Toxic Stress and the Science of Early Brain and Child Development

August 28, 2013
Building Bridges Series

Building Bridges Part I; Toxic Stress and the Science of Early Brain and Child Development

– Sponsored by:
  • Healthy Child Care America
  • Building Bridges Among Health & Early Childhood Systems

Building Bridges Part II; Purposeful Parenting and the Primary Prevention of Toxic Stress

– Sponsored by:
  • Ohio Chapter, American Academy of Pediatrics
– Webinar Date: October 23, 2013
  • Contact hsouthworth@ohioaap.org for registration information
BUILDING BRIDGES Part I: Toxic Stress and the Science of Early Brain and Child Development

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Chair, American Academy of Pediatrics Early Brain and Child Development Leadership Workgroup
3 Objectives For Part 1:

- Provide a **general overview** of advances in developmental science
- Present an organizing, integrated, **ecobiodevelopmental** framework
- Define **toxic stress** and discuss its potentially **lifelong consequences**
Critical Concept #1

Childhood Adversity has Lifelong Consequences.

Significant adversity in childhood is strongly associated with unhealthy lifestyles and poor health decades later.
# ACE Categories

<table>
<thead>
<tr>
<th>Category</th>
<th>Women (n=9,367)</th>
<th>Men (n=7,970)</th>
<th>Total (n=17,337)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Abuse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>13.1%</td>
<td>7.6%</td>
<td>10.6%</td>
</tr>
<tr>
<td>Physical</td>
<td>27.0%</td>
<td>29.9%</td>
<td>28.3%</td>
</tr>
<tr>
<td>Sexual</td>
<td>24.7%</td>
<td>16.0%</td>
<td>20.7%</td>
</tr>
<tr>
<td><strong>Household Dysfunction</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother Treated Violently</td>
<td>13.7%</td>
<td>11.5%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Household Substance Abuse</td>
<td>29.5%</td>
<td>23.8%</td>
<td>26.9%</td>
</tr>
<tr>
<td>Household Mental Illness</td>
<td>23.3%</td>
<td>14.8%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Parental Separation or Divorce</td>
<td>24.5%</td>
<td>21.8%</td>
<td>23.3%</td>
</tr>
<tr>
<td>Incarcerated Household Member</td>
<td>5.2%</td>
<td>4.1%</td>
<td>4.7%</td>
</tr>
<tr>
<td><strong>Neglect</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>16.7%</td>
<td>12.4%</td>
<td>14.8%</td>
</tr>
<tr>
<td>Physical</td>
<td>9.2%</td>
<td>10.7%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

* Wave 2 data only (n=8,667)

Data from: [www.cdc.gov/nccdphp/ace/demographics](http://www.cdc.gov/nccdphp/ace/demographics)
ACE Scores

Number of categories of adverse childhood experiences are summed ...

<table>
<thead>
<tr>
<th>ACE score</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>36%</td>
</tr>
<tr>
<td>1</td>
<td>26%</td>
</tr>
<tr>
<td>2</td>
<td>16%</td>
</tr>
<tr>
<td>3</td>
<td>9.5%</td>
</tr>
<tr>
<td>4 or more</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

- **More than half** (almost 2/3) have at least one ACE
- **1 in 8** have 4 or more ACEs
- Average pediatrician will see **2-4** children with an ACE score of **4 or more each day**

ACEs and Obesity

AOR = 1.9 (1.6-2.2)

Prevalence (% with BMI >35)

Adapted from Anda RF et al., 2006. Eur Arch Psychiatry Clin Neurosci 256: 174-186.
ACEs and Current Smoking

AOR = 1.8 (1.5-2.1)

Also earlier onset!!

Slide modified from V. J. Felitti
ACEs and Alcoholism

AOR = 7.2 (5.9-8.9)

Also earlier onset!!

% Alcoholic

ACE Score

0

1

2

3

4+

LEARNING COLLABORATIVE

Slide modified from V. J. Felitti
ACEs and Illicit Drug Use

AOR = 4.5 (3.9-5.3)

Adapted from Anda RF et al., 2006. Eur Arch Psychiatry Clin Neurosci 256: 174-186.
ACEs and IV Drug Use

AOR = 11.1 (6.2-19.9)

Adapted from Anda RF et al., 2006. Eur Arch Psychiatry Clin Neurosci 256: 174-186.
ACEs and Promiscuity (≥ 30)

AOR = 3.6 (3.0-4.4)

Also earlier onset!!

Adapted from Anda RF et al., 2006. Eur Arch Psychiatry Clin Neurosci 256: 174-186.
ACEs Influence Multiple Outcomes

Risk Factors for Common Diseases

- Smoking
- Alcoholism
- Promiscuity
- High Perceived Risk of HIV
- Obesity
- Illlicit Drugs
- IV Drugs
- Multiple Somatic Symptoms
- Poor Perceived Health
- Cancer
- Skeletal Fractures
- Liver Disease
- Chronic Lung Disease

Prevalent Diseases

- Ischemic Heart Disease
- Sexual Transmitted Diseases

General Health and Social Functioning

- Difficulty in job performance
- High perceived stress
- Married to an Alcoholic
- Relationship Problems

Mental Health

- Depression
- Sleep Disturbances
- Memory Disturbances
- Anxiety
- Panic Reactions
- Poor Anger Control

Sexual Health

- Teen Paternity
- Fetal Death
- Unintended Pregnancy
- Teen Pregnancy
- Sexual Dissatisfaction
- Early Age of First Intercourse

Poor Self-Rated Health

- Hallucinations

ACEs
The True Nature of Preventive Medicine

Mechanisms By Which Adverse Childhood Experiences Influence Adult Health Status

Adverse Childhood Experiences

- Social, Emotional, and Cognitive Impairment
- Adoption of Health-Risk Behaviors
- Disease & Disability
- Early Death

Death

Birth

Slide modified from V. J. Felitti
Developing a Model of Human Health and Disease

Early childhood ecology strongly associates with lifelong developmental outcomes.

How do you begin to define or measure the ecology?

What are the mechanisms underlying these well-established associations?
Defining **Adversity or Stress**

- How do you define/measure adversity?
- Huge **individual variability**
  - Perception of adversity or stress (subjective)
  - Reaction to adversity or stress (objective)

- National Scientific Council on the Developing Child (Dr. Jack Shonkoff and colleagues)
  - **Positive** Stress
  - **Tolerable** Stress
  - **Toxic** Stress

Based on the **REACTION** (objective physiologic responses)
Defining Adversity or Stress

- **Positive Stress**
  - Brief, infrequent, mild to moderate intensity
  - Most normative childhood stress
    - Inability of the 15 month old to express their desires
    - The 2 year old who stumbles while running
    - Beginning school or daycare
    - The big project in middle school
  - **Social-emotional buffers** allow a return to **baseline**
    (responding to non-verbal clues, consolation, reassurance, assistance in planning)
  - **Builds motivation and resiliency**
  - Positive Stress is **NOT** the **ABSENCE** of stress
Defining **Adversity or Stress**

- **Toxic Stress**
  - Long lasting, frequent, or strong intensity
  - More extreme precipitants of childhood stress (ACEs)
    - Physical, sexual, emotional abuse
    - Physical, emotional neglect
    - Household dysfunction

- **Insufficient social-emotional buffering**
  (Deficient levels of emotion coaching, re-processing, reassurance and support)

- Potentially permanent changes with long-term consequences
  - **Epigenetics** (there are life long / intergenerational changes in how the genetic program is turned **ON** or **OFF**)
  - **Brain architecture** (the mediators of stress impact upon the mechanisms of brain development / **connectivity**)

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American Academy of Pediatrics (Ohio Chapter)

Mental Wellness Learning Collaborative
Critical Concept #2

Epigenetics:

• Which genes are turned on/off, when, and where

• Ecology (environment/experience) influences how the genetic blueprint is read and utilized

• Ecological effects at the molecular level

• Stress-induced changes in epigenetic markers

“Genes may load the gun, but the environment pulls the trigger”
Through epigenetic mechanisms, the early childhood ecosystem becomes biologically embedded, influencing how the genome is utilized.
Critical Concept #3

Developmental Neuroscience:

• **Synapse** and **circuit** formation are experience and activity dependent

• **Ecology** (environment/experience) influences how brain architecture is formed and remodeled (**plasticity**)

• Diminishing **cellular plasticity** limits remediation

• Early childhood adversity -> **vicious cycle of stress**

• **Potentially permanent** alterations in brain architecture and functioning
Two Types of Plasticity

- **Synaptic Plasticity** –
  - Variation in the **STRENGTH** of individual connections
  - “from a whisper to a shout”
  - Lifelong (how old dogs learn new tricks)

- **Cellular Plasticity** –
  - Variations in the **NUMBER (or COUNT)** of connections
  - “from one person shouting to a stadium shouting”
  - Declines dramatically with age (**waning by age 5**)

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[Image -1x-1 to 721x540]
Differential Brain Maturation

- The Brake – PFC (with some hippocampal help)
  Frontal lobes:
  Abstract thought, reasoning, judgment, planning, impulse and affect regulation, consequences

Temporal lobe (outside):
Processing sound and language

Limbic System (inside):
Emotions and impulsivity
  + The Gas Pedal + Amygdala

Brain Stem & Cranial Nerves:
Vital functions
Swallowing

Parietal Lobe:
Integration of sensory data and movement

Occipital Lobe:
Visual processing

Cerebellum:
Smooth movements
Coordination
Out of Balance?

Prefrontal Cortex                          Amygdala

Cold Cognition                          Hot Cognition
Judgmental                              Emotional
Reflective                              Reactive
Calculating                             Impulsive
Think about it                          Just do it

Biological maturity by **24**          Biological maturity by **18**

Adapted from Ken Winters, Ph.D.
Impact of Early Stress

Chronic “fight or flight;” ↑ cortisol / norepinephrine

Changes in Brain Architecture

Hyper-responsive stress response; calm/coping

CHILDHOOD STRESS

American Academy of Pediatrics
Mental Wellness Learning Collaborative
Declining plasticity in the developing brain results in potentially permanent alterations in brain functioning and development.
Eco-Bio-Developmental Model of Human Health and Disease

Biology
Physiologic Adaptations and Disruptions

The Basic Science of Pediatrics

Neuroscience
Learning, Behavior, And Health

Development

Ecology
The social and physical environment

Ecology becomes biology, and together they drive development across the lifespan.
The critical challenge now is to translate game-changing advances in developmental science into effective policies and practices for families with children to improve education, health, and lifelong productivity.
Advantages of an EBD Framework

• Though grounded in **developmental science**, the **simplicity** of the EBD framework may promote understanding as well as support for **translation** (investing in childhood is the right thing to do **BIOLOGICALLY**)

• Psychosocial stressors and other salient features of the **ecology** are every bit as **biological** as nutrition or lead (no distinction between mental and physical health, just healthy vs. unhealthy **development**)

• Emphasizes the dimension of **time** – to reflect the **ongoing, cumulative** nature of benefits and threats to health and wellness
Development results from an ongoing, re-iterative, and cumulative dance between nurture and nature.

Experience
Protective and Personal
(versus Insecure and Impersonal)

Brain Development
Alterations in Brain Structure and Function

Epigenetic Changes
Alterations in the Way the Genetic Program is Read

Behavior
Adaptive or Healthy Coping Skills
(vs. Maladaptive or Unhealthy Coping Skills)
Advantages of an EBD Framework

• Underscores the need to improve the early childhood ecology in order to:
  – Mitigate the biological underpinnings for educational, health and economic disparities
  – Improve developmental life-course trajectories
  – Changing the ecology will demand a public health approach and unprecedented levels of collaboration!

• Highlights the pivotal role of toxic stress
  – Not just “step on the gas” or enrichment
  – But “take off the break” by treating, mitigating or immunizing against toxic stress
The Yin and Yang of Early Childhood:

Protect the Brain and ...

Build New Skills.
Linking **Childhood Experiences** and **Adult Outcomes**

- **Childhood Adversity**
- **Toxic Stress**
  - Epigenetic Modifications
  - Disruptions in Brain Architecture
  - Behavioral Allostasis
- **Poor Adult Outcomes**
The **BIG** Questions are...

If **TOXIC STRESS** is the missing link between **ACE exposure** and **poor adult outcomes**, it raises the following **BIG** questions:

- Are there ways to:
  - **treat**, 
  - **mitigate**, and/or
  - **immunize against** toxic stress?

- Is there a mismatch between:
  - what we **KNOW** ... and ...
  - what we actually **DO**?

**YES!!**

See Part 2!!
The **BIG** Questions are...

- **What we DO:**
  - 95% of the trillions of dollars that we spend on health is on **treatment** and **NOT prevention**

- **What we KNOW:**
  - That **70% of early deaths are preventable**, with...
  - The majority (40%) due to **behavioral patterns**
    (behavioral allostasis due to toxic stress!)

McGinnis, Williams-Russo and Knickman, 2002
### Proximal Causes of Death: Chronic Disease

#### EXHIBIT 2
Total Deaths And Age-Adjusted Death Rates (Per 100,000 Population) For The Fifteen Leading Causes Of Death In The Total U.S. Population, 2003

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of Deaths (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diseases of heart</td>
<td>232.3</td>
</tr>
<tr>
<td>Malignant neoplasms (cancer)</td>
<td>190.1</td>
</tr>
<tr>
<td>Cerebrovascular diseases (stroke)</td>
<td>53.5</td>
</tr>
<tr>
<td>Chronic lower respiratory diseases</td>
<td>43.3</td>
</tr>
<tr>
<td>Accidents (unintentional injuries)</td>
<td>37.3</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>25.3</td>
</tr>
<tr>
<td>Influenza and pneumonia</td>
<td>22.0</td>
</tr>
<tr>
<td>Alzheimer’s disease</td>
<td>21.4</td>
</tr>
<tr>
<td>Nephritis, nephrotic syndrome, nephrosis</td>
<td>14.4</td>
</tr>
<tr>
<td>Septicemia</td>
<td>11.6</td>
</tr>
<tr>
<td>Intentional self-harm (suicide)</td>
<td>10.8</td>
</tr>
<tr>
<td>Chronic liver disease and cirrhosis</td>
<td>9.3</td>
</tr>
<tr>
<td>Essential hypertension/hypertensive renal disease</td>
<td>7.4</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>6.2</td>
</tr>
<tr>
<td>Assault (homicide)</td>
<td>6.0</td>
</tr>
</tbody>
</table>


**NOTE:** Numbers in parentheses are age-adjusted death rates per 100,000 population.

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**Acute causes of death are the exception, not the rule**
Distal Causes of Death: Unhealthy Lifestyles

Table 2. Actual Causes of Death in the United States in 1990 and 2000

<table>
<thead>
<tr>
<th>Actual Cause</th>
<th>No. (%) in 1990*</th>
<th>No. (%) in 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tobacco</td>
<td>400 000 (19)</td>
<td>435 000 (18.1)</td>
</tr>
<tr>
<td>Poor diet and physical inactivity</td>
<td>300 000 (14)</td>
<td>400 000 (16.6)</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>100 000 (5)</td>
<td>85 000 (3.5)</td>
</tr>
<tr>
<td>Microbial agents</td>
<td>90 000 (4)</td>
<td>75 000 (3.1)</td>
</tr>
<tr>
<td>Toxic agents</td>
<td>60 000 (3)</td>
<td>55 000 (2.3)</td>
</tr>
<tr>
<td>Motor vehicle</td>
<td>25 000 (1)</td>
<td>43 000 (1.8)</td>
</tr>
<tr>
<td>Firearms</td>
<td>35 000 (2)</td>
<td>29 000 (1.2)</td>
</tr>
<tr>
<td>Sexual behavior</td>
<td>30 000 (1)</td>
<td>20 000 (0.8)</td>
</tr>
<tr>
<td>Illicit drug use</td>
<td>20 000 (&lt;1)</td>
<td>17 000 (0.7)</td>
</tr>
<tr>
<td>Total</td>
<td>1 060 000 (50)</td>
<td>1 159 000 (48.2)</td>
</tr>
</tbody>
</table>

*Data are from McGinnis and Foege. The percentages are for all deaths.

If these unhealthy lifestyles are manifestations of behavioral allostasis, a **FUNDAMENTAL** cause of death is **TOXIC STRESS**!
By 2030, **90%** of the morbidity in high income countries will be due to **Non-Communicable Diseases**

- Most NCDs are due to **unhealthy behaviors** (overeating, smoking, alcohol, promiscuity, and illicit drugs)
Much of the global burden of disease is associated with behaviors—overeating, smoking, excessive alcohol consumption, and physical inactivity—that people recognize as health-harming and yet continue to engage in, even when undesired consequences emerge. To date, interventions aimed at changing such behaviors have largely encouraged people to reflect on their behaviors. These approaches are often ineffectual, which is in keeping with the observation that much human behavior is automatic, cued by environmental stimuli, resulting in actions that are largely unaccompanied by conscious reflection. We propose that interventions targeting these automatic bases of behaviors may be more effective. We discuss specific interventions and suggest ways to determine whether and how interventions that target automatic processes can enhance global efforts to prevent disease.
Critical Concept #5

A PUBLIC HEALTH DILEMMA:

Do we continue to treat disease, the unhealthy lifestyles that lead to disease, or the TOXIC STRESS that leads to the adoption of unhealthy lifestyles??
What is Toxic Stress?

- A physiologic stress response that is excessive or prolonged (reflects an inability to “turn it off”)

- Results in potentially permanent changes in:
  - Gene expression (epigenetics)
  - Brain development (neuroscience)
  - Behavior (allostasis)
SUMMARY

• Why should I care?
  – Toxic stress is a MEDIATOR between early childhood adversity and less than optimal outcomes in learning, behavior and health.
  – Understanding the BIOLOGY underlying these well established associations opens up new opportunities for primary prevention and early intervention.
SUMMARY

• What can I do?
  – Understand the **ecobiodevelopmental framework** (advocate for a public health approach to address toxic stress – see part 2)
  – Help children figure out how to **turn off** their stress response (in developmentally appropriate, healthy ways – see part 2)
  – Intervene early for those children who are at high risk or appear **unable to turn off** their stress response (see part 2)
CONCLUSION:
It is easier to build strong children than to repair broken men.

Frederick Douglass
Question & Answer
How to request a certificate

- When we end the webinar, you will be automatically directed to an evaluation survey.
- This survey link will also be sent via email to those who attended the webinar.
  - Complete the survey and submit.
  - Please allow 4-6 weeks to receive your certificate via email.
THANK YOU!

• Today’s webinar recording will be posted to;
  • [www.healthychildcare.org](http://www.healthychildcare.org)
  • [https://oh.train.org](https://oh.train.org)

Building Bridges Part II; Purposeful Parenting and the Primary Prevention of Toxic Stress

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Webinar Date: October 23, 2013
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