The science of early brain development can inform investments in early childhood. These basic concepts, established over decades of neuroscience and behavioral research, help illustrate why child development—particularly from birth to five years—is a foundation for a prosperous and sustainable society.

1 Brains are built over time, from the bottom up. The basic architecture of the brain is constructed through an ongoing process that begins before birth and continues into adulthood. Early experiences affect the quality of that architecture by establishing either a sturdy or a fragile foundation for all of the learning, health and behavior that follow. In the first few years of life, 700 new neural connections are formed every second. After this period of rapid proliferation, connections are reduced through a process called pruning, so that brain circuits become more efficient. Sensory pathways like those for basic vision and hearing are the first to develop, followed by early language skills and higher cognitive functions. Connections proliferate and prune in a prescribed order, with later, more complex brain circuits built upon earlier, simpler circuits.

2 The interactive influences of genes and experience shape the developing brain. Scientists now know a major ingredient in this developmental process is the ‘serve and return’ relationship between children and their parents and other caregiv-

POLICY IMPLICATIONS

- The basic principles of neuroscience indicate that early preventive intervention will be more efficient and produce more favorable outcomes than remediation later in life.
- A balanced approach to emotional, social, cognitive, and language development will best prepare all children for success in school and later in the workplace and community.
- Supportive relationships and positive learning experiences begin at home but can also be provided through a range of services with proven effectiveness factors. Babies’ brains require stable, caring, interactive relationships with adults—any way or any place they can be provided will benefit healthy brain development.
- Science clearly demonstrates that, in situations where toxic stress is likely, intervening as early as possible is critical to achieving the best outcomes. For children experiencing toxic stress, specialized early interventions are needed to target the cause of the stress and protect the child from its consequences.
ers in the family or community. Young children naturally reach out for interaction through babbling, facial expressions, and gestures, and adults respond with the same kind of vocalizing and gesturing back at them. In the absence of such responses—or if the responses are unreliable or inappropriate—the brain's architecture does not form as expected, which can lead to disparities in learning and behavior.

3 The brain's capacity for change decreases with age. The brain is most flexible, or "plastic," early in life to accommodate a wide range of environments and interactions, but as the maturing brain becomes more specialized to assume more complex functions, it is less capable of reorganizing and adapting to new or unexpected challenges. For example, by the first year, the parts of the brain that differentiate sound are becoming specialized to the language the baby has been exposed to; at the same time, the brain is already starting to lose the ability to recognize different sounds found in other languages. Although the "windows" for language learning and other skills remain open, these brain circuits become increasingly difficult to alter over time. Early plasticity means it's easier and more effective to influence a baby's developing brain architecture than to rewire parts of its circuitry in the adult years.

4 Cognitive, emotional, and social capacities are inextricably intertwined throughout the life course. The brain is a highly interrelated organ, and its multiple functions operate in a richly coordinated fashion. Emotional well-being and social competence provide a strong foundation for emerging cognitive abilities, and together they are the bricks and mortar that comprise the foundation of human development. The emotional and physical health, social skills, and cognitive-linguistic capacities that emerge in the early years are all important prerequisites for success in school and later in the workplace and community.

5 Toxic stress damages developing brain architecture, which can lead to life-long problems in learning, behavior, and physical and mental health. Scientists now know that chronic, unrelenting stress in early childhood, caused by extreme poverty, repeated abuse, or severe maternal depression, for example, can be toxic to the developing brain. While positive stress (moderate, short-lived physiological responses to uncomfortable experiences) is an important and necessary aspect of healthy development, toxic stress is the strong, unrelieved activation of the body's stress management system. In the absence of the buffering protection of adult support, toxic stress becomes built into the body by processes that shape the architecture of the developing brain.

For more information, see "The Science of Early Childhood Development" and the Working Paper series from the National Scientific Council on the Developing Child.

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Research on the developing brain shows us that early childhood experiences build the foundation for a skilled workforce, a responsible community, and a thriving economy. A new evidence base has identified a set of skills that are essential for school achievement, for the preparation and adaptability of our future workforce, and for avoiding a wide range of population health problems.

In the brain, the ability to hold onto and work with information, focus thinking, filter distractions, and switch gears is like an airport having a highly effective air traffic control system to manage the arrivals and departures of dozens of planes on multiple runways. Scientists refer to these capacities as executive function and self-regulation—a set of skills that relies on three types of brain function: working memory, mental flexibility, and self-control. Children aren’t born with these skills—they are born with the potential to develop them. The full range of abilities continues to grow and mature through the teen years and into early adulthood. To ensure that children develop these capacities, it’s helpful to understand how the quality of the interactions and experiences that our communities provide for them either strengthens or undermines these emerging skills.

1. **When children have had opportunities to develop executive function and self-regulation skills successfully, both individuals and society experience lifelong benefits.**

   - **School Achievement**—Executive function skills help children remember and follow multi-step instructions, avoid distractions, control rash responses, adjust when rules change, persist at problem solving, and manage long-term assignments. For society, the outcome is a better-educated population capable of meeting the challenges of the 21st century.
   
   - **Positive Behaviors**—Executive functions help children develop skills of teamwork, leadership, decision-making, working toward goals, critical thinking, adaptability, and being aware of our own emotions as well as those of others. For society, the outcome is more stable communities, reductions in crime, and greater social cohesion.
   
   - **Good Health**—Executive function skills help people make more positive choices about nutrition and exercise; to resist pressure to take risks, try drugs, or have unprotected sex; and to be more conscious of safety for ourselves and our children. Having good executive function primes our biological systems and coping skills to respond well to stress. For society, the outcome is a healthier population, a more productive workforce, and reduced health care costs.

   - **Successful Work**—Executive function skills increase our potential for economic success because we are better organized, able to solve problems that require planning, and prepared to adjust to changing circumstances. For society, the outcome is greater prosperity due to an innovative, competent, and flexible workforce.

2. **The critical factors in developing a strong foundation for these essential skills are children’s relationships, the activities they have opportunities to engage in, and the places in which they live, learn, and play.**

   - **Relationships**—Children develop in an environment of relationships. This starts in the home and extends to caregivers, teachers, medical and human services professionals, foster parents, and peers. Children are more likely to build effective executive function skills if the important adults in their lives are able to:
     
     - **Support** their efforts;
     - **Model** the skills;
• Engage in activities in which they practice the skills;
• Provide a consistent, reliable presence that young children can trust;
• Guide them from complete dependence on adults to gradual independence; and
• Protect them from chaos, violence, and chronic adversity, because toxic stress caused by these environments disrupts the brain circuits required for executive functioning and triggers impulsive, “act-now-think-later” behavior.

Activities—Building these abilities in young children requires communities and caregivers to provide and support experiences that promote emotional, social, cognitive, and physical development broadly, including a range of strategies that:
• Reduce stress in children’s lives, both by addressing its source and helping them learn how to cope with it in the company of competent, calming adults;
• Foster social connection and open-ended creative play, supported by adults;
• Incorporate vigorous physical exercise into daily activities, which has been shown to positively affect stress levels, social skills, and brain development;
• Increase the complexity of skills step-by-step by finding each child’s “zone” of being challenged but not frustrated; and
• Include repeated practice of skills over time by setting up opportunities for children to learn in the presence of supportive mentors and peers.

Places—The home and other environments where children spend most of their time must:
• Feel (and be) safe;
• Provide space for creativity, exploration, and exercise;
• Be economically and socially stable in order to reduce the anxiety and stress that come with uncertainty or fear.

If children do not get what they need from their relationships with adults and the conditions in their environments—or (worse) if those influences are sources of toxic stress— their skill development can be seriously delayed or impaired. That said, science shows that there are opportunities throughout development to provide children, adolescents, and the adults who care for them with the relationships, environments, and skill-building activities that will enhance their executive function capacities. It’s just easier, less costly, and more effective to get them right from the start.

POLICY IMPLICATIONS
• Efforts to support the development of these skills deserve much greater attention in the design of early care and education programs. Policies that emphasize literacy instruction alone could increase their effectiveness by including attention to the development of executive function skills.
• Teachers of young children would be better equipped to understand and address behavioral and learning challenges in their classrooms if they had professional training in the development of executive function skills. Teachers are often the first to recognize serious problems with a child’s ability to control impulses, focus attention, stay organized, and follow instructions. The consequences of mismarketing these problems as “bad behavior” can lead to a highly disrupted classroom, preventable expulsions, or the inappropriate use of psychotropic medications.
• For young children facing serious adversity, policies that combine attention to executive function and reducing the sources of toxic stress would improve the likelihood of success in school and later in life. Adverse conditions such as abuse, neglect, community violence, and persistent poverty can disrupt brain architecture and place children at a disadvantage with regard to the development of their executive function skills. Lessons learned from interventions that have successfully fostered these skills hold considerable promise for incorporation into home visiting, parent education, and family support programs.
• Adult caregivers need to have these skills in order to support their development in children. Programs such as job-skills training that intentionally build executive function and self-regulation capacities in adult caregivers not only help them become more economically secure, but they also enhance their ability to model and support these skills in children.

For more information, see “Building the Brain’s ‘Air Traffic Control’ System: How Early Experiences Shape the Development of Executive Function” and the Working Paper series from the Center on the Developing Child at Harvard University. www.developingchild.harvard.edu/resources/

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ALSO IN THIS SERIES:
INBRIEF: The Science of Early Childhood Development
INBRIEF: The Impact of Early Adversity on Brain Development
INBRIEF: Early Childhood Program Effectiveness
INBRIEF: The Foundations of Lifelong Health
INBRIEF: Early Childhood Mental Health
A vital and productive society with a prosperous and sustainable future is built on a foundation of healthy child development. Positive early experiences provide a foundation for sturdy brain architecture and a broad range of skills and learning capacities. Health in the earliest years—beginning with the future mother's well-being before she becomes pregnant—strengthens developing biological systems that enable children to thrive and grow up to be healthy adults. The science of child development now helps us to see healthy development as a causal chain—policies and programs across the public and private sectors affect the capacities of caregivers and communities to strengthen three foundations of healthy development: stable, responsive relationships; safe, supportive environments; and appropriate nutrition. These foundations, in turn, trigger physiological adaptations or disruptions that influence lifelong outcomes in health, learning, and behavior. Understanding how each link in this chain affects the others can provide a science-based framework for decisions about policies, systems, and practices that support the healthy development of all young children and their families.

1 The biology of health explains how experiences and environmental influences “get under the skin” and interact with genetic predispositions, which then result in physiological adaptations or disruptions that affect lifelong outcomes in learning, behavior, and both physical and mental well-being. Advances in neuroscience, molecular biology, and genomics have converged on three compelling conclusions:

- Early experiences are built into our bodies, creating biological “memories” that shape development, for better or for worse.
- Toxic stress caused by significant adversity can produce physiological disruptions that undermine the development of the body's stress response systems and affect the architecture of the developing brain, the cardiovascular system, the immune system, and metabolic regulatory controls.
- These physiological disruptions can persist far into adulthood and lead to lifelong impairments in both physical and mental health.
2 The foundations of health establish a context within which the early roots of physical and mental well-being are nourished. These include:

- A stable and responsive environment of relationships, which provides young children with consistent, nurturing, and protective interactions with adults that enhance their learning and help them develop adaptive capacities that promote well-regulated stress response systems;
- Safe and supportive physical, chemical, and built environments, which provide places for children that are free from toxins and fear, allow active, safe exploration, and offer families raising young children opportunities to exercise and make social connections; and
- Sound and appropriate nutrition, which includes health-promoting food intake and eating habits, beginning with the future mother’s pre-conception nutritional status.

3 Caregiver and community capacities to promote health and prevent disease and disability refers to the ability of family members, early childhood program staff, neighborhoods, voluntary associations, and the parents’ workplaces to support and strengthen the foundations of child health. These capacities can be grouped into three categories:

- Time and commitment, which includes the nature and quality of time caregivers spend with children and on their behalf, as well as how communities assign and accept responsibility for monitoring child health and developmental outcomes and pass and enforce legislation and regulations that affect child well-being;
- Financial, psychological, and institutional resources, which includes caregivers’ ability to purchase goods and services, their physical and mental health, and their child-rearing skills, as well as the availability of community services and organizations that promote children’s healthy development and supportive structures, such as parks, child care facilities, schools, and after-school programs; and
- Skills and knowledge, which includes caregivers’ education, training, interactions with child-related professionals, and personal experiences, plus the political and organizational capabilities of communities to build systems that work for children and families.

4 Public and private sector policies and programs can strengthen the foundations of health by enhancing the capacities of caregivers and communities in the multiple settings in which children develop. Relevant policies include legislative and administrative actions that affect public health, child care and early education, child welfare, early intervention, family economic stability, community development, housing, environmental protection, and primary health care. In short, nearly any policy that touches the lives of children and families can be seen as an opportunity to improve lifelong health outcomes in our communities and states. The private sector can also play an important role in strengthening the capacities of families to raise healthy and competent children, particularly through supportive workplace policies.

For more information, see “The Foundations of Lifelong Health Are Built in Early Childhood” and the Working Paper series from the Center on the Developing Child at Harvard University.

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POLICY IMPLICATIONS

- Current health promotion and disease prevention policies focused on adults would be more effective if evidence-based investments were also made to strengthen the foundations of health in the prenatal and early childhood periods. For example, obesity-reduction measures focused on changing adult and adolescent behaviors would be more successful if they were coordinated with programs supporting appropriate nutrition and better access to nutritious foods for pregnant mothers, infants, and toddlers.

- Significant reductions in chronic disease could be achieved across the life course by decreasing the number and severity of adverse experiences that threaten the well-being of young children and by strengthening the protective relationships that help mitigate the harmful effects of toxic stress.

- Effective health promotion and disease prevention depend on more than access to high-quality medical care. A wide range of service systems could improve outcomes significantly by applying a unified scientific understanding of the early childhood origins of health, learning, and behavior across multiple sectors. In other words, child welfare agencies could help prevent adult physical and mental health impairments, not just provide immediate child protection. Zoning and land-development policies could facilitate improved population health (and reduced health care costs), not just generate commercial profit. High-quality early care and education programs that buffer young children from excessive stress could promote health and prevent disease, not just prepare the children to succeed in school.
FIVE NUMBERS TO REMEMBER ABOUT EARLY CHILDHOOD DEVELOPMENT

700 PER SECOND
18 MONTHS
90-100%
3:1 ODDS
4-9 DOLLARS

This feature highlights five numbers to remember about the development of young children. Learn how the numbers illustrate such concepts as the importance of early childhood to the learning, behavior, and health of later life and why getting things right the first time is easier and more effective than trying to fix them later. This feature is also available in a web-based slideshow format at http://developingchild.harvard.edu/resources/multimedia/interactive_features/five-numbers/

For more resources from the Center on the Developing Child at Harvard University visit http://developingchild.harvard.edu/resources/

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The early years matter because, in the first few years of life, 700 new neural connections are formed every second. Neural connections are formed through the interaction of genes and a baby’s environment and experiences, especially “serve and return” interaction with adults, or what developmental researchers call contingent reciprocity. These are the connections that build brain architecture – the foundation upon which all later learning, behavior, and health depend.

18 MONTHS: AGE AT WHICH DISPARITIES IN VOCABULARY BEGIN TO APPEAR

Early experiences and the environments in which children develop in their earliest years can have lasting impact on later success in school and life. Barriers to children's educational achievement start early, and continue to grow without intervention. Differences in the size of children's vocabulary first appear at 18 months of age, based on whether they were born into a family with high education and income or low education and income. By age 3, children with college-educated parents or primary caregivers had vocabularies 2 to 3 times larger than those whose parents had not completed high school. By the time these children reach school, they are already behind their peers unless they are engaged in a language-rich environment early in life.

FIVE NUMBERS TO REMEMBER ABOUT EARLY CHILDHOOD DEVELOPMENT

90-100% CHANCE OF DEVELOPMENTAL DELAYS WHEN CHILDREN EXPERIENCE 6-7 RISK FACTORS

Significant adversity impairs development in the first three years of life—and the more adversity a child faces, the greater the odds of a developmental delay. Indeed, risk factors such as poverty, caregiver mental illness, child maltreatment, single parent, and low maternal education have a cumulative impact: in this study, maltreated children exposed to as many as 6 additional risks face a 90-100% likelihood of having one or more delays in their cognitive, language, or emotional development.

Source: Barth et al. (2008)
Early experiences actually get into the body, with lifelong effects—not just on cognitive and emotional development, but on long term physical health as well. A growing body of evidence now links significant adversity in childhood to increased risk of a range of adult health problems, including diabetes, hypertension, stroke, obesity, and some forms of cancer. This graph shows that adults who recall having 7 or 8 serious adverse experiences in childhood are 3 times more likely to have cardiovascular disease as an adult. And children between birth and three years of age are the most likely age group to experience some form of maltreatment—16 out of every thousand children experience it.

Source: Dong et al. (2004)
FIVE NUMBERS TO REMEMBER ABOUT EARLY CHILDHOOD DEVELOPMENT

4-9

$4 - $9 IN RETURNS FOR EVERY DOLLAR INVESTED IN EARLY CHILDHOOD PROGRAMS

TOTAL RETURN PER $1 INVESTED

To Individuals
Increased earnings

To The Public
Crime-cost, special education and welfare savings, increased income taxes

Providing young children with a healthy environment in which to learn and grow is not only good for their development—economists have also shown that high-quality early childhood programs bring impressive returns on investment to the public. Three of the of the most rigorous long-term studies found a range of returns between $4 and $9 for every dollar invested in early learning programs for low-income children. Program participants followed into adulthood benefited from increased earnings while the public saw returns in the form of reduced special education, welfare, and crime costs, and increased tax revenues from program participants later in life.

Sources: Masse, L. and Barnett, W.S., A Benefit Cost Analysis of the Abecedarian Early Childhood Intervention (2002); Karoly et al., Early Childhood Interventions: Proven Results, Future Promise (2005); Heckman et al., The Effect of the Perry Preschool Program on the Cognitive and Non-Cognitive Skills of its Participants (2009)

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1. Getting things right the first time is easier and more effective than trying to fix them later.

2. Early childhood matters because experiences early in life can have a lasting impact on later learning, behavior, and health.

3. Highly specialized interventions are needed as early as possible for children experiencing toxic stress.

4. Early life experiences actually get under the skin and into the body, with lifelong effects on adult physical and mental health.

5. All of society benefits from investments in early childhood programs.