiologic consequences of toxic stress, which can range from the life-threatening consequences of compromised immune function to the impaired learning that results from disrupted brain circuitry. Stated simply, the future of more effective early childhood policy calls for a balanced approach to both stimulating minds and protecting brains.[156] Recent reports from the American Academy of Pediatrics call for new approaches to health promotion based on this concept.[157,158]

Within this context, as ministries of health continue to prioritize child survival, ministries of education focus on schooling, and ministries of finance promote economic development, an integrated biology of adversity offers a compelling knowledge base that could inform a unifying strategy across policy sectors. The fruits of that synergy, a healthy and well-educated population, secure and well-functioning communities, and a prosperous and self-sustaining society, will be harvested by those nations that make science-based investments in the healthy development of their youngest members.

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