



FETAL BRAIN DEVELOPMENT & RESILIENCE

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LOCAL AGENCY WIC NUTRITIONISTS, NOVEMBER 26, 2019

DISCLAIMER

- I have no financial interests to disclose.
- I do not intend to discuss any unapproved or investigational use of commercial products or devices.

OBJECTIVES

At the conclusion of this presentation attendees will be able to:

- Name one developmental outcome adversely affected by maternal stress
- Describe an evidence-based association between fetal exposure to stress in utero and infant behavior
- Describe one resilience factor that may protect the developing fetus from adverse consequences of maternal stress

INFANT MENTAL HEALTH ENDORSEMENT

Core Competency

- Pregnancy & Early Parenthood



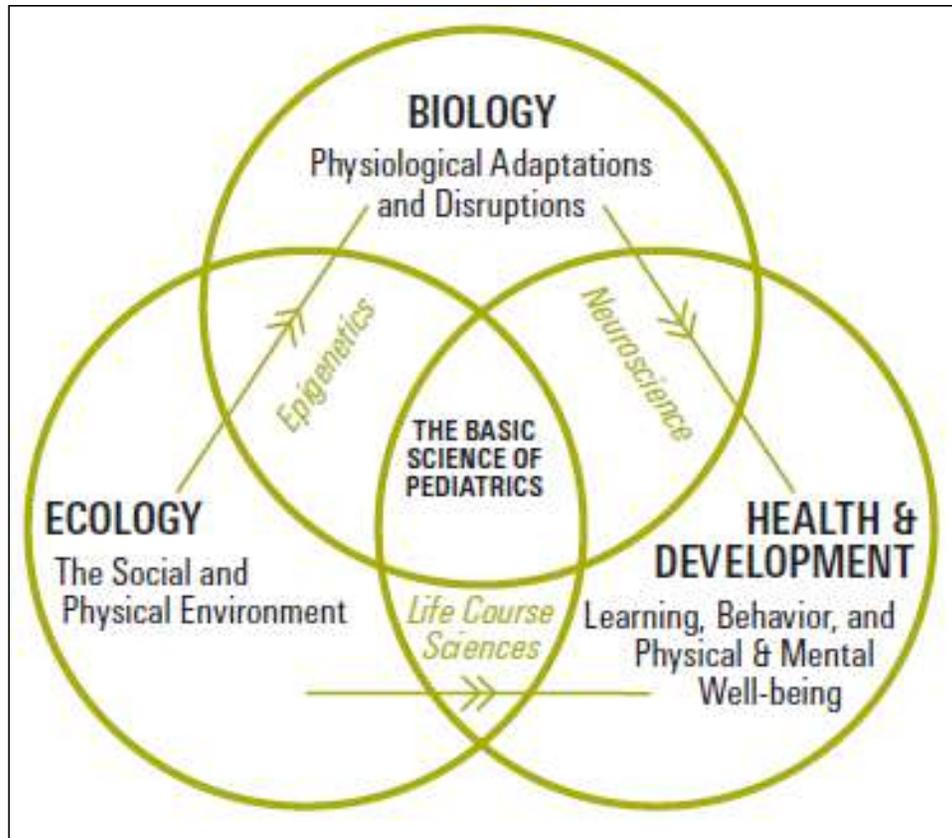
*“Environment can be as deterministic
as we once believed only genes could
be, and...the genome can be as
malleable as we once believed only
environments could be...”*

Kaufer & Frances



*How we care for our children is how,
at last,
we take charge of our own destiny.*

Laurence Frank, 1939



Shonkoff, Garner 2012



AGENDA

Part 1: The Neuroscience of Brain Development

Part 2: Fetal Programming & Resiliency

Part 3: Approaches to Intervention

Part 4: Discussion



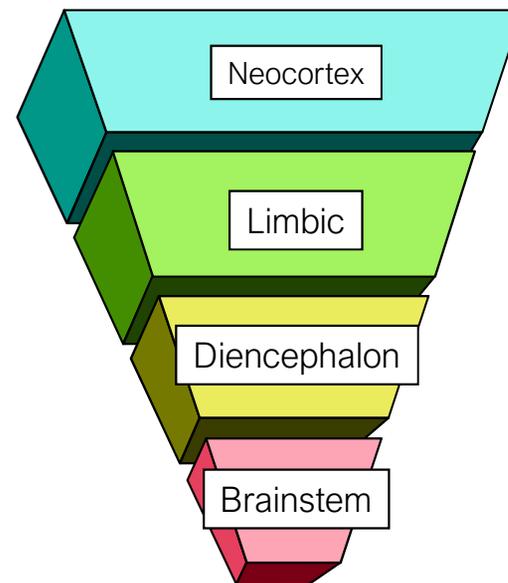
PART 1

NEUROSCIENCE OF BRAIN DEVELOPMENT



BRAIN DEVELOPMENT—4 CORE PRINCIPLES

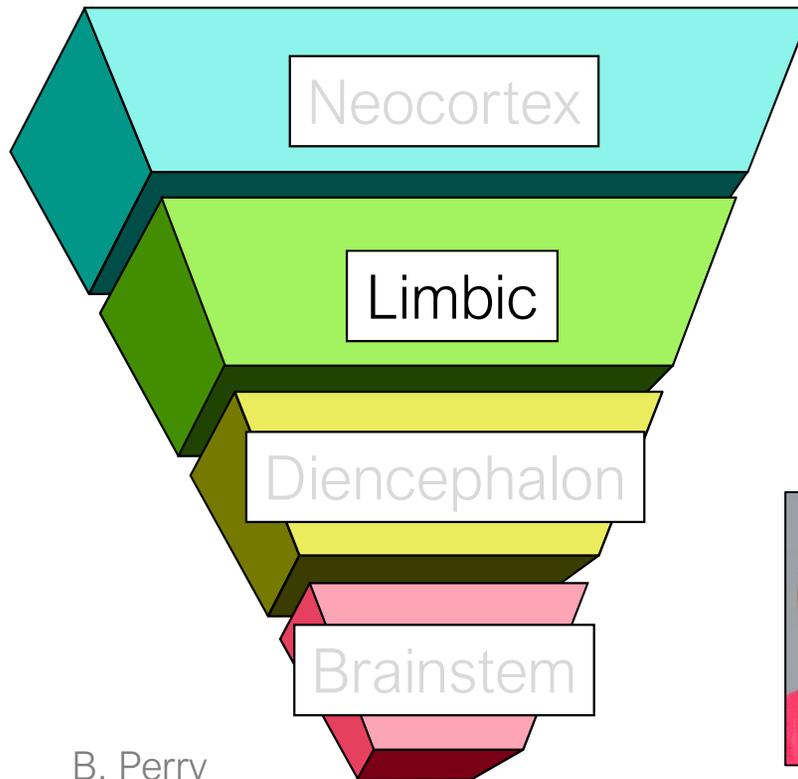
- Genetics & environmental influences
- Sequential/hierarchical development
- Experience-dependent neurodevelopment
- « Sensitive periods » opportunity & vulnerability



Perry B 2002

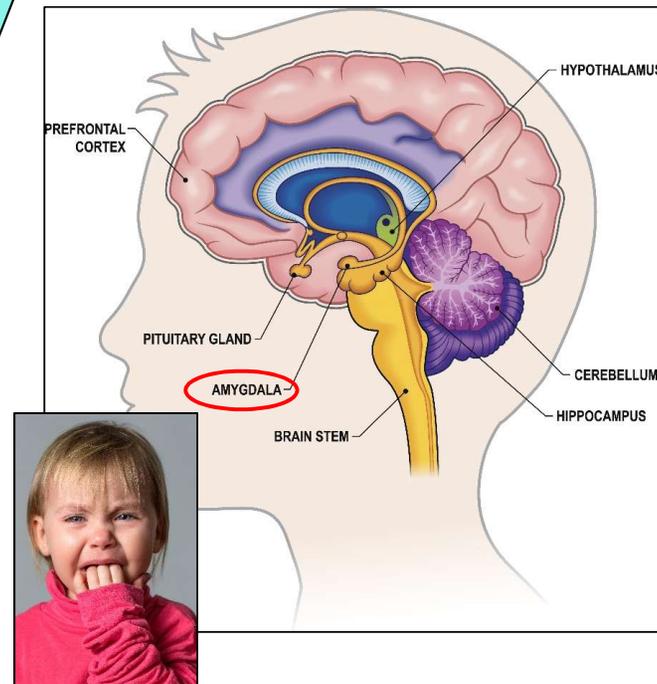
National Research Council & IOM 2000

BRAIN DEVELOPMENT

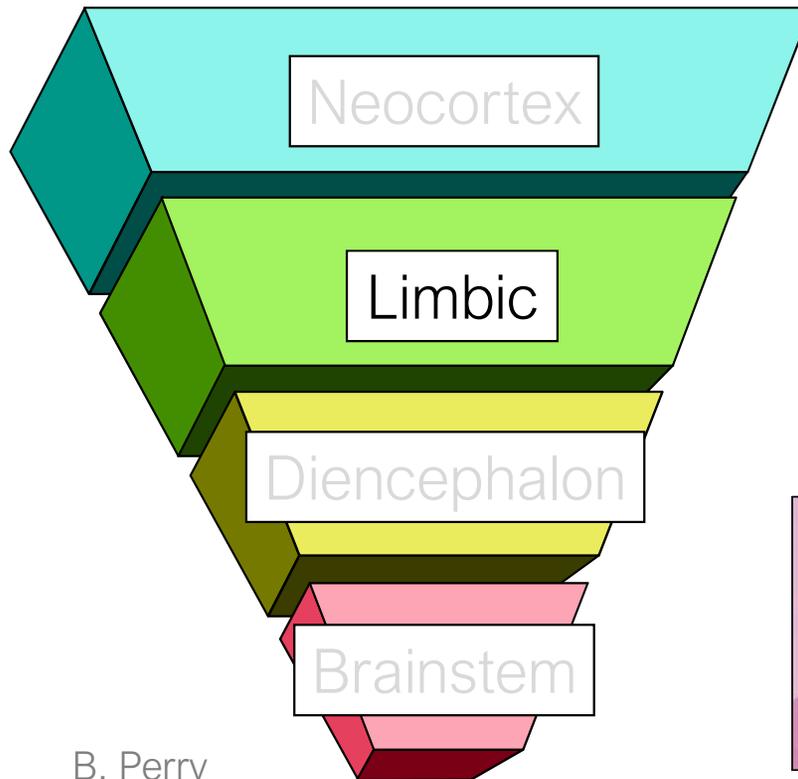


B. Perry

Amygdala

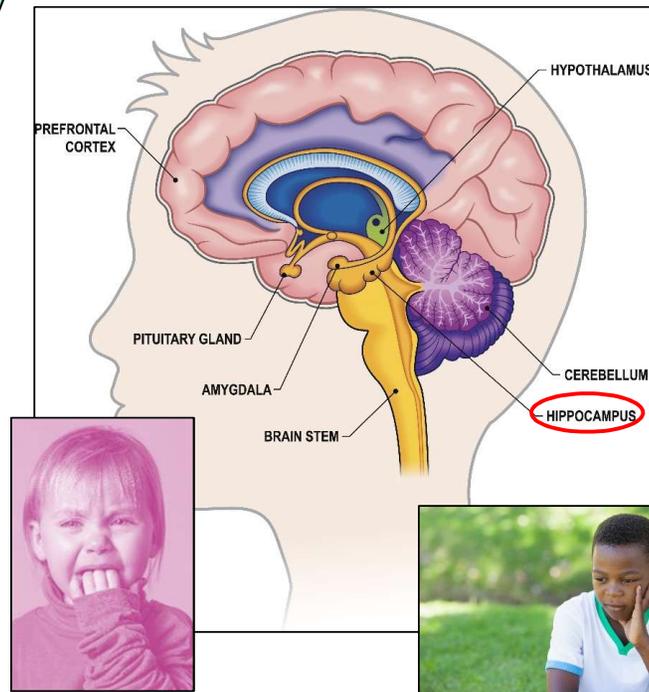


BRAIN DEVELOPMENT

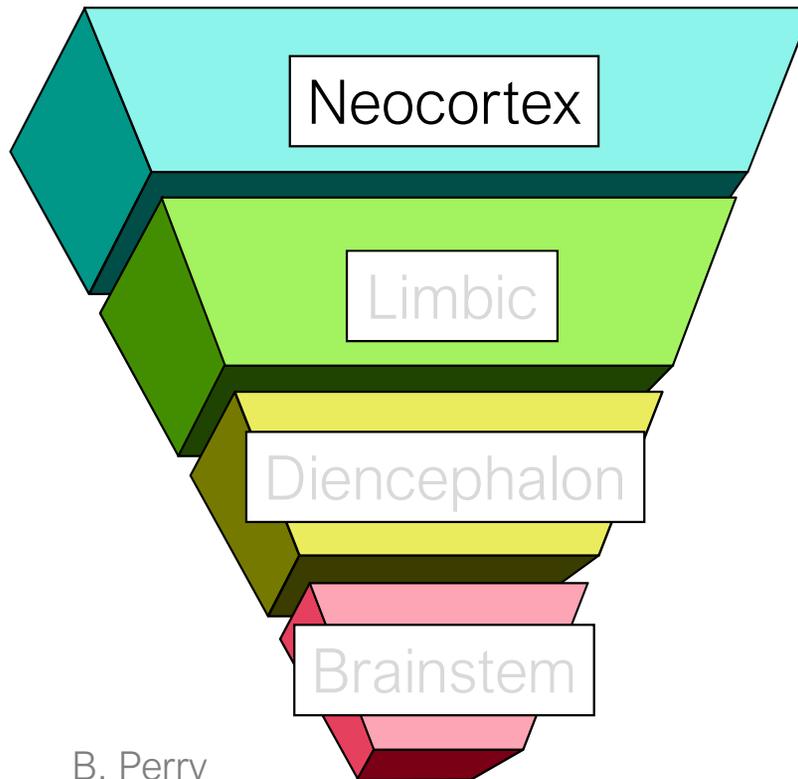


B. Perry

Hippocampus

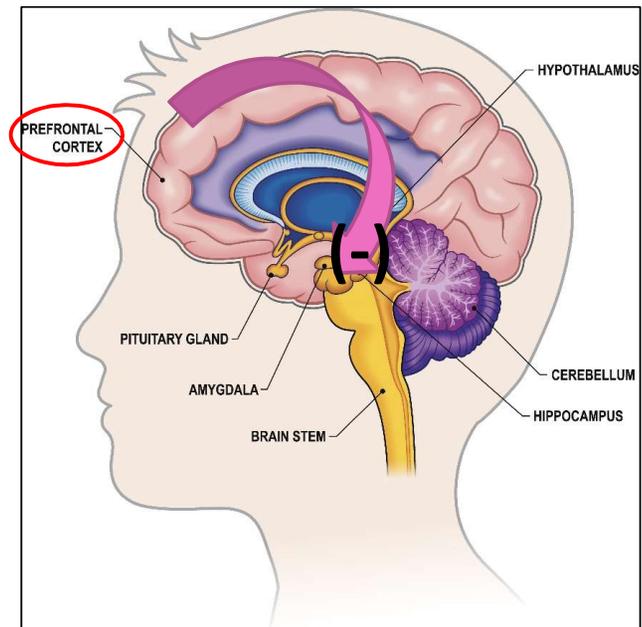


BRAIN DEVELOPMENT

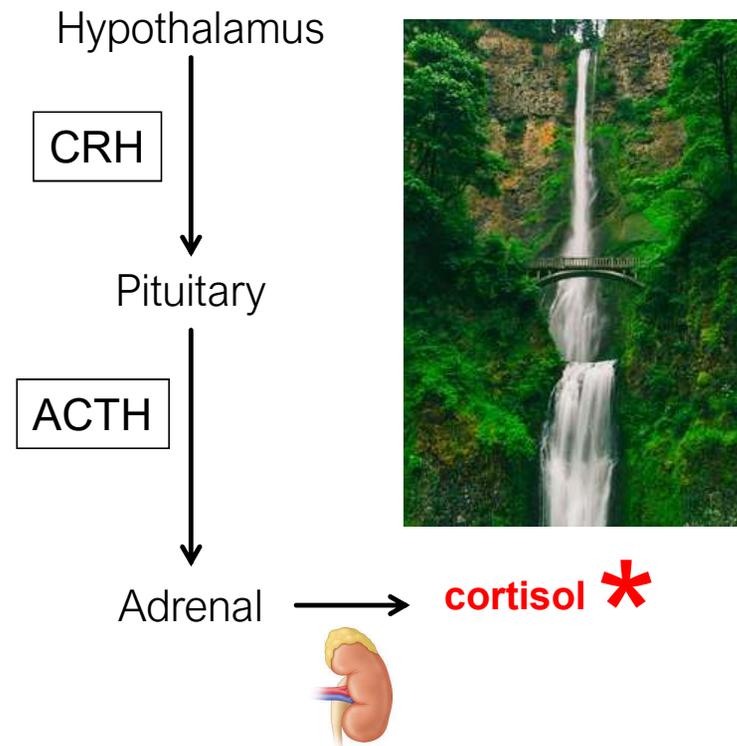
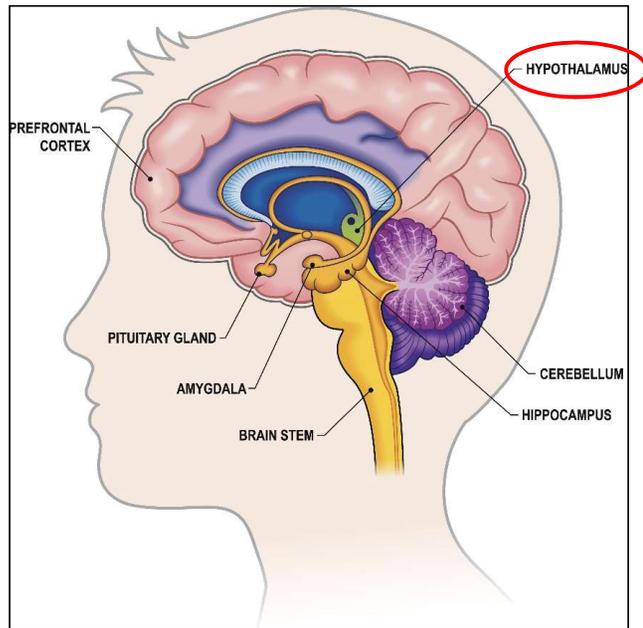


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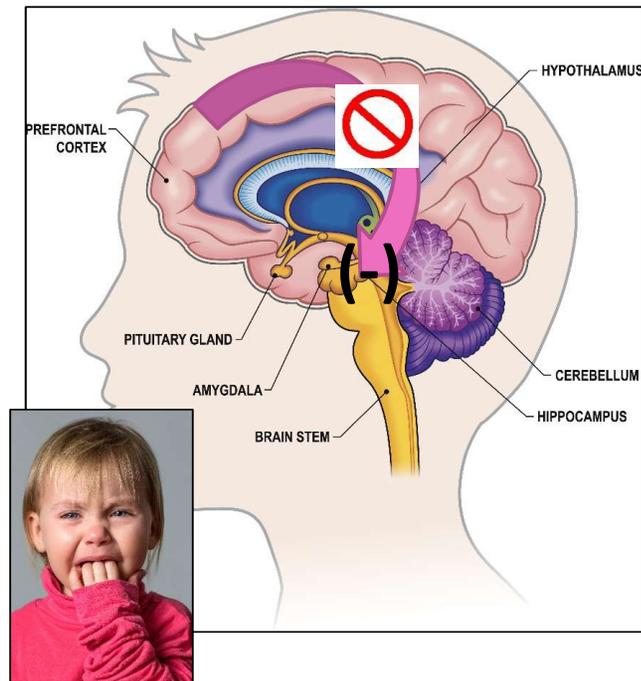
Prefrontal Cortex



HYPOTHALAMIC-PITUITARY-ADRENAL AXIS

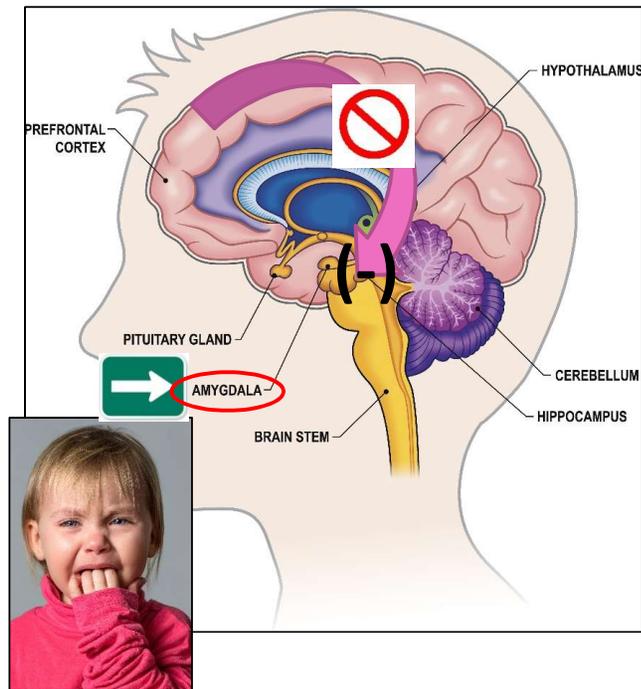


STRESS



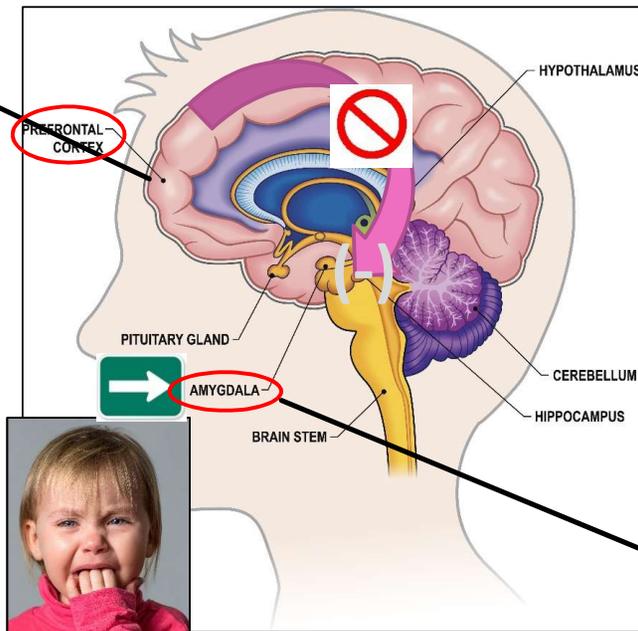
STRESS

Implicit Memory



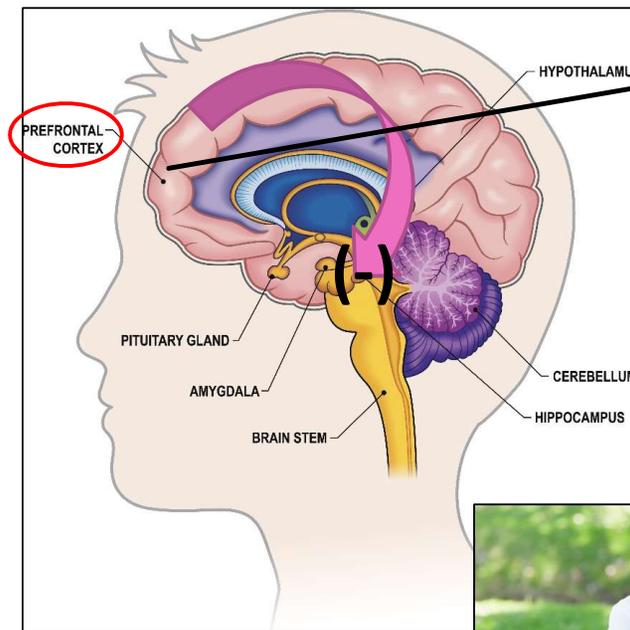
Hypoplasia
under developed

STRESS



Hypertrophy
overgrowth

HEALTHY BRAIN DEVELOPMENT

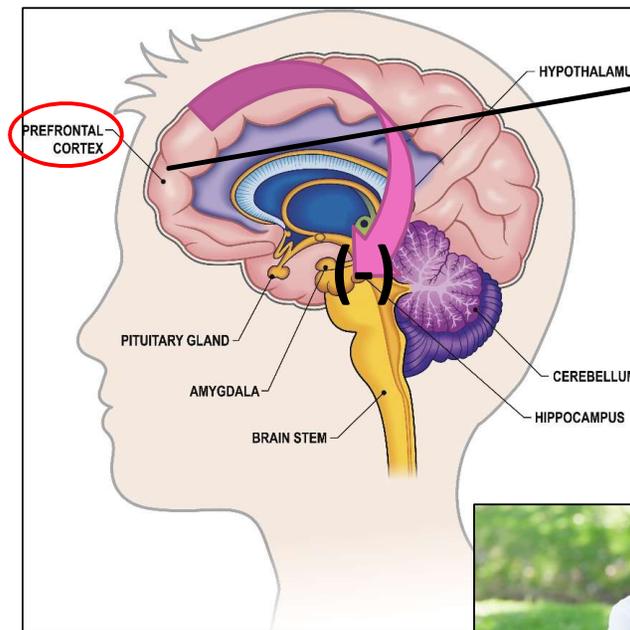


- Focus & Self Control
- Communication
- Perspective Taking
- Making Connections
- Critical Thinking
- Taking on Challenges
- Self-Directed, Engaged Learning



E. Galinsky

HEALTHY BRAIN DEVELOPMENT



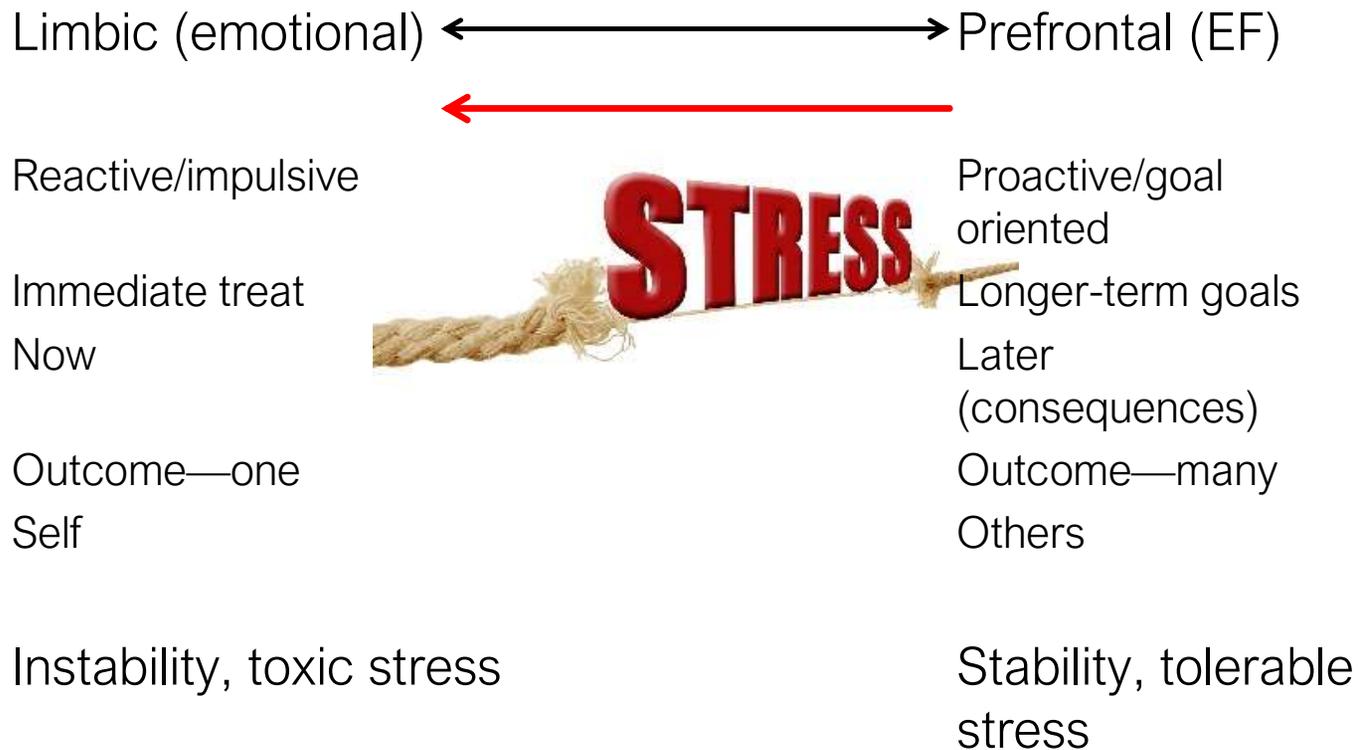
- Focus & Self Control
- Communication
- Perspective Taking
- Making Connections
- Critical Thinking
- Taking on Challenges
- Self-Directed, Engaged Learning



E. Galinsky

Executive Function

CONTINUUM OF BEHAVIOR



Center for the Developing Child 2016

REFLECTION ACTIVITY

Map out where you are on the continuum of behavior for each category

Place a dot on each bidirectional arrow

SL Alderman

Reflection Activity

Mapping out State-of-Mind to Promote Attunement Limbic—Prefrontal Cortex Continuum

Limbic (emotional)

Prefrontal (thoughtful)



INSTRUCTIONS: Place a dot somewhere along each double-pointed arrow indicating where you are now emotionally.

Adapted from Center for the Developing Child 2016

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PART 2

FETAL BRAIN DEVELOPMENT & RESILIENCE

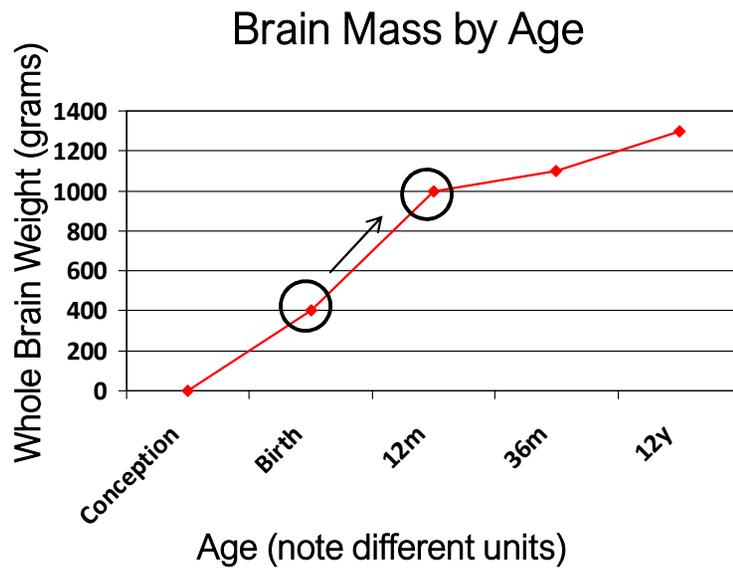


INFANT BRAIN DEVELOPMENT



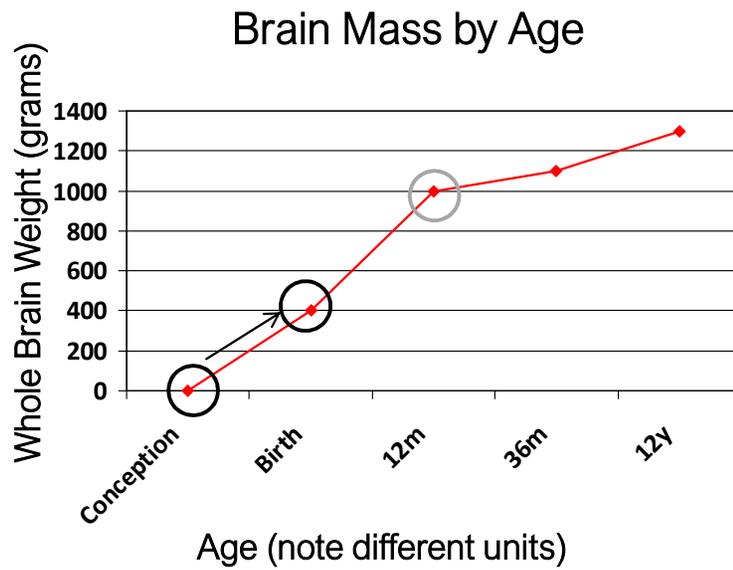
- At birth, the infant's brain is the most undifferentiated organ in the body
- Infant brains have neuroplasticity
- Neuroplasticity is both an opportunity & a vulnerability

INFANT BRAIN DEVELOPMENT



- The infant's brain more than doubling in mass in the first year (from 400g to 1000g)

FETAL BRAIN DEVELOPMENT



- A newborn's brain is 10% of body weight (adult 2%)

FETAL & INFANT BRAIN DEVELOPMENT

“Human development is shaped by a dynamic and continuous interaction between biology and experience.”

Perry B 2002

National Research Council & IOM 2000



FETAL BRAIN DEVELOPMENT

Of all organ systems, the nervous system is the most critically vulnerable throughout gestation

FETAL & INFANT BRAIN DEVELOPMENT

- Neurogenesis
 - 250,000 cells/minute
- Migration
- Differentiation
- Synaptogenesis
 - 40,000 synapses/minute
 - 10,000 synapses/neuron

FETAL PROGRAMMING

DEFINITION

The result of the influences of environment on the developing brain's architecture during gestation that creates persistent consequences of health & disease risk

- Prepares the developing fetus for the environment they are going to be born in
 - Survival
 - Increased maternal stress → high vigilant hypersensitive infant

Barker 1998

Glover et al. 2014



PREGNANCY

NORMAL PREGNANCY

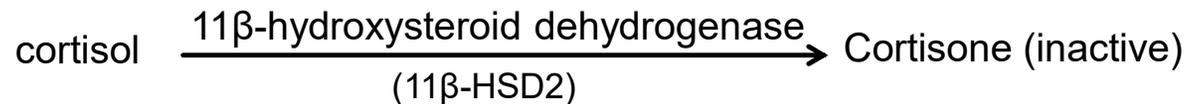
- Maternal cortisol levels rise 2-5 fold from 1st to 3rd trimester
- By 3rd trimester, maternal cortisol levels reach equivalent to stress response in nonpregnant woman

Glover et al. 2014

Placental Function

The placenta

- An enzyme in the placenta breaks down maternal cortisol before it reaches the fetus



- Changes filtering capacity in response to maternal chemical signals
- Plays a role in regulating pregnancy
 - Maturing fetus
 - Determining timing of delivery

Davis & Thompson 2014
Glover et al. 2014



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Placental Function



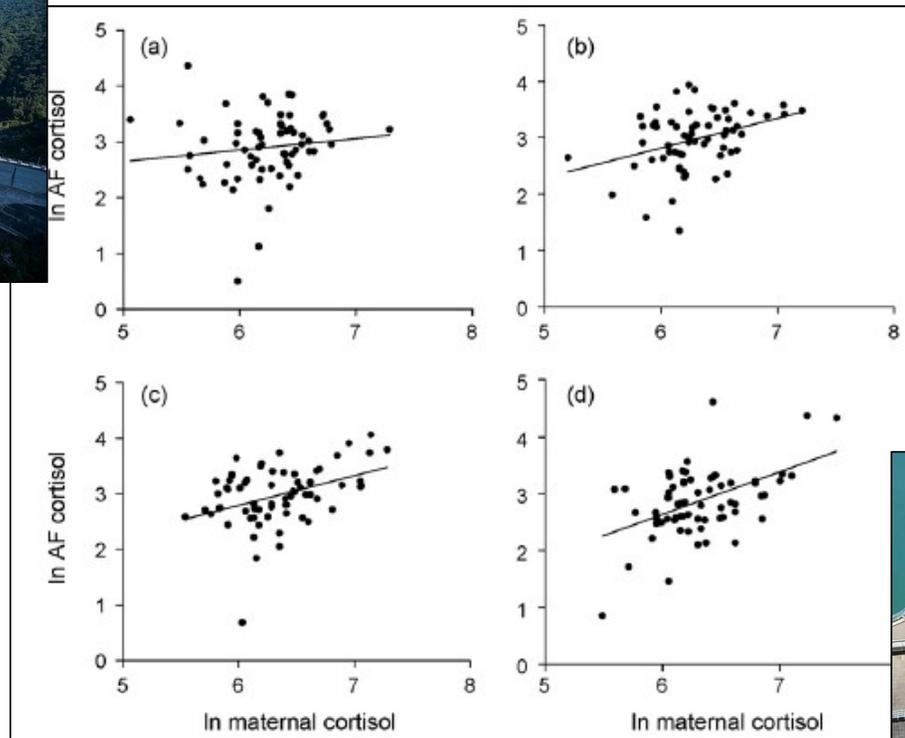
e.g., enzyme down-regulation

e.g., third trimester



Placental Function

Amniotic vs Maternal Serum Cortisol Levels by Trait Anxiety Quartiles



$p < 0.001$
1st quartile vs. 4th

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Glover et al. 2009

Placental Function

Prenatal stress levels:

- Alter brain architecture
- Shorten gestation (premature birth)
- Stunt fetal growth (IUGR, SGA)

Toxic Stress Prenatally

- n=116 women & their term infants
- Maternal plasma cortisol & report of stress, anxiety, and depression 5 times throughout pregnancy
- Baby's cortisol response to heel-stick at 24 hours after birth



Association between elevated concentrations of maternal cortisol during late second and third trimesters and larger infant cortisol response to heel-stick & slower rate of behavioral recovery

Davis et al. 2011

Toxic Stress in Infancy



« What Sleeping Babies Hear »

- Interparental conflict correlates with heightened brain activity in sleeping babies exposed to very angry tone of voice
- Rostral anterior cingulate cortex
- Subcortical regions (caudate, thalamus and hypothalamus)
- Rostral ACC implicated in emotional processing & regulation

Graham 2013

Toxic Stress Outcomes

	Outcome	Study Parameters	Reference
A.	Pregnancy-specific anxiety associated with infant <u>negative emotional reactivity</u> at 6 months of age (male & female)	n = 282 Finnish women; prospective	Nolvi, et al. 2016
B.	Elevated amniotic fluid cortisol at 17 wks gestation associated with <u>higher pre-stress cortisol levels</u> in 14-19 month old children	n = 110 American mother-child dyads; prospective	O'Connor, et al. 2013
C.	Prenatal partner relationship strain correlated with <u>delayed cognitive development & increased fearfulness</u> in 14-19 month old children	n = 125 British mother-infant dyads; retrospective; [strain: serious argument &/or partner emotionally cruel	Bergman, et al. 2007
D.	Accelerated pCRH at 22-23 wks gestation associated with <u>higher internalizing symptoms</u> in 5 year olds (male and female)	n = 83 pregnant American women; prospective; pCRH in maternal serum; [maternal cortisol and pCRH release positive feedback loop]	Howland, et al. 2016
E.	Higher maternal cortisol at 31 wks gestation associated with <u>internalizing problems & "network cost"</u> in 6-9 year old girls	n = 49 American mother-child dyads; prospective; [network cost: less segregated network organization, increased number of neural connections]	Kim, et al. 2016

Pregnancy Anxiety

A negative emotional state tied to worries about the health and well-being of one's baby, the impending childbirth, of hospital and healthcare experiences, birth and postpartum , parenting or maternal role (Guardino & Schetter et al. 2014)

- Linked to **preterm birth** (Rini et al. 1999, Roesch et al. 2004, Kramer et al. 2009)
- Infant attention **regulation** at 3-8 months after birth (Huizink et al 2002)
- **Cognitive & motor delay** at 8 months (Huizink et al. 2003)
- **Reduced gray matter volume** at 6-9 yo (Buss et al. 2010)

Pregnancy Anxiety

Theoretical Mechanism of Action

Dysfunctional sympathetic, neuroendocrine and cardiovascular system



Muscle tension
Increased heart rate
Difficulty sleeping
GI discomfort



Adverse impact on fetal development
Shortened gestation

Guardino & Schetter et al. 2014

Pregnancy Anxiety

Risk Factors for Pregnancy Anxiety

- Low self-esteem
- Low perceived control of important outcomes
- Pessimistic about one's future
- Lack of social supports (including with baby's father)
- Low income
- First pregnancy

Rini et al. 1999
Gurung et al. 2005

Parenting

Risk Factors for Building Parenting Capacity

- Psychiatric illness
- Substance use during pregnancy
- Single parenthood
- Unavailable support from family and friends
- Scarcity of maternal resources (housing, financial)
- Low education attainment

Resilience

- The set of skills needed to respond to adversity and thrive
- Situation-specific
- Developmental process
- Results from the dynamic interaction between internal predispositions and external experiences

National Scientific Council on the Developing Child 2015

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Resilience

Factors for building resilience

- Stable, caring and supportive relationships
- A sense of mastery over one's own life circumstances
- **Strong executive function and self-regulation skills**
- Affirmed faith and cultural traditions

National Scientific Council on the Developing Child 2015

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PART 3

APPROACHES TO INTERVENTIONS



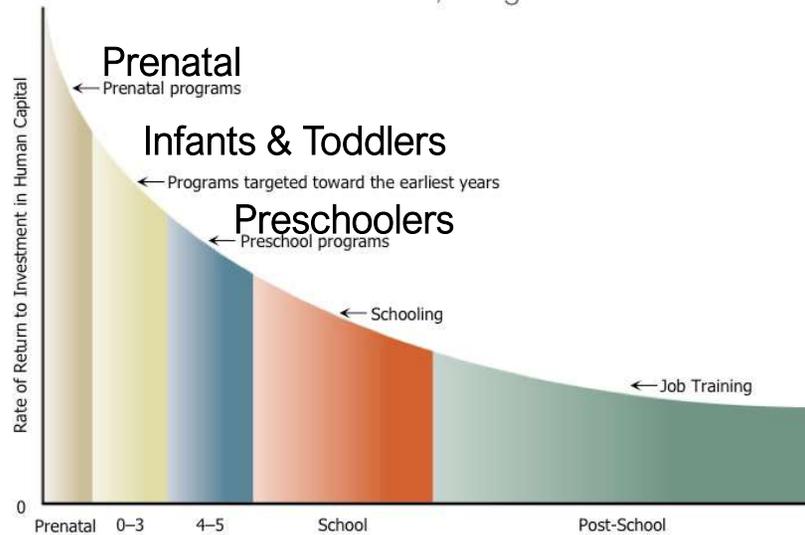


“Every system that touches the lives of children offers an opportunity to strengthen the foundations and capacities that make lifelong healthy development possible.”

Center on the Developing Child at Harvard University
2010

EARLY CHILDHOOD DEVELOPMENT IS A SMART INVESTMENT

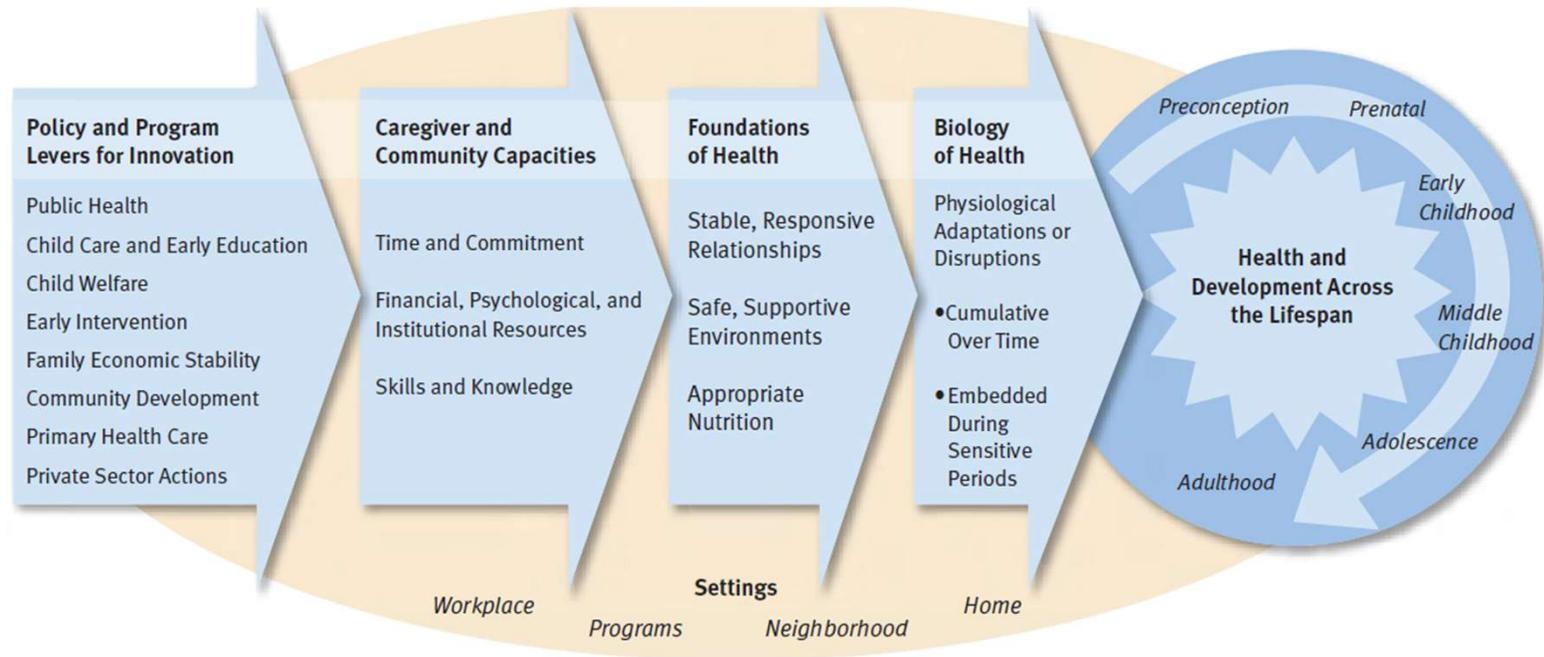
The earlier the investment, the greater the return



Source: James Heckman, Nobel Laureate in Economics

RATE OF RETURN TO INVESTMENT BY AGE

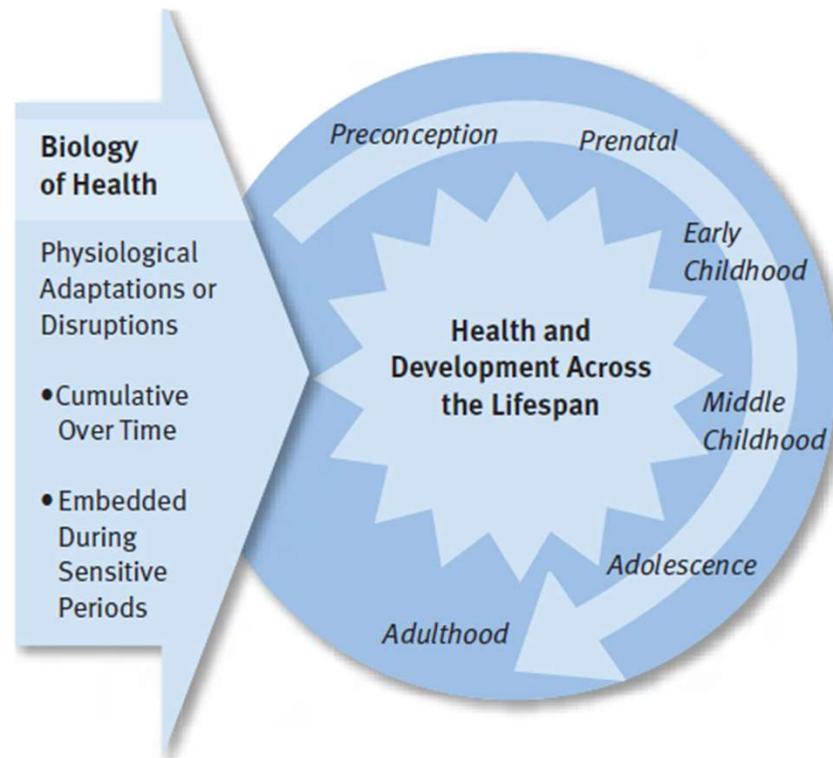
Strategies for Building the Foundations of Lifelong Health in Early Childhood



Center for the Developing Child at Harvard 2010

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Strategies for Building the Foundations of Lifelong Health in Early Childhood



Center for the Developing Child at Harvard 2010

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Strategies for Building the Foundations of Lifelong Health in Early Childhood



- Integrated system across physical health, mental health, public health, child care and early education, child welfare
- Gainful employment
- Paid parental family leave
- Green spaces

Center for the Developing Child at Harvard 2010

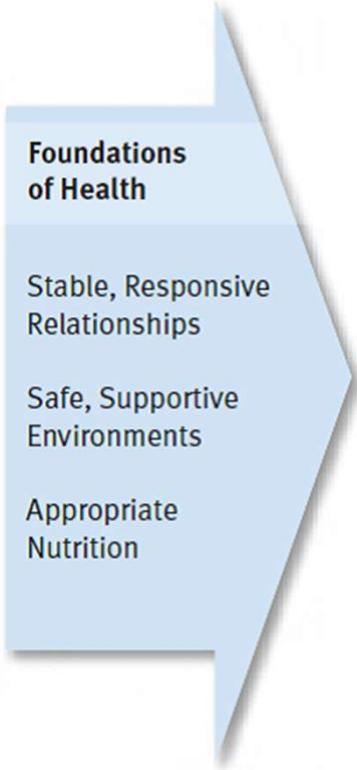
Strategies for Building the Foundations of Lifelong Health in Early Childhood



- Early identification & treatment of mental health issues and substance use disorder
- Home visiting, including universal home visiting
- Public library programs
- Oregon Parent Education Collaborate

Center for the Developing Child at Harvard 2010

Strategies for Building the Foundations of Lifelong Health in Early Childhood



**Foundations
of Health**

Stable, Responsive
Relationships

Safe, Supportive
Environments

Appropriate
Nutrition

- Parental supports starting prenatally
- Programs/services/supports targeting fathers
- Trauma-informed medical clinic
- WIC
- Community-based, culturally sensitive & responsive projects

Center for the Developing Child at Harvard 2010

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LULLABY PROJECT

- Pregnant women who have experienced adversity
- Work with experienced, professional musicians to write lullabies for their babies
- Lullabies professionally recorded and performed live in Carnegie Hall

LULLABY PROJECT

- Outlet for creativity
- Puts feelings into words
- Promotes self-regulation & self-reflection
- Showed them their own strengths
- Instills hope for the future
- Some continued to write poetry for their babies
- Some became active in their communities, organizing events and supporting other women

Carnegie Hall Lullaby Project 2011

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LULLABY PROJECT

- <https://soundcloud.com/carnegiehalllulla>
[by](#)

Carnegie Hall Lullaby Project 2011

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PART 4

DISCUSSION



Thank you!

FETAL BRAIN DEVELOPMENT & RESILIENCE

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