The Lasting Imprint of Childhood Trauma:

How Adverse Childhood Experiences Shape Health and Well-Being Across the Lifespan

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Adverse Childhood Experiences (ACEs) Among US Adults

17,000+ adult patients

ABUSE

- Physical
- Emotional/ Psychological
- Sexual

NEGLECT

- Physical
- Emotional

HOUSEHOLD DYSFUNCTION

- Mental Illness
- Substance Abuse
- Divorce/Separation
- Parent treated violently
- Incarcerated relative

2 out of 3

1 ACE

1 out of 8

4 or more ACEs

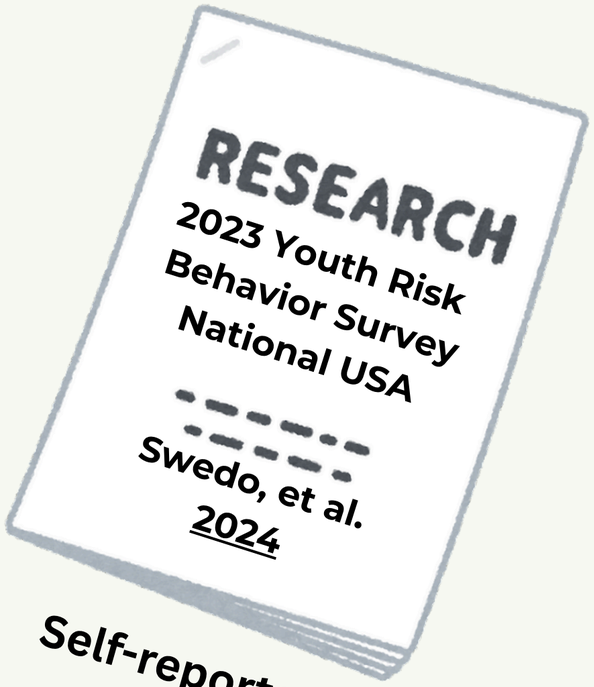
4 or more ACEs

- Diabetes 1.6 x more likely
- Severe Obesity 1.6 x more likely
- Cancer 1.9 x more likely
- Heart disease 2.2 x more likely
- Stroke 2.4 x more likely
- Chronic bronchitis 3.9 x more likely
- Depression 4.6 x more likely
- Alcoholism 7.4 x more likely
- Drug abuse 9.7 x more likely
- Suicide attempt 12.2 x more likely

6 or more ACEs

Life expectancy decreases by nearly 20 years

Adverse Childhood Experiences (ACEs) Among US Adolescents



Self-reported among HS students

ABUSE

Physical

Emotional/ Psychological

Sexual

NEGLECT

Physical

HOUSEHOLD DYSFUNCTION

Mental Illness

Substance Abuse

Parent treated violently

Incarcerated relative

76.1%

1 or more ACEs

4 or more ACEs (18.5%)

- LGBQ+
- Non-Hispanic multiracial
- Female
- Non-Hispanic American Indian or Alaska Native

Prevalence of Types of ACE

Emotional Abuse: 61.5%
Physical Abuse: 31.8%
Mental Illness: 28.4%

Population-attributable fractions associated with experiencing ACEs were highest for:

- **Suicide attempts (89.4%)**
- **Seriously considering attempting suicide (85.4%)**
- **Prescription opioid misuse (84.3%)**

Abuse

Neglect

Household dysfunction

- **Foster care placement**
- **Bullying or harassment at school**
- **Parent or guardian died**
- **Deportation-related separation**
- **School or neighborhood violence**
- **Discrimination**
- **Genocide**
- **War**
- **Immigration/refugee status**

Adverse Community Environments

Intergenerational transmission

- **Poor housing quality and affordability**
- **Systemic discrimination and racism**
- **Lack of access to educational opportunity**
- **Deteriorating physical environment**
- **Low sense of collective agency**

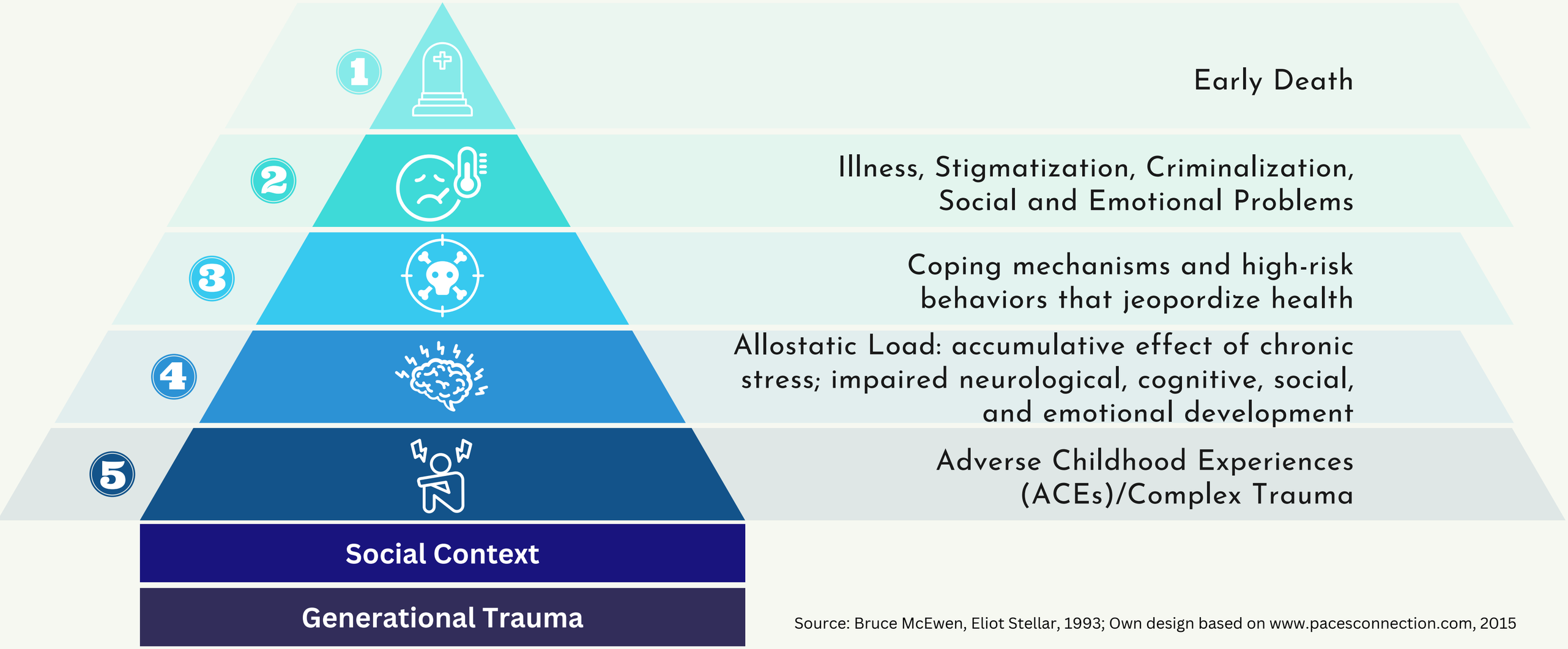
- **Intergenerational poverty**
- **Lack of economic opportunity and social mobility**
- **Poor transportation system**
- **Community violence**
- **Damaged social fabric/network and trust**
- **Lack of access to healthy choices**

Socio-cultural environment **Economic environment**

Physical environment

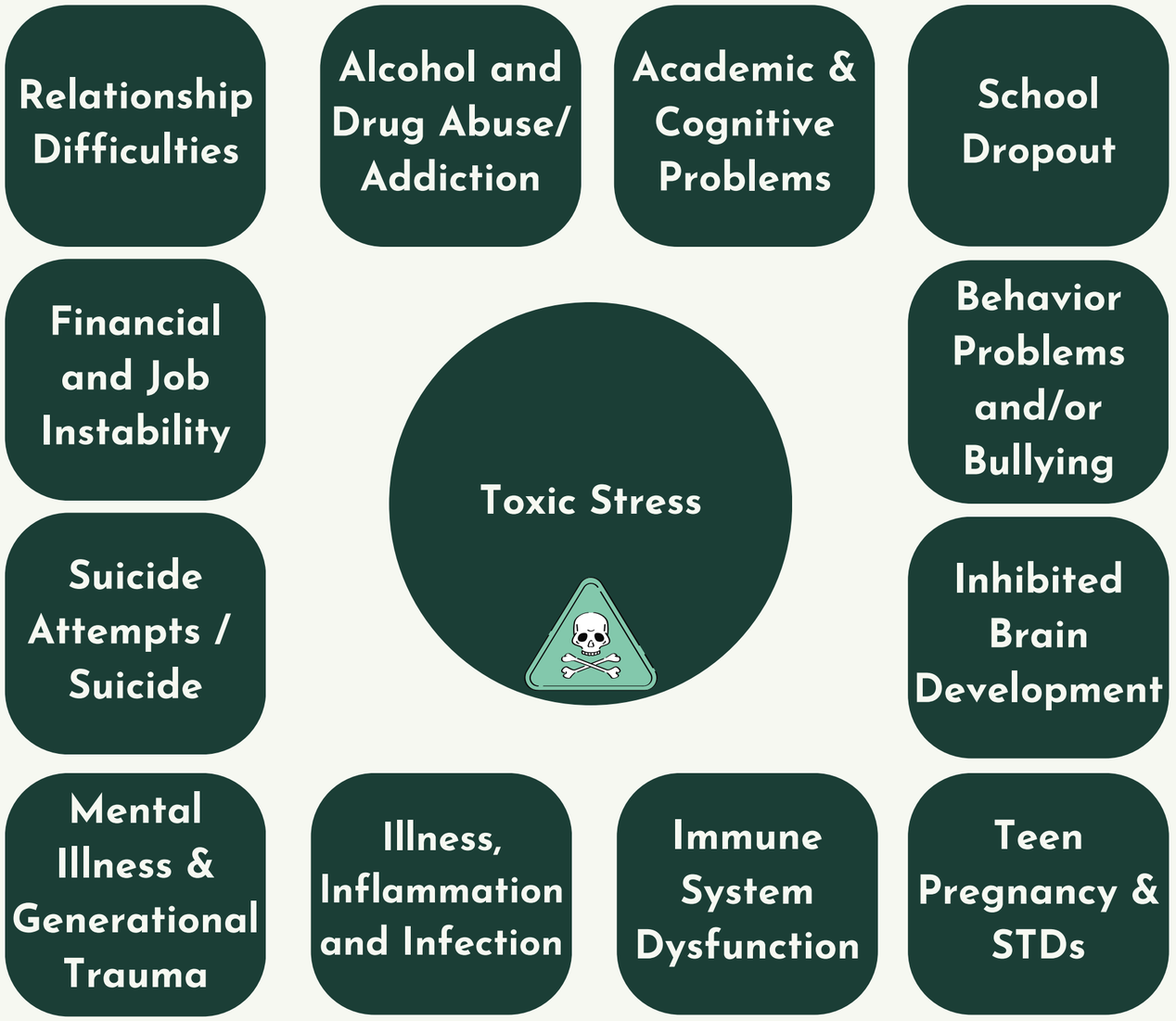
Adapted from: Ellis, W. R. & Dietz, W. H., Building Community Resilience Model, Academic Pediatrics, 2017.

Trauma and Social Context



Source: Bruce McEwen, Eliot Stellar, 1993; Own design based on www.pacesconnection.com, 2015

Medium- and Long-Term Risks from ACEs

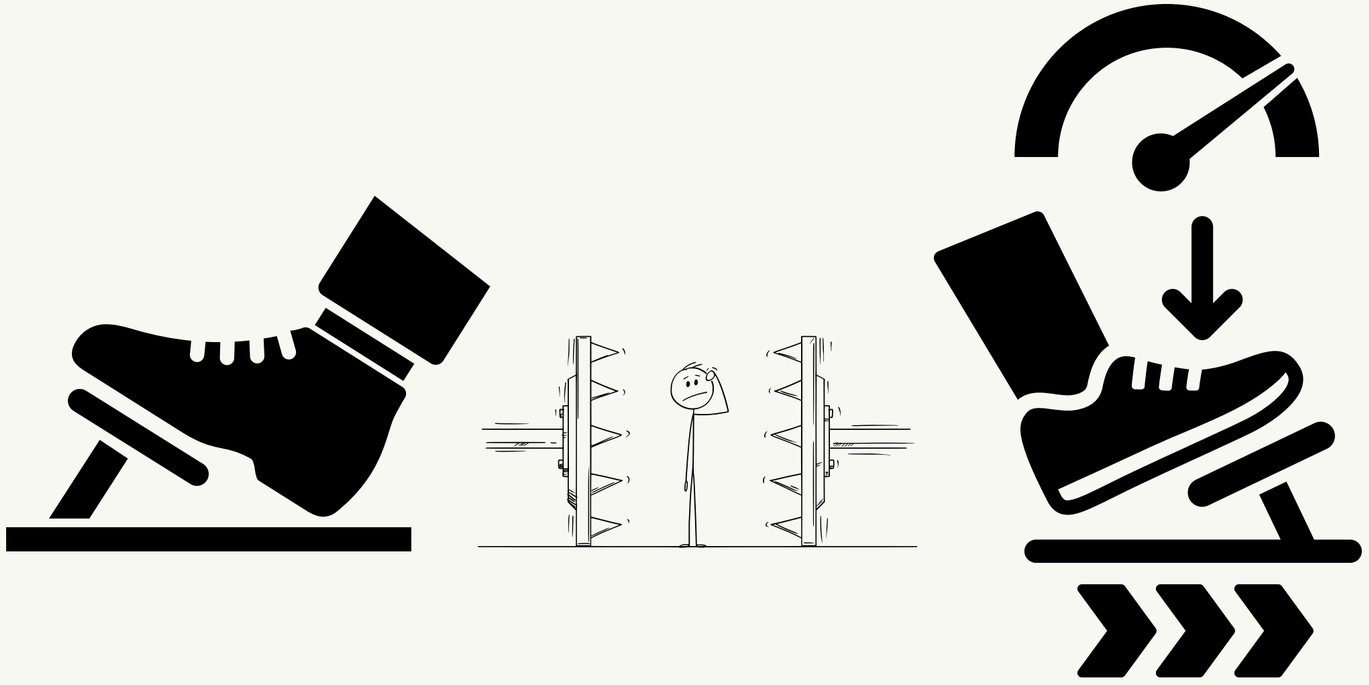


Sources: Webster, 2022; CDC, 2024; Bethell, et al., 2014

Trauma and the Nervous System

Parasympathetic NS

Sympathetic NS



Degrees of Stress

Brief **increase** in **breathing**, **heart rate**, **mild** elevation of **stress hormones**

Normal, essential part of healthy development.
Example: Track athlete feeling an adrenaline rush before starting the race, body getting ready to focus on winning the race.
Stress response example: fast breathing, increased heart rate, dry mouth, sweating.

Serious, temporary **stress response**, cushioned by **supportive relationships**

When buffered by supportive relationships with adults who help child adapt, this builds resilience and helps recovery.
Examples: Loss of a loved one, natural disaster, traumatic accident, parental divorce.
Stress response example: bedwetting in potty trained kids.

Prolonged activation of the stress system, **absence of supportive relationships** or emotional containment

Frequent or prolonged adversity without sufficient adult support.
Examples: Physical, emotional, or sexual abuse, neglect, caregiver mental illness, exposure to violence.
Stress response impacts: disruption of brain development and other organ systems, increased risk for cognitive impairment and stress-related disease and mental illness.

Dysregulated Stress Response System

For every **ACE** a child has, the risk of tolerable stress becoming **TOXIC STRESS** increases. (Dose Response)

ACEs

When the stress response is activated too frequently or if the stressor is too intense, the body can lose its ability to shut down the HPA and SAM axes. **Disruption of the Feedback Inhibition** occurs; the body's stress thermostat is broken. It keeps producing CORTISOL.

TOXIC STRESS

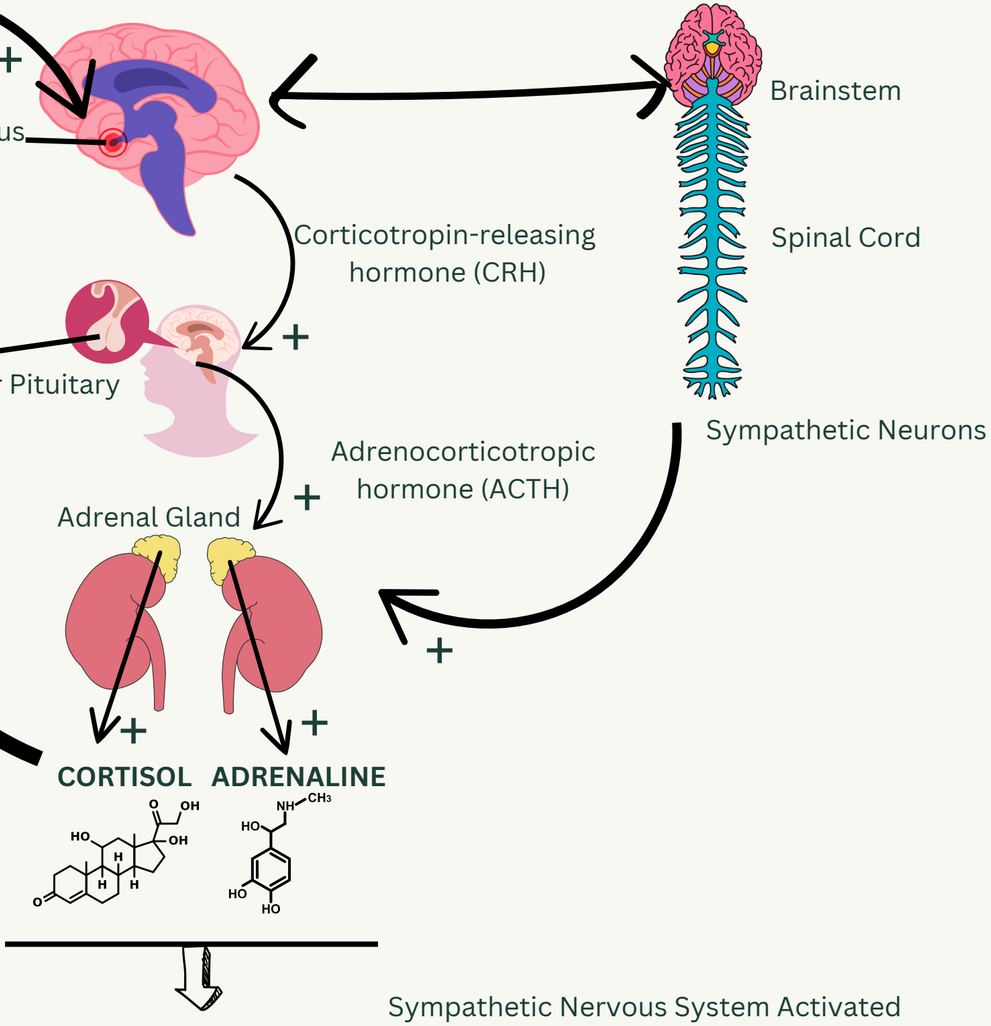
STRESSOR (Physical/Emotional)

Hypothalamus-Pituitary-Adrenal Axis

HPA-Axis

Sympathomedullary Pathway

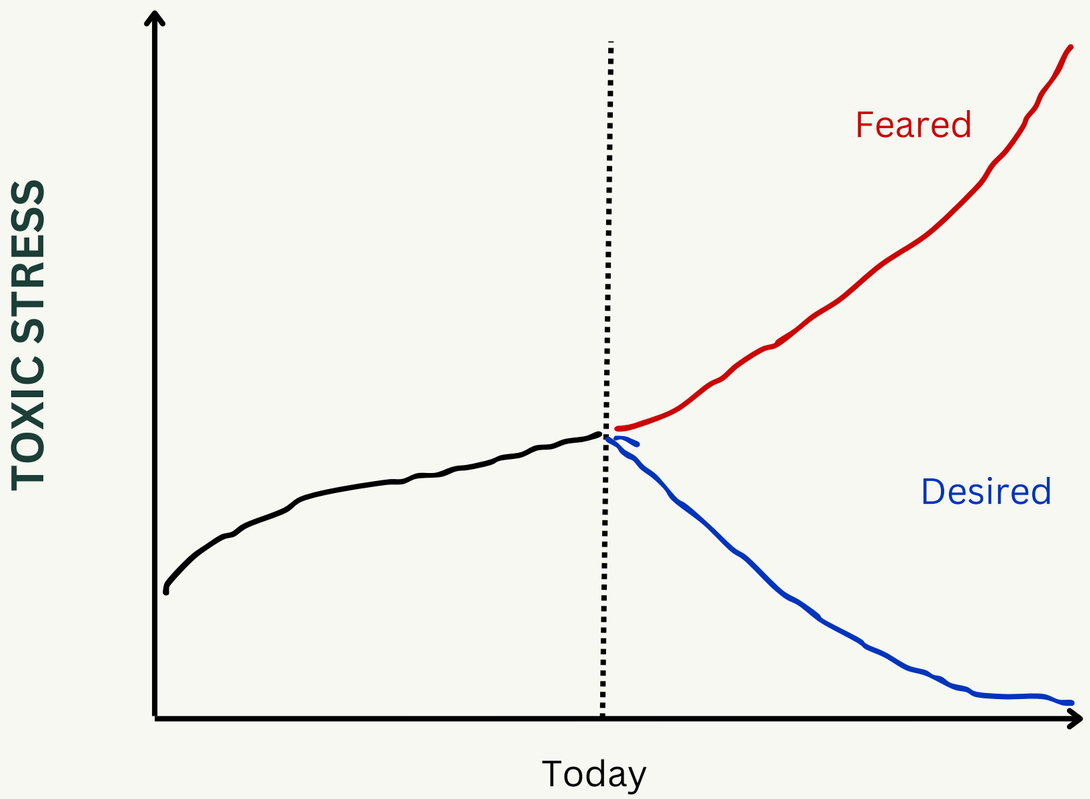
SAM-Axis



Once the 'threat' is over, the Parasympathetic branch takes control through the stress thermostat called **feedback inhibition**, triggering the stress response to turn off, and brings the body back into a balanced state.

ACUTE STRESS

Reference Mode



- **Feared Increase** (Red Line): If no interventions are implemented, toxic stress continues to rise, leading to worsening long-term effects.
- **Desired Decrease** (Blue Line): With effective interventions (such as trauma-informed care, supportive relationships, and stress regulation strategies), toxic stress can be reduced over time.

Limitation: There is not currently a consensus in the medical community about how to operationalize “Toxic Stress,” therefore, there’s no specific data available on “Toxic Stress” to map over time.

Reference Mode Description

Feared Direction: Escalating Toxic Stress Over Time

Without intervention, toxic stress is expected to follow a reinforcing (self-amplifying) growth pattern, leading to worsening outcomes over time. This trajectory is characterized by:

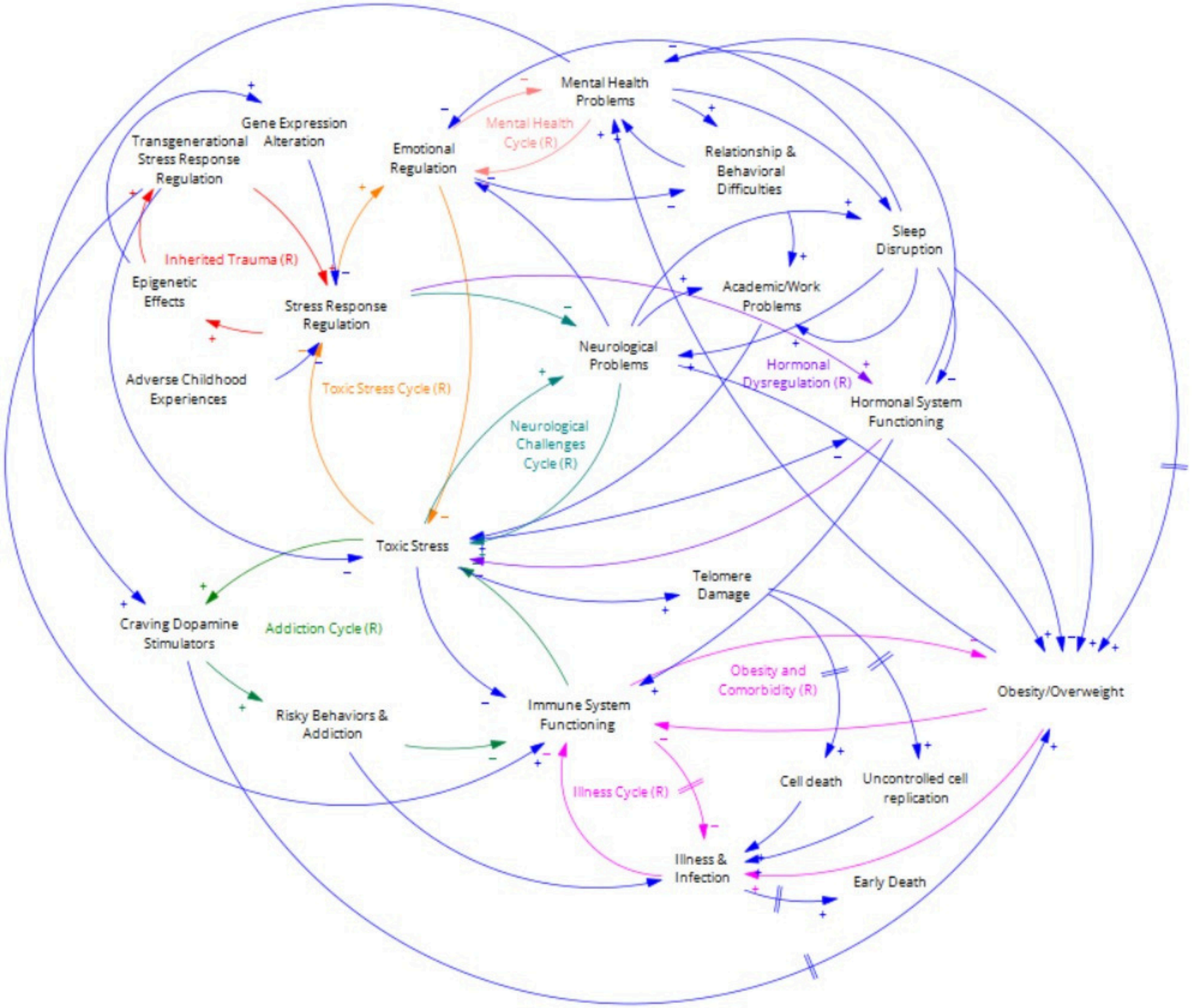
- Cumulative Exposure: Children who experience ACEs early in life may face continued stressors (e.g., poverty, neglect, unstable relationships), reinforcing the toxic stress response.
- **Dysregulated Stress Systems**: Chronic exposure to toxic stress impairs the body's ability to regulate stress hormones (cortisol, adrenaline), leading to persistent hyperactivation of the stress response.
- **Health and Behavioral Decline**: Over time, toxic stress contributes to mental health challenges (anxiety, depression), poor academic performance, high-risk behaviors (substance use, aggression), chronic diseases (heart disease, respiratory disease, etc), and early mortality.
- **Intergenerational Transmission**: The epigenetic impact of toxic stress can alter gene expression, increasing susceptibility to stress in future generations, continuing the cycle.

Desired Direction: Declining Toxic Stress Through Intervention

With effective, multi-level interventions, the trajectory of toxic stress can be mitigated and reversed, leading to long-term improvements. This desired direction includes:

- **Early Identification & Support**: Screening for ACEs in medical, educational, and community settings can help identify at-risk children early and provide targeted interventions.
- **Building Resilience**: Programs that strengthen emotional regulation, social and emotional skills, problem-solving, and social support can buffer the effects of toxic stress and reduce its impact over time.
- **Trauma-Informed Care**: Schools, healthcare providers, and child welfare systems adopting trauma-sensitive approaches can create environments that promote healing and emotional safety.
- **Family and Community-Based Interventions**: Strengthening positive caregiving relationships, social connectedness, and access to mental health services can disrupt the feedback loops that perpetuate stress.
- **Public Health and Policy Interventions**: Policies that reduce childhood adversity (e.g., parental leave, economic support, mental health access, child abuse prevention programs) play a crucial role in shifting the trajectory.

Model CLD


Mental Health Problems
Mental Health Cycle (R)
Gene Expression Alteration
Transgenerational Stress Response Regulation
Emotional Regulation
Relationship & Behavioral Difficulties
Sleep Disruption
Inherited Trauma (R)
Epigenetic Effects
Stress Response Regulation
Academic/Work Problems
Neurological Problems
Hormonal Dysregulation (R)
Adverse Childhood Experiences
Toxic Stress Cycle (R)
Hormonal System Functioning
Neurological Challenges Cycle (R)
Toxic Stress
Telomere Damage
Craving Dopamine Stimulators
Addiction Cycle (R)
Obesity and Comorbidity (R)
Obesity/Overweight
Risky Behaviors & Addiction
Immune System Functioning
Illness Cycle (R)
Cell death
Uncontrolled cell replication
Illness & Infection
Early Death

Model Insights

Main Feedback Loops in the Model

1. **Toxic Stress Cycle** (Reinforcing - R) (**Orange**)
   - Adverse Childhood Experiences (ACEs) → Stress Response Dysregulation → Toxic Stress → Emotional Regulation Issues → More Stress Response Dysregulation
   - This loop illustrates how ACEs disrupt a child's stress response, making them more susceptible to chronic stress and emotional dysregulation, leading to persistent toxic stress. Without intervention, this cycle perpetuates itself over time.
2. **Mental Health Cycle** (Reinforcing - R) (**Salmon**)
   - Toxic Stress → Mental Health Problems → Relationship & Behavioral Difficulties → Academic/Work Problems → More Stress & Mental Health Issues
   - This loop shows how chronic stress and early trauma increase the risk of mental health problems, which then negatively impact relationships, academic performance, and work, further worsening stress levels.
3. **Addiction Cycle** (Reinforcing - R) (**Green**)
   - Toxic Stress → Craving Dopamine Stimulators → Risky Behaviors & Addiction → More Stress and Health Problems → Further Addiction Risk
   - This cycle captures how individuals exposed to chronic stress and trauma may turn to addictive behaviors (substance abuse, risk-taking, screen-use) as a coping mechanism, further reinforcing a cycle of stress and poor health outcomes.

Model Insights

4. **Hormonal Dysregulation Cycle** (Reinforcing - R) (**Purple**)
    - Toxic Stress → Hormonal System Dysfunction → Hormonal Dysregulation → Increased Stress & Emotional Dysregulation → More Toxic Stress
    - Chronic activation of the stress response system (elevated cortisol and adrenaline) leads to hormonal imbalances, which in turn affect mood, metabolism, and immune function, reinforcing the negative impacts of stress.
5. **Illness Cycle** (Reinforcing - R) (**Pink**)
    - Toxic Stress → Immune System Dysfunction → Increased Illness & Infection → Further Stress & Weakened Health → Increased Risk of Chronic Disease
    - This loop shows how prolonged toxic stress weakens the immune system, leading to greater susceptibility to infections, inflammation, and chronic disease.
6. **Obesity and Comorbidity Cycle** (Reinforcing - R) (**Pink**)
    - Hormonal Dysregulation + Toxic Stress → Obesity/Overweight → Increased Risk of Comorbidities → Increased Inflammation & Cellular Damage → Early Death
    - Chronic stress and hormonal disruption increase the likelihood of obesity, which then contributes to metabolic diseases, immune dysfunction, and early mortality.

Model Insights

7. **Inherited Trauma Cycle** (Reinforcing - R) (**Red**)
    - ACEs → Epigenetic Effects & Gene Expression Alteration → Transgenerational Stress Response Dysregulation → Higher Risk of ACEs in Future Generations
    - This loop highlights the intergenerational transmission of trauma, showing how early adversity alters gene expression and stress responses, perpetuating the cycle across generations.

- **Key Takeaways:**
    - Reinforcing feedback loops dominate the model: Most cycles in the system are self-reinforcing, meaning once ACEs set these processes in motion, they continue to escalate unless external interventions disrupt the cycle.
    - Multiple pathways converge on health outcomes: ACEs impact mental health, immune function, stress response, addiction, and chronic disease in interconnected ways.
    - Intervention at multiple levels is critical: Breaking the cycles requires multi-level interventions—trauma-informed care, mental health support, family-centered interventions, and public health policies.

Prevention Strategies

Source: National Center for Injury Prevention and Control (U.S.). Division of Violence Prevention, 2019.

STRATEGY	APPROACH
Strengthen families' financial situation and supports	• Strengthening family financial security • Family-friendly labor policies, such as paid paternal and maternal post-natal leave
Encourage social norms that reduce violence and adversity & promote non-violent communication	• Public education campaigns • Reduce corporal punishment through public policy • Bystander training and sensibilization • Garnering prevention support from men and boys as allies
Enrich childhood environment and family support	• Early childhood home visits • High-quality child care • Enriched preschool environments & family engagement
Skill Building	• Social-emotional learning; mindfulness, compassion, and self-compassion • Healthy relationships educational programs • Positive parenting coaching and strengthening secure attachment
Fostering caring relationships among youth and adults	• Mentorship programs • After-school & recreational programs
Intervene to mitigate short- and long-term impacts	• Primary care ACE screening and transdisciplinary clinical intervention • Child-parent psychotherapy for young children who have experiences ACEs • Trauma informed survivor-centered services • Treatment to reduce the negative impacts of ACEs • Treatment to promote prosocial behavior and prevent future involvement in violence; break the cycle • Family-centered treatment for addiction & substance use disorders

Intervention Strategies

STRATEGY	Benefits & Impact
Nervous System Regulation - mindfulness, breathwork, vagus nerve exercises, grounding techniques, and acupuncture	• Regulates the Nervous System • Mindfulness enhances emotional regulation, impulse control, concentration, attention, memory, reduces depression and anxiety, enhances overall wellbeing
Compassion and Gratitude	• Fosters resilience and a sense of agency • Posttraumatic growth through helping others with what they have learned through their own recovery
Self-Compassion and Forgiveness	• Enhances positive self-concept, self-efficacy, wellbeing; reduces self-criticism, negative thoughts, suicidal ideation • Allows for healing from past traumas and reduces the emotional burden of carrying resentment, anger & shame
Nurturing Care & Healthy Relationships	• Parent coaching; parent-child therapy; positive parenting training • Community support, support groups, mentoring, connecting youth with caring adult role models
Mental Health Support/Therapy	• Cognitive-Behavioral Therapy (CBT); Music Therapy; Eye Movement Desensitization and Reprocessing (EMDR), Mindfulness-Cognitive-Behavioral Therapy (M-CBT)
Adequate Sleep	• Enhances emotional regulation and cognitive functioning; cleans toxins in the brain • Reduces sleep distruption
Balanced Nutrition	• Fosters neuroplasticity and resilience, enhances immune system functioning, reduces inflammation and hormonal dysfunction or imbalance
Exercise	• Enhances neuroplasticity, neurogenesis (brain's ability to produce new brain cells), memory, resilience, and emotional regulation. Improves sleep, immune system functioning and hormonal regulation. • Improves behavior, academic performance, ttention, learning

Conclusions

Effectively addressing Adverse Childhood Experiences (ACEs) requires a combination of targeted interventions, policy reforms, and continued research to identify the most effective strategies for prevention and mitigation.

1. Expanding Trauma-Informed Policies and Practices

Addressing the widespread and long-term impact of Adverse Childhood Experiences (ACEs) requires a comprehensive, multifaceted approach that integrates public health strategies, trauma-informed care, and resilience-building interventions. Given the strong association between ACEs and negative health, developmental, and social outcomes, efforts to mitigate their effects must extend beyond individual treatment to systemic change. A public health approach—focusing on prevention, early detection, early intervention, and policy-level initiatives—can help reduce the prevalence of ACEs and support children, adolescents, and adults in overcoming their effects.

2. Enhancing Community-Based Prevention and Support Programs

Key strategies include promoting family-centered care, integrating trauma-informed practices into healthcare and educational systems, and fostering community resilience through access to mental health resources, social support networks, and stable, nurturing environments. By prioritizing prevention and early support, policymakers, educators, and healthcare professionals can work together to buffer the impact of ACEs and create a foundation for healthier, more resilient individuals and communities. Ultimately, a society-wide commitment to addressing childhood adversity can break intergenerational cycles of trauma and improve lifelong health and well-being.

3. Strengthening Individual and Family Resilience Strategies

On an individual level, parents, caregivers, educators, and healthcare providers play a critical role in buffering the effects of ACEs. Nurturing supportive relationships, practicing responsive and emotionally attuned caregiving, and teaching social and emotional skills and self-regulation skills can significantly impact a child’s ability to cope with adversity. Encouraging mindfulness, self-compassion, forgiveness, and positive coping strategies in both children and adults can foster resilience and promote long-term well-being. Additionally, increasing awareness about ACEs and reducing stigma around mental health support can empower individuals to seek help when needed.

Recommendations & Future Research

Areas for further research:

- Longitudinal studies on resilience (protective) factors.
- Epigenetic and neurobiological impacts: Exploring how ACEs influence gene expression and brain development over time and whether early interventions can reverse or mitigate these effects.
- Equity and disparities in ACEs outcomes.

Areas for future qualitative and quantitative modeling:

- Causal loop diagramming of this issue from a macro and mezzo level to examine the community and societal factors that influence adverse childhood expierences.
- Examine the highest leverage points for preventing ACEs on a macro, mezzo and micro level and for reducing the negative impacts of ACEs.
- Develop simulation models to test the potential outcomes of proposed policies, such as universal childcare, expanded paid parental leave, and mental health funding, to determine their effectiveness in reducing ACE prevalence and impact.
- Predictive analytics for early intervention: Leveraging machine learning and big data to identify at-risk children and families early, enabling targeted support before adverse experiences escalate.

Definitions

- Uniformity in the operationalization of “Toxic Stress” is necessary to reduce inconsistency in definition and measurement.

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