Where Education Meets Medicine: The Science of Adversity, Resilience and Human Potential

A Report on the Past Year and Plan for Impact Moving Forward

Dr. Sheila Ohlsson Walker

May 2016

"You cannot educate a child who is not healthy, and you cannot keep a child healthy who is not educated."

Dr. Jocelyn Elders
16th Surgeon General of the U.S.

Table of Contents

Introduction

Recent years have seen dramatic advances in understanding the science of the brain - from how information and emotions are processed, to how myriad stimuli create physiological responses that have significant implications for mental health, physical health and education. These advances offer the hope of novel and innovative solutions to seemingly intractable problems affecting many diverse populations, with important implications for medicine and education. Collectively, these advances reinforce the notion that the deterministic "nature vs nurture debate" is a long-held myth and that the more scientifically accurate "nature *via* nurture" paradigm is squarely in place. This new template for human development is well–grounded in our current understanding of epigenetics – the study of changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself.

The most gripping example of how genes and environmental context shape each other reveals how the unremitting stress associated with conditions endemic to living in poverty can become toxic to a child, "embedding under the skin" in their brains and immune systems, and affecting characteristics that are foundational for health and learning. Indeed, the science of toxic stress creates a critical bridge between the fields of medicine and education. Good health – mental and physical - is fundamental for learning. Importantly, insight has been gained into ways in which the toxicity of stress can be buffered and ameliorated, offering a road map for solutions that can reshape the trajectory of a child's life. In short, science conveys an optimistic story about how healthy and supportive environmental contexts have the power to shape a child's biology, hence their ability to lead a happy, healthy and productive life. This has profound multi-generational implications for the dialogue around resource allocation, opportunity, equity and social justice.

Unfortunately, the pace of knowledge expansion has not been matched by practical dissemination of this information, presented in a common taxonomy and translated into accessible language, to people with the power and ability to take critical actions. This group includes adults who have regular, meaningful interaction with children and young people, such as parents, teachers, coaches and pediatricians. Accordingly, an enormous opportunity exists to advance this cause through strategic efforts to increase the effective dissemination and practical application of this valuable information.

This strategic planning process document represents a collaboration between S&R Foundation and Dr. Sheila Ohlsson Walker to address the aforementioned dissemination gap – with a specific focus on bio-social scientific translation for the field of education. S&R Foundation has been a committed supporter of educational causes, particularly for children at high risk of adverse outcomes due to the myriad challenges of living in poverty. The body of work presented in this plan is strongly aligned with S&R's overall mission of funding science-based efforts designed to advance innovative solutions to significant educational and societal problems.

Dr. Walker, who is an Assistant Scientist at the Johns Hopkins Bloomberg School of Public Health, an Assistant Professor in the Johns Hopkins School of Education, and a Faculty Affiliate at the University of California, Irvine, is the inaugural recipient of the Dr. Sachiko Kuno Fellowship for Applied Science. Consistent with the mission of S&R and the goals of the Dr. Kuno Fellowship, Dr. Walker's own professional aspiration is to advance the transformation of public education in the United States by harnessing biosocial science to help all children reach their full potential. Dr. Walker's work to date – doctoral research in the field of Behavioral Genetics with a specific focus on education, experience presenting to

a broad variety of scientific and lay audiences, teaching of undergraduate students at Georgetown University and Johns Hopkins, and broad expertise in the biology of behavior – has all been intended to advance that aspiration. Moreover, her previous experience in the financial investments industry provides an important lens through which to frame issues relevant for policy and system-level change: economic return on investment.

Dr. Walker has formulated a plan, laid out in detail in this document, that in its initial phases will focus rigorously on the highest-priority problem associated with brain function in education – ***toxic stress and its antidotes*** – given the known and powerful implications for long-term health, behavior, and critical aspects of cognition relevant for school success. This plan is built around *three overarching strategies* comprising several well-defined initiatives that leverage her strengths to advance the goals shared by Dr. Walker and S&R Foundation. These strategies, described in full in a subsequent section, are as follows:

1. Equip Influential Adults to Change Behavior: Initiatives intended to equip educators and school leaders with additional tools for application in school and classroom settings to optimize the potential of their students by translating cutting edge neurobiology, psychoneuroendocrinology, genetics and epigenetics into accessible and practical in-person / instructional coach and web-based professional development content.

2. Raise General Awareness: Engagement in activities and events that will broadly increase awareness and the understanding of the causes of toxic stress – as well as potential solutions - amongst audiences including educators, education administrators, parents, medical professionals, nonprofits, policymakers and the popular media to lay the foundation for future action in better connecting the fields of medicine and education.

3. Build Practical Knowledge: Initiatives intended to engage a variety of experts to design, pilot and test promising interventions, as well as collect longitudinal biological-social (biosocial) data supporting the long-term economic case for the co-investment in mental health, physical health and education starting before birth.

While formulating a compelling plan for future action has been the primary goal of this effort, much has already been accomplished to date on all three fronts. Accordingly, this document will also serve as a status report on each initiative.

The Problem

Although recent advances in brain science research have myriad implications for health, disease and quality of life, the primary focus of this plan is on the phenomenon known as "*toxic stress*." Despite no formal symptomatic nor diagnostic criteria for toxic stress in the 5th edition of the Diagnostic and Statistical Manual (DSM-V)[1], it is a newly established top priority for the American Academy of Pediatrics (AAP), the largest and most highly respected professional membership organization for the field of pediatrics in the United States.

This stated, some clinics working with vulnerable children and families nationwide, such as the Center for Youth Wellness in San Francisco[2], have focused on refining clinical protocol to address toxic stress in a holistic, family-wide manner. The unrelenting stressors of growing up in poverty, detailed below, make the prevalence of toxic stress notably higher in low-

resource populations. That is, the accumulation of multiple "hits" to a child's biological system, both prenatally and in early childhood, can exacerbate vulnerability to a host of adverse health and cognitive outcomes over the life course.

A scientific proxy of this cumulative biological risk is provided by a deep research base demonstrating higher rates of "allostatic load". This term refers to the cumulative physiological build-up and embedding of the biological concomitants of stress in the bodily system through dysregulated metabolic, inflammatory, hypothalamic-pituitary (HPA) axis biomarkers, as well as other key molecular mediators of chronic stress[3].

Allostatic Load can occur in all socio-economic strata within various populations, regardless of culture or ethnicity, but is of higher prevalence in under-resourced populations due to the myriad chronic stressors endemic to living in poverty[4-7]. The insidious and broad-ranging effects of toxic stress on a developing child's brain and immune system demands a particular sense of urgency in action, considering that 16 million children in the United States, or 22% of the total (range: 11% in New Hampshire to 32% in Mississippi), currently live in poverty[8].

Fortunately, there is a growing body of biosocial research underscoring the remarkable malleability and resilience of the human body and brain. It is within this body of research that we are beginning to understand that the bridge between adversity and human potential lies in personalized context, deployed atop a foundation of solid mental and physical health.

By understanding and applying bio-social science, adults that touch the lives of our children will have better tools available than ever before to give each child the best chance to reach his or her full potential, benefiting not only their children, but also generations to come.

Toxic Stress and the Implications for Education

An extensive body of scientific research provides insight into how biological characteristics and social environments shape life trajectories for children. A critical example is that of chronic stress, which left unaddressed, can cause *seemingly* invisible wounds.

While stress is a necessary and important factor for motivation and performance, it can become "toxic" when circumstances force the stress response system - designed to help our bodies and brains manage daily life - to go into overdrive. Experiences of prolonged adversity, or a cumulative build-up of "adverse childhood experiences" (ACEs) can result in the widespread psychological and physiological consequences of toxic stress[9-11].

ACEs come in several forms, including emotional and/or physical neglect, abuse, neighborhood violence, parental mental illness and mood disorders, parental incarceration, and a basic lack of safety and stability; more detail is provided in the following section. These factors are exacerbated by other issues endemic to low-resource populations such as environmental toxins, food and housing insecurity, sleep deprivation, and other persistent issues that trap the child's developing brain and body in a state of unpredictability and hypervigilance.

The biology of the stress response is an intricate process that scientists are gaining more insight into every day. When an extraordinarily stressful situation (i.e. an ACE) is experienced, unbuffered by an offsetting protective and compensatory experience (PACE) such as a trusted, safe and supportive relationship with an adult, molecules such as cytokines and cortisol are released into the blood stream in response to the trauma.

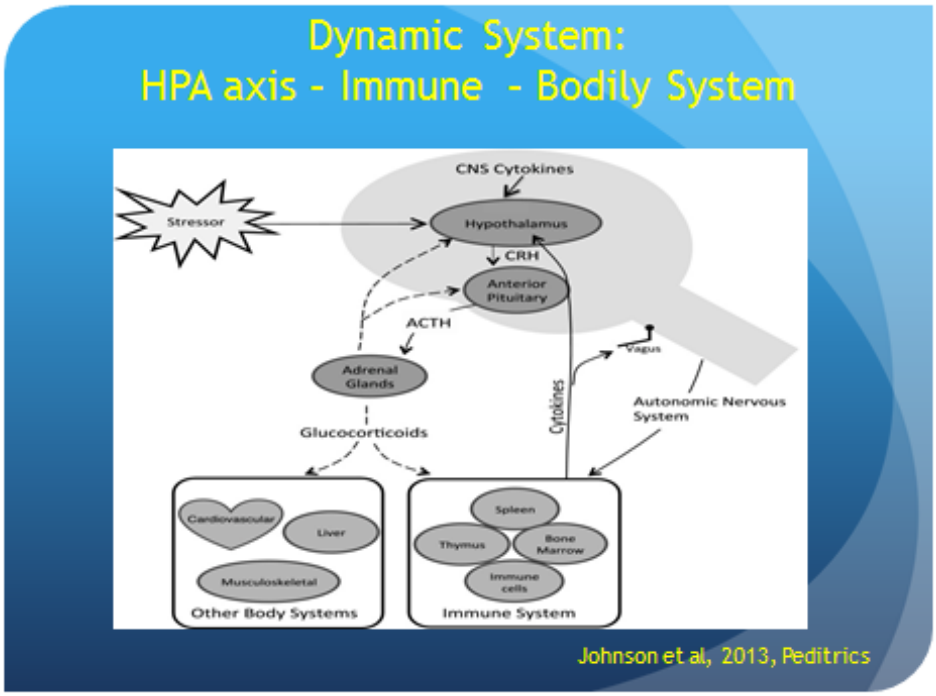
These molecular concomitants of stress have a dynamic and inter-related effect on the entire human system, in a manner so ubiquitous that it is virtually impossible for scientists to tease apart effects on the immune system versus the brain. The omnipresent nature of the toxic stress response in the child's hypothalamic-pituitary-adrenal (HPA) axis can cause the stress response "gas pedal" to get locked in the "floored" position, flooding the immune system and brain with an unrelenting deluge of stress-induced biochemicals and hormones.

This dynamic can cause changes to neural signaling patterns as well as the physical brain structures themselves, which can profoundly affect school performance, as well as mental and physical health over both the short- and long-term. Individual differences between children and the contexts they are exposed to – the "nature and nurture" of their own unique stress response systems – shape these various outcomes. Importantly, "injuries" from unrelenting stress, unlike a skinned knee upon which an adult can easily place a band-aid, are hard to see without specialized information and good training. However chronic and toxic stress give rise to invisible wounds that require a trained eye to identify and heal.

Rather than ask "What's wrong with you?", we must ask "What happened to you?" It is through this non-judgmental lens of empathy and curiosity that true healing can begin.

The experience of unbuffered childhood and adolescent adversity sets into motion a complex biological cascade effect that can, over time, exacerbate risk for a variety of chronic physiological, behavioral and psychological issues. The mechanisms by which toxic stress can become biologically embedded in a child, affecting the brain and immune system, are depicted in Figure 1 below.

Figure 1: Mechanisms for the Biological Embedding of Stress



The Process by Which Stress Becomes Embedded "Under the Skin"

Myriad sources of unrelenting, life-long stress can result in the dysregulation of a child's ***HPA axis***, the body's primary stress response system[12]. Under this scenario, ***cytokine*** signals to the ***hypothalamus*** are perpetually in a state of alarm, sending out steady signals to the ***pituitary glands*** that the body and brain must be ready to react at any moment. This cascade alerts the child's ***adrenal glands***, which produce ***cortisol*** – a stress hormone that has powerful ***inflammatory*** effects. Cortisol plays many important roles in the brain and body, including regulation of blood sugar levels, immune function, metabolism, and other key bodily organs[13].

Levels of cortisol are designed to increase and decrease as necessary to respond to a wide variety of life situations and stressors. However, when stress is unremitting, and *no safe, trusted adult is available to buffer the stress*, the persistent inflammatory effects can become toxic, ultimately damaging brain and body. This process unfolds in a manner specific to the individual child, and is partly based on genes, environmental context, epigenetics and previous life experience.

Imaging studies tell us that the very structure and function of key brain centers for meaningful, intrinsically motivated learning in a child's brain can be impacted by the toxic effects of unrelenting, unbuffered stress. The ***prefrontal cortex***, more colloquially known as the brain's "Chief Executive Officer", is important for attention, executive function and self-regulation, and can atrophy over time[14-18]. The ***hippocampus***, important for learning and memory, also has been shown to become reduced in size under conditions of chronic stress[12,19-27].

Structures such as the ***amygdala***, the brain's emotional "smoke detector," show structural differences associated with hyper- (enhanced) or hypo- (reduced) reactivity in individuals exposed to trauma relative to those who have not [14,28-32]. These volume changes in areas of the brain, detected through MRI (magnetic resonance imaging) studies, are theorized to relate to stimulation and use, akin to building muscle strength in the gym.

Importantly, connectivity (electrical "traffic patterns") between brain structures via neural pathways (from "side streets" to "super-highways"), are detectable by using fMRI (functional magnetic resonance imaging) techniques, and are transformed via usage. Practice and repetition increases myelination, a neural substance that enhances conductivity and efficiency, thus building signal strength and also message transmission speed. For example, behavior stemming from the stimulation of a child's amygdala that is under-myelinated, hence poorly connected to the prefrontal cortex, is likely to manifest as impulsive and reactive behavior.

In practical terms, this means while dealing with stressors in a thoughtful, non-reactive manner is *already* a challenge for most children, there are neurobiological limitations that make it even more so for those young people who have been exposed to significant adversity without offsetting protective factors.

Conversely, a well-connected, adequately myelinated pathway between the amygdala and prefrontal cortex bolsters the odds that the child will be able to self-regulate (press the emotional pause button) and reflect on an alternative strategy to manage the stressor. This dynamic is illustrated in fMRI studies, which display underdeveloped / under-myelinated connections between the amygdala and prefrontal areas of the brain, compromising a child's ability to reframe negative stimuli or remain calm in the heat of the moment[33-35].

Finally, the child's ***nucleus accumbens (NA)***, a brain center important for motivation, reward and addiction, can become less responsive to external stimuli[36-40]. This happens because under conditions of chronic unbuffered stress, the NA's sensitivity to the key "novelty" neurotransmitter *dopamine* can become dulled and inefficient. This can translate into an elevated inclination to engage in higher-risk behavior to achieve the same neurochemical reward or "dopamine hit" that was previously possible by staying within societal norms and taking appropriate risks.

These biological processes provide a snapshot as to how multiple ACEs can impair, or at worst, derail health and learning over the course of a child's life. Further detail on ACEs are provided in the following section.

Adverse Childhood Experiences (ACEs)

Sadly, childhood adversity is very common, as established in the original ACE Study[9]. The landmark study, first published in 1998, was a collaboration between the Centers for Disease Control (CDC) and Kaiser Permanente. The study population comprised over 17,000 middle- and upper- income, predominantly Caucasian adults. The main goal was to elucidate the link between early life trauma and mental as well as physical health in adulthood.

Participants were asked to list how many of 10 different types of adverse childhood experiences they'd had, including sexual, physical or emotional abuse; neglect; loss of a parent due to death, divorce or incarceration; parental mental illness; and drug or alcohol abuse by a parent. An expanded ACE questionnaire, with adversities specific to children and adolescents, includes experiences such as foster care, discrimination, bullying and intimate partner abuse (see original ACE questionnaire and extended version in Appendix 1)[10].

In the original ACE study, two-thirds of the respondents had an ACE score of at least one. Of the individuals who had one ACE, 87% had 2 or more. A similar pattern is evident for individuals with higher ACE scores. The bottom line: ACEs tend to cluster.

Study results revealed that:

- Childhood trauma was very common, even in employed white middle- and upper-class, college-educated people with excellent health insurance coverage;
- There is a strong and graded link between childhood trauma and long-term health outcomes including chronic disease, lung cancer, diabetes, various autoimmune diseases, depression, and elevated incidence rates of high-risk behavior such as committing an act of violence, being a victim of violence, and suicide;
- There was evidence of a compounding effect: more types of trauma increased the risk of health, social and emotional problems;
- Typically, people experience more than one type of trauma – rarely is it only sexual abuse or only verbal abuse;
- Premature mortality statistics tell the most bracing story: individuals with 6 or more ACEs showed a 20-year decrement in life span.

The cut-off for behavioral, psychological and health risk is 3 or 4 ACEs (13% of the original study population had 4 or more). Statistics and odds ratios from the original Kaiser-CDC study are as follows for individuals with 4 or more ACEs:

Health Condition	Odds Ratio
Ischemic Heart Disease	2.2x
Cancer	2.2x
Chronic Obstructive Pulmonary Disorder (COPD)	2.6x
Stroke	2.4x
Type 2 Diabetes	1.6x
Alzheimer's Disease	4.2x*
Autoimmune Disease	2x
Emphysema	4x
Depression	4.6x
Obesity	Elevated Risk
High-Risk Behavior	
Suicide Attempt	12.2x
Injection Drug Use	10.3x
Alcoholic	7.4x
Smoker	2x
Teenage Pregnancy	2x
Risk of Accident	Elevated Risk-#4 cause of death in U.S.

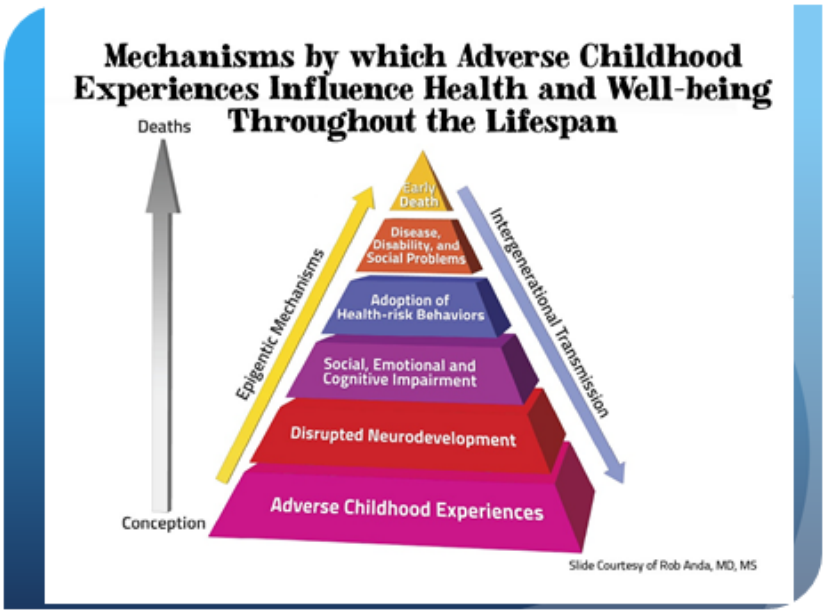
* California ACEs Study

It is well established that for individuals living in poverty, ACE scores are generally higher, stemming from the myriad adversities that are endemic to the challenges of daily life[13,41-44]. For example, an increasing number of researchers are systematically tracking ACEs and have found that in some school districts, particularly those in low-income urban communities, up to 70% of children have had personal exposure to violence, and 80% have been direct witnesses to violence[45].

For these children, the exposure is less of a one-time "incident," and more of a "constant presence" – similar to post-traumatic stress disorder (PTSD). This is reflected in behavior, health and academic performance for even our youngest children – in a recent study of kindergartners the cut-off for behavioral and learning risk was 3 ACEs[46]. Moreover, it is possible that earlier life ACEs have a stronger negative effect, given that early childhood is a key "critical period" for developmental and health risk[47,48]. Fortunately, this is also the time when intervention can have the greatest positive effect.

Eighteen states have since done their own ACE surveys, and statistics are highly similar to the original study. At present, a literature search in PubMed, the primary medical search engine for academic research, yielded over 600 peer-reviewed papers when placing "Adverse Childhood Experiences Study" in as the search term, and a Google search yielded 5,390,000 results. The bio-social processes by which toxic stress and childhood trauma, as captured by ACEs, are believed to interfere with healthy development and significantly exacerbate risk for disease, disorder and negative life outcomes are depicted in Figure 2:

Figure 2:



Vignette: The Story of Lisa

This process is illustrated by the story of Lisa, an 11 year-old 5th grader who loves painting, singing, and spending time with her friends. She lives with her 4-year-old identical twin brothers, Johnny and DeShawn, and is being raised by her mother Tanya. Lisa has never known her father, as he was incarcerated just before she was born.

All Lisa has ever known is transition, having moved between various low-income housing establishments and homeless shelters since infancy. She has become used to the sound of police sirens, gunshots, angry shouting voices, and broken glass.

Tanya has done her best under exceedingly difficult circumstances, yet it has been hard for her to maintain a job that provides adequate money for food, rent, utilities and healthcare. Tanya is severely depressed, a mood disorder she quells by drinking large volumes of hard liquor nightly, impairing her ability to care for herself – and even more – her three children. As such, Lisa has assumed a maternal role for Johnny and DeShawn, as she loves them dearly, and above all she hopes to spare them some of the pain she has suffered.

Lisa's behavior – the outward-facing manifestation of her chaotic and unpredictable home life - can look very different – depending on the context. At school, her behavior appears disruptive and disorderly. She presents with symptoms that look like attention-deficit hyperactivity disorder (ADHD), making it difficult for her to sit still, pay attention and learn. Lisa is more outwardly aggressive than other girls her age. She appears emotionally detached and unrepentant when inflicting harm - either physically or emotionally - on another child. She has been to the Principal's office multiple times for bullying, and for disrespecting authority figures.

These types of inappropriate behaviors are likelier to present in someone like Lisa because her brain and autonomic nervous system are locked in a constant state of hypervigilance.

She displays symptoms of post-traumatic stress (PTSD), and accordingly perceives even innocuous situations as a substantive threat. For Lisa, an imaginary bear is circling her house – 24 hours a day, 7 days a week - and for her there is legitimate perceived danger at every turn.

Accordingly, her grades are far from her true potential, and frequent "cool down" breaks and suspensions from class, or trips to the Principal's office are part of her expected, normal routine. The combination of these issues have resulted in several suspensions, and now have Lisa on the short list for expulsion. Because of the compounding psychological effect of the consequences of her behavior, her self-esteem has suffered greatly. She's started to believe that she really isn't that smart, that she's incapable of controlling her own behavior, and that her dream of high school graduation and maybe even college are beyond reach – even though she's only in the 5th grade.

Lisa's behavior in the home context looks entirely different – and would come as a great surprise to her teacher. At home, as reliable caregiver to Johnny and DeShawn due to her mother's myriad challenges, Lisa is responsible and nurturing. She prepares breakfast and dinner, manages bath and bed time, and when she has the energy, reads her brothers a story. In the home context, she occupies the mental space of being a stand-in parent to the brothers she loves so dearly – someone akin to the mother she wishes she had.

Being a surrogate parent often means that Lisa does not have time to do her own homework, sit down for a proper meal, nor go to bed at a time that allows her to get the AAP-recommended 10 hours of sleep necessary for a child her age. Rather, after her siblings go to bed, Lisa frequently finds herself taking care of her mother, who by this time in the evening is in an alcoholic stupor.

Lisa is carrying a load greater than any one person – particularly a child – should have to bear. On paper, she has an ACE score of 5: raised by a single mother, has an incarcerated father, experiences regular neighborhood violence, Tanya has a mood disorder, and as a result is emotionally neglectful towards Lisa. Realistically, Lisa's score is probably higher, as not all adversities are officially covered by the ACE questionnaire. Moreover, the powerful stressors of poverty tend only to exacerbate the already untenable issues. Sadly and shockingly – Lisa is bearing much of this load alone.

Resilience factors that could buffer the adversity in her life, such as "having a caring adult to talk with", "having positive memories of her mother from childhood", "feeling fundamentally loveable" (see AAP Resilience questionnaire - Appendix I), are either not present, or have been reframed negatively in her mind over the course of time. She is laser focused on getting through each day, with limited cognitive bandwidth to think about much else other than survival.

She does have some protective factors – such as being "independent and a go-getter" and believing that "life is what you make it". However, she would benefit greatly from a safe, nurturing and trusted relationship with an adult. Heartbreakingly, the kind and caring aunt Lisa relied on for a listening ear, a laugh, and a hug moved out of town a year ago. Since then, it's been harder for her to keep all of the balls in the air.

What Lisa does not fully understand is that her behavioral, cognitive and emotional issues are a product of the underlying issues – the toxic factors in her life that she has no control over which have a damaging biochemical effect in her brain and immune system. She's unable to see that she's not a "bad" child, and unfortunately, nor do key adults in her life that could serve as important resources for positive adaptation.

Were there a diagnostic category at the pediatrician's office for toxic stress, Lisa would easily meet the criteria. As such, her stress response "gas pedal" is locked in the floored position, and the evidence shows in her behavior, attention, emotion regulation and mental health.

Importantly - there are *also* important physical health related repercussions. The powerful inflammatory biochemical effects have left Lisa with a physiological metabolic profile (e.g. blood pressure, blood sugar, lipids, inflammatory markers, etc.) well beyond her chronological age of 11 years old. She is significantly overweight with a BMI of 32, has elevated blood pressure as well as high cholesterol.

Lisa has also been afflicted with chronic asthma – a common autoimmune condition in children with high ACE scores[12,49,50] – since she was a toddler. Her asthma has been poorly contained due to a lack of health insurance, proper preventative care, and oversight by Tanya. These issues significantly affect Lisa's ability to properly absorb curricular material in class, and frequently, also affect her attendance. Importantly, attendance is a very strong leading indicator of school dropout – a tremendous risk factor for a host of negative life outcomes[51-54].

More broadly, the health conditions Lisa is afflicted with, in the absence of a counterbalancing healthy lifestyle, set the stage for major longer-term chronic illnesses such as type 2 diabetes, cardiovascular disease, and chronic obstructive pulmonary disorder – all of which are on the list of the 10 leading causes of death in the U.S.[55]. It is important to note that these types of chronic diseases, which account for roughly 86% of U.S. healthcare expenditures[56], are preventable with early identification and proper treatment.

However, it is in the arena of chronic mental health conditions – which have now replaced chronic physical illness in the top 5 most significant pediatric health issues - that the most profound and costly damage can frequently occur[57]. Psychologically, children like Lisa who have experienced toxic stress are at higher risk for mood disorders such as depression, anxiety, learning difficulties such as ADHD. Moreover, symptoms of PTSD, which are now being identified in even our youngest children, result in emotional shut-down and over- or under-reactivity to even the most minor stressors, and affect all aspects of life – both in and out of school.

Neurobiologically these "invisible" dynamics, which are harder for the untrained adult to identify as they simply meet the eye as unruly behavior, are particularly important because of the manner in which the brain is cross-wired. All of the aforementioned brain structures, which are key for learning, emotion and behavior all "talk" to each other.

Accordingly, the neural activity of one structure is influenced by signals from the others. In practical terms, this means that if a child's emotional smoke detector has been biologically recalibrated to sound the alarm for a *fire* every time there is *smoke*, the persistent stress response can trigger an ongoing cycle of changes to neural traffic patterns that present formidable and persistent cognitive, behavioral and emotional challenges.

Lisa's adverse experiences have shaped her life in a profound manner that has permeated her body, brain, and overall well-being. As she lives year in and year out being misunderstood, undervalued for her unique strengths, her "way out" – high school graduation – the one legitimate chance she has to beat the odds and break the inter-generational cycle of poverty – slips further and further away.

As this occurs, the tremendous knowledge gap for key adults in Lisa's life who are capable of shifting her trajectory becomes more and more relevant. That is, having awareness and specific knowledge about how to most effectively help Lisa could be the *tipping point* towards a healthy path in life.

Tanya clearly needs additional support to be a support to be the mother she'd like to be, however her own high ACE score and lack of counter-balancing resilience factors as a child left her developmentally constrained. Systems level parent and family-focused intervention for trauma is critical and tremendously important, however this lies outside the scope of the current report, which is focused on resources within schools.

It follows that Lisa's teacher, school principal, and administrators **do** have the potential to fill a key void in her life at this time. With awareness, they can thoughtfully intervene with internal school resources, provide referrals to appropriate community agencies, or if necessary connect her with necessary healthcare services. I

f such intervention happens before Lisa becomes enmeshed in a lifestyle of high-risk behavior: like becoming addicted to drugs or alcohol, getting arrested, or becoming pregnant, they can help shift Lisa's life course before the deck becomes irrevocably stacked against her.

Information, skills and support that allow these key adults to establish a healthy, safe, and trusting relationship can begin to transform Lisa's biochemistry – and the story she believes about herself and what's possible in the world – at a time when her brain neuroplasticity is highest – the most "sensitive" and malleable it will be across life. Collectively, this support could provide the context necessary for Lisa not only to survive, but to thrive.

Other Key Knowledge Gaps for Teachers

While the central focus of this report and proposed work is to provide insight and understanding to educators about *toxic stress and solutions*, consistent with Lisa's story above, a secondary aim is to broadly enhance the understanding of *educationally relevant biological science*. This includes professional development (PD) material from the fields of brain science, genetics, epigenetics, behavioral genetics, and psychoneuroimmunology.

Our material will also provide accurate information on "neuromyths", or pseudo-science that has become accepted as fact within the field of education but has little to no grounding in science. Collectively, this material will provide the learner with an expansive view on the latest cutting-edge, replicated validated science, with an overarching aim of providing information that can be reflected upon to change patterns of thought and at best applied to change behavior – teacher and student – in classroom settings.

- Mind, Brain and Education Science**:** The latest science on what we know about how the child and adolescent brain learns. This includes what we know about why emotional connection is essential for intrinsically motivated learning and long-term retention.

- The Neurobiology of Human Potential: The bio-social science of individual differences, biological sensitivity to context, and the promise of personalization to optimize each child's potential.

- Nature via Nurture**:** The Science of epigenetics, and implications for a child's development, cognitive functioning, behavior and health.

- Schools as Dynamic Systems: Emotions are contagious, and as such consideration must be given to systems-level dynamics in creating healthy, stimulating and healing learning environments. This includes school climate, safety, stress, and wellness for students, teachers, administrators and leaders – all those who are involved in the everyday life of the school.

- Meta-Cognition: "How my Motor Runs" self-understanding material on a child's own brain, teacher self-care, wellness programs, mindfulness meditation / stress reduction / "brain breaks".

- "Neuromyths" Revealed: Dispel inaccurate neuroscientific information that has made its way into the belief systems of educators[58,59], potentially shaping learning curriculum and student-teacher relationships in maladaptive ways.

- Public Education is a Public Health Issue: Mental and physical health is the foundation for all meaningful learning, and a system-wide, collaborative effort is required to establish healthy conditions for each child to reach their potential. The Centers for Disease Control (CDC) and Association for Supervision and Curriculum Development's (ASCD) "Whole school, Whole Community, Whole Child" (WSCC) model is a sound representation of how a systemic approach to education might appear in practice. Basics on public policy and regulatory issues (Healthcare Information Portability and Accountability Act – HIPAA and the Family Education Rights Protection Act - FERPA) will be included.

Grounds for Hope: The Neurobiology of Resilience

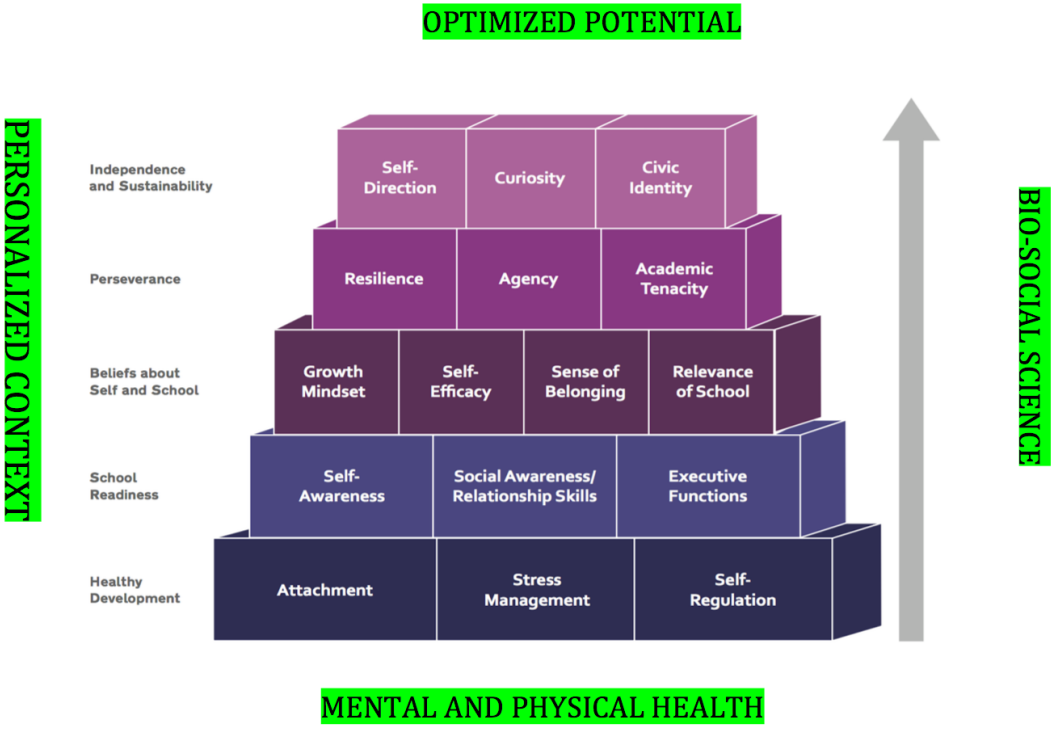
Antidotes to Trauma

Despite experiencing toxic stress, children like Lisa can and do succeed, and a growing body of research is shedding critical light on why. Just as ground-breaking studies are elucidating the implications of trauma for the immune system and the developing brain, they are also telling us about the *antidote* to trauma, and how these positive outcomes manifest in neural pathways that affect learning, behavior, and mental as well as physical health. Improved knowledge combined with neurobiological evidence-based interventions can change the very course of a child's life. These changes stem from the physiological resilience that is built into our systems throughout the life span: tools that can restore health even after the experience of adversity.

Figure 3 represents a framework illuminating some key *measurable* and *malleable* building blocks required for intrinsically motivated learning and success in school - as well as life[60]. At the foundation of all building blocks for learning lies mental and physical health – as without health – a child's optimal range is inherently restricted.

Optimal human development lies in the healthy establishment of basics such as attachment, self-regulation and stress management: factors upon which higher-order behaviors are built and become galvanized. Characteristics such as having a growth mindset, a sense of agency and self-direction are key ingredients in positive long-term outcomes, as behavior and skills, for better and for worse, tend to "snowball" over time – epigenetically and neurobiologically[61] - as practice becomes habit[62]. In short, rather than a deterministic, developmental dead-end, biological science continues to elucidate an optimistic bio-social story of "what can be" given safe, nurturing and personalized environmental context.

Figure 3: Building Blocks for Learning



Adapted from Stafford-Brizard, 2016

The recipe for resilience and perseverance lies in a set of interactions influenced not by nature *or* nurture, but by nature *via* nurture[61,63-65]. It is increasingly apparent that, if left unbuffered, the damaging effects of trauma can disrupt the architecture of the developing brain[16,22,24,32]. However, epigenetic research in animals and humans suggests that this damage can be mitigated or potentially even reversed through adaptive coping, stimulated by reliable support from a safe and trusted adult[13,66-71]. With positive environments and relationships, a molecular cascade of restorative changes in the brain and body can make stress "tolerable" rather than "toxic."

Safe and trusting environments can facilitate healthy transcription patterns in genes important for mood and behavior[67,70] – the mechanisms of which are expounded upon below. Moreover, positive environments have effects on a broad range of biochemicals that can prepare a child's cognitive "canvas" for learning, including increased levels of the "love hormone", oxytocin, which fosters feelings of social connectedness, and decreased levels of the aforementioned "stress hormone" cortisol[72-79].

The best-case scenario is one in which challenging stressors can be reframed, with the help of an informed and caring adult, into a source of positive and personalized motivation – termed "eustress". This change in the adult's prism can help provide tools for the child to manage challenges with resilience and coping skills that pay dividends in and outside of the school setting, and over a lifetime.

Several separate and interconnected biological mechanisms are key to this transformational dynamic – most notably the process of epigenetics. These mechanisms are at the core of how genes are expressed into proteins, and underlie how nurture shapes nature by "tagging" genes to turn them on or off – in response to experience[80]. For example, if DNA is the body's "hardware," epigenetics is the "software," and interactive nature-nurture "software updates" constantly reprogram how the body and brain function over time.

While there are various types of epigenetic processes, DNA methylation is the most well studied at present across behavioral research[80]. Methylation operates in a similar manner to a dimmer switch, "up-regulating" (producing more of) or down-regulating (producing less of) the gene's particular protein product. Genes are, at the simplest level, recipes for proteins, which are the active biological molecules in the human body.

If a gene produces too much or not enough of the protein it is designed to manufacture - and in some cases may produce none at all – it can affect behavior and health over both the long and short term. Even identical twins show divergent epigenetic profiles at birth – patterns which grow more distinct over time and relate to individual differences in phenotypic (observable) outcomes[81-83].

While the field of epigenetics is still relatively young, the growing body of validated and replicated scientific research has captured the interest of behavioral researchers, highlighting the transformative potential of this field for child development[80,84-86]. Critical neurobiological processes, including neural plasticity (the perpetual experience-dependent remodeling of the brain) and neurogenesis (the formation of new brain cells) drive growth and adaptability essential for healthy development and learning[48,87-91].

Although a growing body of behavioral epigenetic research has focused on basics such as relationship attachment, nutrition, exercise and sleep, some of the strongest and most advanced studies have been performed in the biological pathways related to stress[80,84]. Specifically, this body of work has focused on glucocorticoid genes and others in the HPA axis pathway – the body's primary stress response system[80].

Much of the research focus has been on so called "critical periods" in child development such as preconception/prenatal, early childhood, puberty, and the adolescent years[12,48,92]. It is potentially during these periods when intervention and prevention efforts may have their most powerful effect in establishing pathways for healthy and adaptive responses to stress, and in teaching children strategies to be flexible in their cognitive processes around learning, transitions and self-regulation.

This stated, it is essential to bear in mind that epigenetic processes take place throughout life: they are fundamental to the manner in which human beings evolve[93-98]. These neurobiological mechanisms enable the same systems that can embed adversity to also program adaptability and resilience. This is the way in which nature works *via* nurture to change the course of a child's development, health and life. A more thorough synthesis of behavioral epigenetic findings, and the implications, is available elsewhere[80,84].

The Opportunity

Curiously, although our collective understanding of both the underlying problems and potential solutions related to toxic stress have expanded greatly in recently years, this relevant and evolving body of research has not been disseminated effectively to the committed, supportive adults who are well-positioned to make a positive difference in the lives of vulnerable children.

In particular, this content is rarely, if ever, included in teacher, principal or education administrator training, resulting in a deficit in essential tools necessary to optimize child and adolescent outcomes. Moreover, human beings - whether at home, school or out in the world - operate in dynamic systems via the social networks in which they participate[99-103]. This means that broadly speaking emotions, both positive and negative, are in a word, contagious – which has important implications for school culture and climate.

Dynamic systems theory has deep roots in systems biology, and shines a spotlight on the need to think about the whole as well as the individual as the health and behavior of one can affect that of the other[100,103]. For students, this means instituting protocols that foster healthy school and classroom emotional climates, such as Trauma Informed Curriculum[104] and Positive Behavior Intervention and Support (PBIS) programs, which can intercept problem behavior before it starts[105].

Other relevant research shows that while children age 6-17 who have experienced multiple adversities have lower school engagement and higher rates of chronic health issues[106], the literature also reveals that building resilience through providing self-care and de-escalation tools can improve health, behavior and school performance – despite the experience of adversity[85,107-110].

These behaviors and supports, when integrated into classrooms along with evidence-based interventions such as mindfulness programs designed for children and youth[34,107,108,111-116], academic material and context personalized and appropriate for the individual child[117], and a more holistic understanding of the child not only as a learner - but as a human being - can change a life story.

Relative to teachers, school leaders and administrators, a dynamic systems focus means placing a strong emphasis on self-care and wellness to maintain the energy and emotional bandwidth to engage with students in a way that helps optimize their unique strengths. Bio-social research links teacher depression with decrements in student academic performance, motivation, and self-efficacy[118,119].

The power of a safe, trusted caring adult transform young lives highlights the importance of teacher wellness and self-care, as a developmental relationship with an educator can pay dividends for a child over the course of a lifetime[120-127]. Clearly - for a teacher to be the most connected with the student hence effective in delivering the support and guidance that transcends academic work, she or he must be healthy, rested, and balanced.

On a positive note, studies illuminate the myriad health and cognitive benefits of neuro-restorative interventions such as mindfulness meditation[128-132], sleep[133-138], exercise[139-143] and sharing emotions as well as strategies with friends and colleagues who can empathize[110,137,144,145].

In short, a coordinated effort must be made to fill key knowledge gaps and translate existing knowledge about ACEs, resilience, and wellness into national, state and local practice as well as policy. Within this, there must be a focus on addressing childhood trauma in health and education systems as they evolve during ongoing reform. The American Academy of Pediatrics has taken major steps to address this awareness gap within the medical community, and this proposal aims to do the same for the field of education.

A Final Note: Re-Conceptualizing Health and Education

The interactive effect of social networks at the home, school and community levels, and the emerging bio-social picture that is coming into focus tells us that in order to truly serve vulnerable children we must effect change at a systemic level[146]. In order to change developmental trajectories for children we must hold a broader and more *holistic* conceptualization of public education – particularly for our most vulnerable children – as a public health issue.

Healthy students are better learners[147], and we must design schools that are integrated with the communities around them, in a manner that provides necessary services (e.g. key social services such as mental health care), connections with local businesses (e.g. apprenticeships and career path development), as well as synergistic nonprofit partners (e.g. reading intervention specialists, sports programs, art).

Importantly, family engagement is key to a highly functioning relationship between schools and students – making home visiting a key part of this ecosystem. A holistic educational operating system will require an entirely new frame in terms of how we think about our schools, consistent with the Whole School, Whole Community, Whole Child model[148], as shown in Figure 4 below:

Figure 4: The Whole School, Whole Community, Whole Child (WSCC) Model

One major point of focus must be to move towards adequate sharing of information between the fields of health and education. From a regulatory standpoint, this means that there must be a level of permeability between the Healthcare Insurance Portability and Accountability Act (HIPAA) and the Federal Education Rights and Privacy Act (FERPA), while simultaneously respecting the need for privacy for children and their families.

While regulatory and policy issues are beyond the scope of the current report, this topic has been a key focal point in Dr. Walker's public presentations to a wide variety of audiences. Rather than remaining siloed within a school, the context for optimal child development includes mental and physical healthcare, support for at-risk families, early childhood education and enrichment programs, a broad variety of community connections, and a shared vision and sense of collective responsibility about achieving goals.

From an economic standpoint, this will require longitudinal studies that validate the long-term return on investment – in key areas such as healthcare costs, productivity, and incarceration - for holistically supporting children and families from the very start. Results from studies such as the Carolina Abecedarian Project and Perry Preschool tell part of this story. Together, these studies revealed that high-quality early intervention bolsters later life educational outcomes, yielding a ROI in excess of the stock market (savings primarily in productivity and incarceration), and importantly, improved health outcomes in some of the costliest categories of chronic non-communicable illness: cardiovascular and metabolic disease[149-151].

More longitudinal studies of this nature are needed to quantify the big-picture benefits of early childhood investment – studies which allow program developers and policymakers to view child health, development and education through a long-term lens. The bottom line: bio-social science tells an optimistic story of what can happen, of each child reaching their potential, given the right contextual variables at the right time. However, to effect real systemic change we need hard metrics to substantiate economic value.

Ultimately, program design should encompass preventative mental and physical healthcare, educational interventions as needed, support for vulnerable families, and communities that are set up to provide a steady path ("march") of needed interventions over the course of time[152].

Collectively, these factors can set a child on a path for good health, as well as economic and life success despite – and in some cases *because of* - the experience of adversity. A large and growing evidence base demonstrates that learning to deal with challenge in an effective manner, developing grit, and having a positive mindset – skills that are teachable and malleable - pay substantive dividends academically and behaviorally, throughout a lifetime[153-158].

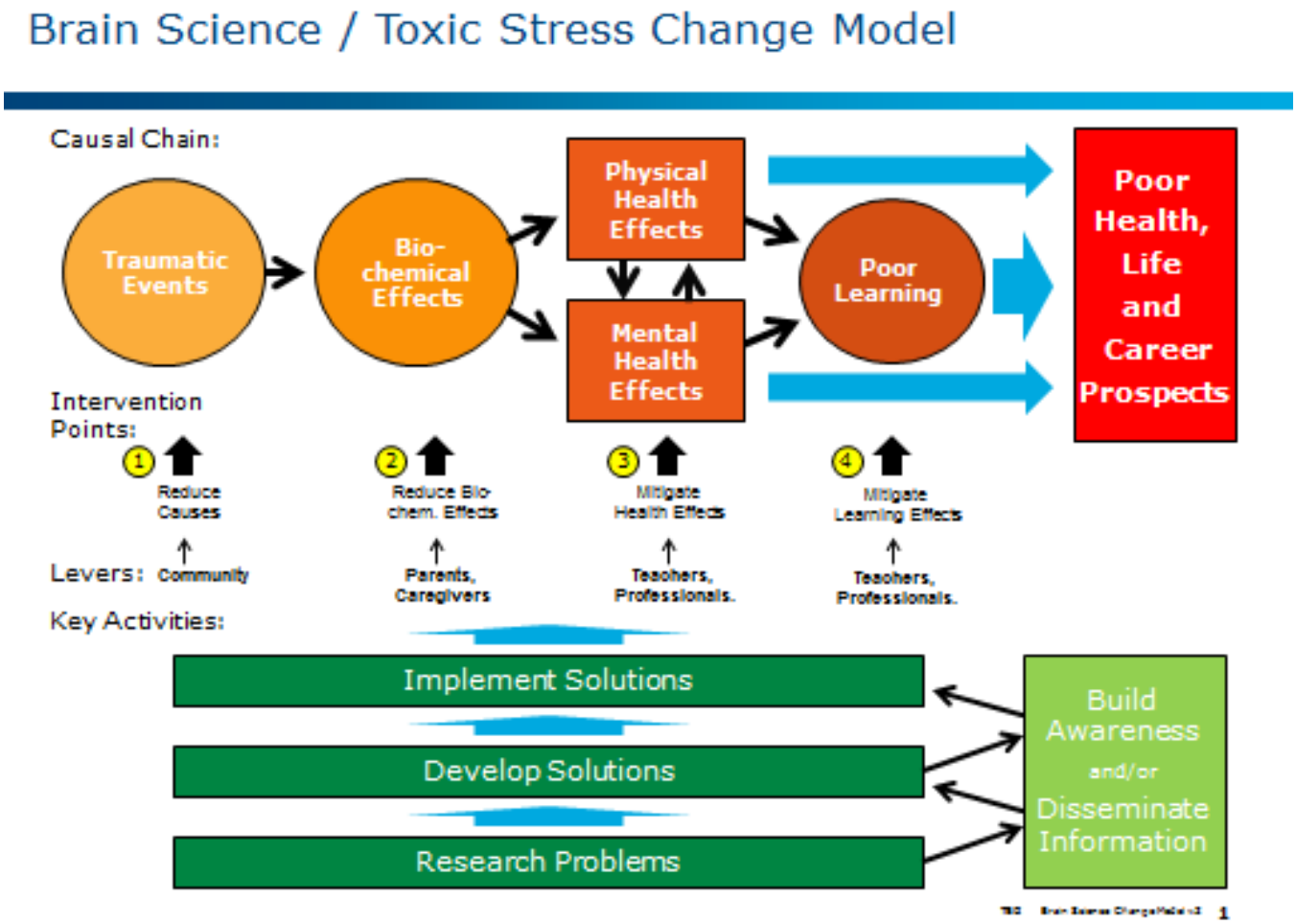
Proposed Strategies: Supporting Action, Knowledge & Awareness

As is now evident, toxic stress is a complex problem with multiple manifestations, myriad contributing causes and with many *time points* and also *types* of potential intervention. Figure 5 presents a summary view of this complexity, beginning with the causal chain that connects ACE's with changes in the brain, then to mental and physical health, and ultimately to long-term life consequences.

Figure 5 also provides a framework for identifying and isolating potential intervention points that parties aiming to address toxic stress might choose to pursue. To illustrate, parties

aspiring to devise and implement new solutions might focus their energies on general research, development of particular solutions or the dissemination of solutions, while other parties might focus on supporting those processes by building awareness or facilitating the flow of information in specific ways that add value to the efforts of others.

Figure 5:



As noted above, this plan sets forth a 3-pronged strategy, which builds on this general approach but focuses at three different points on figure 5.

1. Equip Influential Adults to Change Behavior: The first strategy embraced by Dr. Walker is to equip specific categories of committed, caring adults who occupy positions of influence – beginning with teachers – with basic, actionable, user-friendly information that gives them enhanced capability to act in ways that mitigate the effects of toxic stress for children and youths. On Figure 5, this would mean focusing on intervention points 2-4 by providing high-quality information about toxic stress and how to address it, as well as educationally relevant biological science.

2. Raise General Awareness: The second strategy is to focus on raising the overall functional awareness of these issues – with particular emphasis on the connection between medicine and education – on the part of many other categories of adults

who are positioned to make a difference. On Figure 5, this would mean focusing on "awareness" in ways that potentially enable action via any path depicted.

3. Build Practical Knowledge: The third strategy is to proactively undertake and support research projects that provide fertile settings for advancing the knowledge base about toxic stress and what we know about mitigating or even reversing its effects. This includes evaluation of long-term outcomes relative to mental/physical health, education, productivity, incarceration, and other key economic metrics that stem from transforming "toxic" into "tolerable" stress. On Figure 5, this would mean focusing on the boxes relating to development and implementation of specific approaches.

Strategy 1: Equip Influential Adults to Change Behavior

As discussed above, research decisively validates the fundamental role of a committed, caring adult – not necessarily a parent – in mitigating the effects of toxic stress[19,159-161]. In fact, several distinct groups of adults have been identified who have high potential to positively influence young people in addition to parents, including education leaders, teachers, and administrators; coaches, and also medical professionals, notably pediatricians. In general, Strategy 1 is grounded in the belief that proactive efforts to equip these adults to interact more effectively with children and youth experiencing toxic stress can yield significant benefits.

Other Approaches Active in the Space

Not surprisingly, there are many players active in this space that share this belief, and are working with groups of adults to enhance the understanding of the effects of adversity, with the intention of helping them to be more effective in assisting children. Examples include the following:

Solutions for Parents

- Zero to Three (http://www.zerotothree.org/parenting-resources/): Comprehensive resources on early child development and parenting. National nonprofit organization that provides parents, policymakers and professionals the knowledge and know-how to nurture early development, to ensure that all babies and toddlers have a strong start in life. The site provides content for parents on stages of development, attachment, social-emotional learning, play, sleep, challenging behaviors, and school readiness. While specific resources on the parent portal related to toxic stress and ACEs are currently being further developed, Zero to Three's December 2015 training institute covered these topics in depth. Parent-targeted content designed for practical everyday use would be of tremendous value, particularly given Zero to Three's broad reach and strong reputation in the field.

- Too Small to Fail (www.toosmall.org): Attachment and learning. Website focused on helping parents and businesses provide meaningful actions to improve the lives of children aged 0-5, so that more children are poised to succeed over the course of their life. Content (e.g. videos, articles and other web-based materials) focused on awareness building around brain development, early learning and early health, provides a wide variety of resources to parents and caregivers to help build reading and math skills, as well as resilience, in their children. Television awareness building campaign is currently in process with high profile individuals delivering simple and easy to use messages.

- Vroom (http://www. vroom.org): Practical tips on attachment and development via a mobile phone application. Provides creative and user-friendly tools to teach and inspire families to turn everyday moments into opportunities for brain building and positive attachment. Designed by parents, early childhood experts, neuroscientists and community leaders. Easy to access "app"s provides short, simple and timely messages and reminders to parents based on the developmental stage of their child. The primary focus is on healthy neurodevelopment and attachment, yet there is an opportunity to extend the content with material related to recognizing and mitigating toxic stress.

Solutions for Doctors/Pediatricians

- American Academy of Pediatrics (www.aap.org): Policy and Practice. Toxic stress – screening, identification, and treatment – was a lead topic at the AAP annual conference in 2015. They have developed resources for pediatricians and the public to learn about its effects as well as solutions. The AAP has framed a "Public Health Approach" to toxic stress focused on pediatric practice and public policy. The site carries information on: 1) The underlying science, 2) An eco-bio-developmental model of human health disease, 3) What this means for pediatricians: translating science into practice.

- AAP: Continuing Education: Toxic Stress. The following modules are offered on the AAP website, and contain videos, power point presentations, and documents outlining current science and practice: https://www.aap.org/en-us/advocacy-and-policy/aap-health-initiatives/EBCD/Pages/educationModules.aspx
  - Module 1: Building brains: The Core Story of Early Brain and Child Development (EBCD)
  - Module 2: Toxic Stress: Why Environment Matters
  - Module 3: Adverse Childhood Experiences: What Happens Early can Change Lives
  - Module 4: Supporting Parents and Cultivating Community Relationships
  - Module 5: EBCD Advocacy: An Opportunity to Change Childhood Outcomes

- AAP: Resilience. The Center on Healthy, Resilient Children: Website provides content on child nutrition, fitness, sports, oral health, sleep, emotional wellness, and healthy development (https://www.healthychildren.org). In addition to the ACE questionnaire, the AAP offers a resilience questionnaire – with the core premise that a high number of resilience factors in a child's life can trump a high ACE score.

Solutions for Educators, Administrators and School Leadership

- U.S. Department of Education: Policy and Practice (2016). "Healthy Students, Promising Futures": State and local action steps and practices to improve school-based health. The DOE is collaborating with the Department of Health and Human Services (HHS) to leverage the Affordable Care Act and partner with other organizations to use school as a capture point to provide health insurance for vulnerable families. A toolkit was developed in 2016 (http://www2.ed.gov/admins/lead/safety/healthy-students/toolkit.pdf) that outlined the importance of health and social services for at-risk children and providing accessible web-based resources designed to: 1) Help eligible students and family members enroll in health insurance; 2) Provide and expand reimbursable health

services in schools; 3) Provide or expand services that support at-risk students, including through Medicaid-funded case management; 4) Promote healthy school practices through nutrition, physical activity and health education; 5) Build local partnerships and participate in hospital community health needs assessments. Information on toxic stress is included in these resources with links to academic websites that describe the effect on brain development and health.

- Annenberg Learner: Neuroscience PD Content. Neuroscience and the Classroom: Making Connections. (http://www.learner.org/courses/neuroscience/PD). Content for teachers in basic neuroscience, learning difficulties, emotion, neural networks and implications for schools. Excellent basic science and anecdotal examples of neuroscience, but aimed more towards general knowledge building, not practical application for teachers. No material on toxic stress.

- National Education Association: Neuroscience PD Content. The Brain and Learning (http://www.neafoundation.org/pages/courses/) courses are on brain development, plasticity, emotions and learning, social and cultural contexts, the role of emotions in learning, and neuromyths. No material on toxic stress.

  Graduate Student Instruction: Dr. Walker recently completed teaching a graduate course at the Johns Hopkins Bloomberg School of Public Health (spring term of 2016) called "Schools and Health". Students were masters and doctoral students in public health, education, as well as medical students. The curriculum focused on an overview of the Whole School, Whole Community, Whole Child (WSCC) model[148]. The course included lectures on empirical research, guest speakers supporting the efficacy of community-connected schools, and the importance of providing medical care and health education to give our most vulnerable children the best chance for success. Student assignments included attendance at school district board meetings, school site visits, an in-class presentation, and a detailed policy brief with specific WSCC-based recommendations at the culmination of the course. Details of the course syllabus are laid out in Appendix II.

Solutions for Club, Travel-Team and Elite Youth Athletic Coaches

- Certification / Professional Development: Youth athletic coaches have the potential to be a trusted and inspiring adult who can embed into a child key life skills that, collectively, foster long-term health and success. This is possible by instilling in the child a love of physical activity, and by teaching and modeling critical life skills, encompassed by the term "grit"[153,157,162], such as perseverance, discipline and resilience, as well as a positive mindset about emotions surrounding both winning and losing. Recent research conducted through a public health frame has focused on understanding how to reduce attrition in youth sports. The study revealed that young athletes' engagement and persistence in sports is significantly related to having *fun*, a key driver of which is their relationship and connection with the coach[163].

  Similar to student-teacher relationships, awareness, understanding and connectedness are often the formula for reaching a child at a deep level, setting the stage to maximize potential. Having a basic level of understanding about how a child's brain develops and receives information is important data for coaches. It provides them with tools with which to develop deeper relationships with their athletes, potentially improved learning, and higher retention. From a public health standpoint, a sustained link with sports – and the commensurate health and cognitive benefits – will yield benefits over a life time[126,164-171]. Despite their

significance in the lives of children, most club level coaches receive no formal training. While very little high-quality PD content for coaches exists, below are several organizations and initiatives that offer helpful information:

  - Beyond Peak Performance: Brain Training for Athletes
  - Center for Youth Sports (Michigan State)
  - Clinton Health Matters
  - Nike Coaching Initiative
  - Project Play (Aspen Institute, Tom Ferry *Game On*)
  - The Positive Coaching Alliance

- U.S. Olympic Committee (USOC): As previously stated, the vast majority of coach PD offers little to no brain-targeted material. Offering this content may bolster the skill sets of coaches, providing an opportunity to better understand and connect with their athletes, potentially reducing the typically high rate of athlete attrition that takes place between 13 and 18 years of age. The USOC, which provides web-based education for hundreds of thousands of coaches through their 47 National Governing Body sites (http://www.teamusa.org/about-the-usoc/athlete-development/coaching-education), is the largest known distribution channel for coach education and PD. The USOC has expressed interest in leveraging the basics of brain science to bolster coach efficacy and elevate the professionalism of coaches nationwide.

Initial Focus for This Plan

While there are many gaps to be filled, as alluded to above, one key pressing and immediate need is to put this important information into the hands of teachers, school leaders, and administrators who are actively engaged in classroom work, and in establishing the social and emotional climate of the school. This includes both the most experienced, "master" teachers and others of lesser experience levels – all, ideally, who have direct experience working with students who are living with toxic stress. This plan will focus on methods of harnessing the most cutting-edge knowledge and web-based tools to deliver accredited professional development (PD) courses, and augmenting the knowledge base of all that touch the lives of children in school settings.

The rationale for this initial focus on PD for teachers is multifaceted and well supported by existing research:

- Influence of teachers. Many studies establish that teachers, who have an important role in establishing school climate can be very positive forces in influencing and protecting young people who have multiple risks in their lives[120-125], and, accordingly, that the attitudes and behaviors of teachers in the classroom matter – on multiple levels. Research shows that high quality relationships with teachers appears to decelerate the deleterious effects of risk and promote healthy functioning for children with both internalizing and externalizing problems[120-122,172], which can translate into improved social skills[121,123,173], peer relations[174] and academic outcomes[120,121,175]. Strong teacher relationships can equilibrate achievement scores between high- and low-risk students[120]. Moreover, research suggests that high teacher-child closeness, and high teacher sensitivity can reduce behavior problems, even if the child has a challenging home life[176]. Accordingly, it is clear that teachers have the potential to play an important protective role in mitigating at least some of the effects of toxic stress in ways that can enhance the ability of troubled students to learn.

- Effectiveness of PD. Research also reinforces the value and importance of effective teacher training and PD in equipping teachers to change their attitudes and behaviors in constructive ways that drive outcomes that are important for children in school[177-179]. While the research effort is still in its relative infancy, most of what we know about practical solutions for toxic stress in schools has occurred in the context of "trauma-informed curriculum." Effective programs address the issue of trauma from multiple levels: 1) Student, 2) Family, 3) Caregiver / Teacher, 4) School system[104,180]. Students learn strategies for calming down under stress, and may receive social services support or psychotherapy[104]. Caregivers / parents may receive home visits, are invited to attend support groups, and can attend school-based workshops on stress management. Educators and administrators receive trauma-focused professional development, in which the lens is focused on "what happened" to the child, rather than "what's wrong" with the child. For schools that have put these principles into practice, using programs such as Cognitive Behavioral Intervention for Trauma in Schools (CBITS)[108,181], Structured Psychotherapy for Students Responding to Chronic Stress (SPARCS)[182], University of California, San Francisco's "Healthy Environments and Trauma Response in Schools"[183] (HEARTS) program, or Trauma Systems Theory (TST)[184], educators receive in-school PD to help children learn by teaching them to calm anxieties. This training allows them to more effectively recognize when children are struggling with self-regulation or experiencing intense emotions, and provides an array of appropriate, empathic supports and responses, helping de-escalate problem behavior, allowing children to focus and learn. A comprehensive overview of the trauma informed arena, from curriculum to policy is provided by publications by the Trauma and Learning Policy Initiative (TLPI), which is a collaboration between Massachusetts Advocates for Children and Harvard Law School[104,185].

- Results: While larger-scale studies are underway[186], substantive outcomes metrics associated with trauma-informed PD and curriculum are relatively limited at present. The single study available in a PubMed search showed improved teacher-rated emotional regulation, social and academic competence, classroom behavior and discipline[108]. More common is the small but growing body of school-specific research that provides visibility on broad positive short-term outcomes: fewer absences, reduced suspensions and expulsions, fewer 911 calls, and improved academic performance – though grades are typically "lagging indicators" of intervention effectiveness[180,187]. These metrics that are indicative of significant student outcomes that unfold over time.

  Other important long-term outcomes that may be influenced by effective trauma-informed PD - such as mental and physical healthcare costs, school dropout, job productivity and incarceration - require longitudinal studies that are necessary but have not yet been undertaken. With this stated, economic studies show that the return on investment (ROI) for providing a "march of interventions" over time – e.g. reading, math, behavioral and other - throughout childhood and adolescence is significant: according to the Brooking Institute's Social Genome model, the ROI is just over 5x[152].

  Continuity is key, as it helps to sustain and strengthen positive neural connections, allowing new, adaptive behavior to become habit. Effective PD is just one component of this "march of interventions": done well, can change teacher thinking and behavior, hence instructional techniques, and ultimately, shape healthier classroom systems.

- Inadequacy of existing content. Unfortunately, much PD content is inadequate in terms of factors such as relevance, opportunities for practical application in classroom settings, an embedded feedback / communication loop to reinforce learning, and importantly – rigorous collection of student or teacher outcomes evaluation metrics[188]. As related to working with children living with adversity, one reason so many teachers are ill-equipped to deal with these kinds of student challenges is that they've never been given the proper tools to manage unpredictable and sometimes explosive classroom situations. Current content is limited to non-existent as related to the brain science of adversity, despite evidence that well-delivered material can change teacher behavior, practice, and importantly - student outcomes[179].

In summary, the essence of this strategy will be to develop high-quality content to instruct classroom teachers, which has the potential to inform both practice and policy. The courses will cover a variety of critical topics related to the functioning of the brain and toxic stress, including neuroscience, the neurobiology of adversity, individual differences, behavioral genetics, the importance of nurture / context, and other related concepts and material all oriented towards deepening a teacher's understanding of the whole child. It is expected that material will be composed of in-person coaching sessions and workshops, as well as short, interchangeable discrete modules that can be deployed in various settings and combinations in order to personalize desired learning outcomes.

This content will be developed and disseminated in collaboration with partners serving distinct teacher segments through different channels. At this point in time, the plan envisions three separate but related initiatives that would leverage the same core body of expertise and knowledge but different forms and combinations of content for very widespread effect. These initiatives, described in detail below, are as follows:

- Initiative A: Collaboration with the New Teacher Center (NTC)
- Initiative B1: Web-based PD content
- Initiative B2: Workshops for instructional coaches and master teachers

In all of these initiatives, Dr. Walker's key role will be as co-designer of the essential content for these courses. In terms of on-going engagement, especially regarding distribution, she would expect to serve as a consultant to the delivery partner, in order to ensure the highest level of quality assurance and success.

It should be noted that Dr. Walker gave careful consideration to other ways to leverage her expertise in the distribution phase. Most importantly, she examined the possibility of actually starting and managing a new enterprise that would engage in the development and dissemination of proprietary content, primarily via the internet. However, two major factors drove her to reject this option: first, the daunting financial investment required, along with the attendant risks of not seeing sufficient revenues to achieve sustained profitability; second, the existence of selected high-quality organizations with established positions in key sectors who were seeking partners capable of creating and maintaining superior content addressing the problem of toxic stress.

The proposed content will feed into an evolving body of multi-disciplinary work aimed at shaping not only practice, but also policy. The aforementioned resources produced by TLPI[104,185] are examples of living documents that provide a rough roadmap outlining a process for creating schools designed to manage adversity in a positive manner, and a policy agenda to provide the support schools need to achieve this goal. The material is grounded in theory and practice, in schools and with families, and is intended to grow and change as more schools become trauma / adversity informed, adding ideas, best practice

protocols, and outcomes metrics to the knowledge base. The guides put forth a policy agenda that calls for changes in laws, policies, and funding streams to support schools in this work. More information is available at: http://traumasensitiveschools.org/tlpi-publications/download-a-free-copy-of-a-guide-to-creating-trauma-sensitive-schools/

While the core focus of the current effort is towards professional development in the educational arena, future efforts will engage other categories of key adults (e.g. parents and youth athletic coaches), ideally in ways that will effectively leverage the content and methods developed and utilized for teachers.

Initiative A: Collaboration with the *New Teacher Center (NTC)*

Beginning in late Spring, early Summer of 2016, Dr. Walker will engage in an exclusive collaborative relationship with the New Teacher Center, (https://newteachercenter.org/about-ntc/), a large and well-respected nonprofit organization that serves 40,000 K-12 teachers per year, with a goal of reaching 60,000 within the next 2 years. In partnership, we will explore integrating material on toxic stress, child development, social-emotional learning, and educationally relevant biological science on individual differences, nature via nurture, epigenetics, mental and physical wellness and other topics into their existing PD curriculum. NTC works with school districts, state policymakers and educators across the country to increase the effectiveness of teachers and school leaders at all levels. They have developed a series of results-oriented programs that align with district learning goals and address teacher induction, instructional coaching and school leadership development. More broadly, NTC is closely involved with policymakers and education leadership interested in new educator induction and mentorship. NTC's major funders are the Bill and Melinda Gates Foundation and the William and Flora Hewlett Foundation, and they are a portfolio company of New Profit, the venture philanthropy fund.

Since inception, NTC has reached nearly 7 million students. Their primary mission is focused on accelerating the effectiveness of teachers and school leaders so that students achieve more. Their training programs have demonstrated statistical significance in student achievement gains in math and English. 88% of teachers enrolled in the new Teacher Induction Program report a direct impact on student achievement as a result of their mentorship relationship. NTC-supported teachers demonstrate a higher capacity for analyzing student work and adjusting their teaching practice accordingly. Teachers who have gone through their training also report higher demonstrated proficiency in engaging students, as well as higher efficiency using assessment in instruction.

To date, NTC's content has been predominantly focused on academic topics associated with the Common Core, per requirements set forth by the Department of Education under No Child Left Behind (NCLB). Since the reauthorization of the Every Student Succeeds Act (ESSA) in December of 2015, NTC has been exploring the integration of a broader range of material into their teacher training – with a particular focus on the whole child. This includes basic material on child development, mental and physical health, learner diversity, social-emotional learning, and specific material focused on adaptive management of adversity and toxic stress in classroom and school settings.

Dr. Walker's collaboration with the NTC will support four discrete yet inter-related programs, working with their academic team to provide knowledge, content and insight for:

- *New teachers*: Dr. Walker will work with NTC's academic team and focus on integrating the aforementioned information into existing NTC PD content for newly inducted teachers. Moreover, incoming classroom teachers will be given weekly on-the-job coaching sessions provided by an experienced peer.

- *Master teachers*: Higher-level material will also be woven into curriculum for experienced (Master) teachers who work as instructional coaches. This program entails on-the-job coaching for all teachers by well-prepared peers, both via in-person instruction and also web-based module resources.
- *School Leadership:* Materials will also be adapted for delivery to school leadership, to develop heightened level of awareness in order to proactively instill culture, programs and processes at a system-wide level within their school.
- *Assessment Design*: For all programs, Dr. Walker and the NTC team will develop and refine tools within the existing Formative Assessment and Support System to ascertain outcomes metrics. Specifically, the assessment system will guide instructional coaches' PD work with teachers, assist in classroom application of the material, and provide necessary data to identify and refine effective strategies that are both accelerating teacher efficacy and also student learning and behavioral, developmental and health outcomes.

Initiative B1: Web-Based PD Content

This project, expected to launch in late Fall 2016, will be specifically focused on web- and workshop-based professional development, comprising a series of flexible modules to be developed in collaboration with two distinguished parties: Glenn Whitman and his team at the Center for Transformative Teaching and Learning (CTTL) at St. Andrews Episcopal School in Potomac, MD, and Dr. Todd Rose, Director of the Mind, Brain and Education program at the Harvard Graduate School of Education.

The modules will be developed by Dr. Walker in collaboration with teaching faculty from St. Andrews Episcopal School in Potomac, MD, the Johns Hopkins School of Education and the Harvard Graduate School of Education. In addition, Teach for America (TFA) fellows and alumni have agreed to partner in piloting the content, which will help the academic team fine-tune practical elements of content delivery and teacher collaboration. Rigorous evaluation to best understand effectiveness (e.g. how information is internalized and applied by classroom teachers, school leadership and staff) will be a key focus. Modules will be concise and targeted, and flexible so that they can be personalized to each individual learner's needs. TFA, the Johns Hopkins School of Education, Harvard Graduate School of Education and the University of Virginia's Curry School of Education have agreed to be test sites for pilot launch subsequent to development of the modules.

Together, these modules will constitute a complete course, preliminarily entitled *Mind, Brain, and Education Science in the Classroom: Bridging the Gap Between Research and Practice.* This course will consist of eight modules, the preliminary structure and content of which are set forth in Appendix III. Each module will have five elements:

1. A prior knowledge survey and reflection
2. Theoretical video: "What does research say?"
3. Classroom strategy/ "next day application" video and on-line, cohort convening.
4. Self-reflection (narratives, videos) demonstrating "visible thinking" or course participants.
5. An assessment of understanding and "next day application" that needs to be passed/presented in order to move onto the next module (narrative and/or video).

Dr. Walker and the CTTL currently have a proposal into the Teaching Channel (TC - https://www.teachingchannel.org), a highly respected organization that provides web-based curricular material to roughly 800,000 educators across the country. The rationale for targeting TC is multi-faceted. First, it has excellent reach in its current base, with hundreds of thousands of existing users for the front-end platform, which is branded "The Teaching

Channel." Second, in response to data supporting *blended learning platforms* as highly efficient delivery vehicles for PD, TC has launched a new venture called Learning Labs (LL) that aims to leverage the large existing user base and become a leader providing specialized content for teachers. Third, CTTL / JHU will be allowed to retain propriety content, which is a key part of a larger teacher education program in MBE education. Fourth, they have a strong commitment to developing rigorous evaluation metrics.

Initiative B2: Workshops for Instructional Coaches and Master Teachers

A second phase of collaboration with the CTTL, likely to launch during winter 2016 / spring 2017, would focus on leveraging "brain science" content created in Initiative B1 to develop a PD program aimed at "master teachers." The concept here is to focus on educating the best, most experienced and influential teachers in each district about brain science, adversity and toxic stress as a complement to the more broadly focused web-based effort represented in Initiative B1. Not only are master teachers assumed to be the most effective in influencing the behavior of students, they are also leaders within their schools and their districts, so could be expected to positively affect the commitment and effectiveness of other staff teachers.

Rather than delivering this content on-line, Dr. Walker envisions leveraging the existing in-person / workshop system developed by the CTTL that currently delivers PD in neuroscience and other curricular areas to master teachers. Indeed, a core part of CTTL's base business is the design and delivery of in-person and workshop-based instruction to teachers.

Plan Details

Strategy 1 (Professional Development for educators) is currently being advanced on several fronts. Key details are as follows:

Initiative A (collaboration with New Teacher Center):

- Dr. Walker has entered into a consulting arrangement with NTC to explore the potential for a significantly broader collaborative relationship for content development, in line with all aforementioned areas.

Initiatives B1 and B2 (collaboration with Center for Transformative Teaching and Learning):

- Financial requirements: $1.06 million over one year is the estimated amount required to support the development of the planned course / modules / workshops, including the contribution of Dr. Walker and Glenn Whitman (and staff) over the duration of the program.
- Outcomes indicators and metrics: Dr. Walker and team anticipate working with Teaching Channel / Learning Labs (TC/LL) on evaluation. TC/LL has relationships with evaluation partners, although it will be critical to determine whether they have the rigor required by the academic community.
- Timetable for Implementation: Dr. Walker and the CTTL have submitted a proposal to TC/LL to start developing actual module content starting in the winter of 2016. If funded, a pilot version of the product could be available for teachers by late 2017.
- Current Status:
  - A grant proposal has been submitted to TC/LL. However, organizational structure changes have delayed funding decisions.
  - TC has expressed strong interest in moving forward in an efficient fashion to ensure rapid provision of this content, which is not provided elsewhere. It is

estimated that Dr. Walker / CTTL's content would reach approximately 5,000 teachers in the first year, and grow quickly thereafter.

Strategy 2: Build General Awareness on Toxic Stress Science and Solutions

As noted above, while enormous progress has been made in advancing our basic knowledge about the causes, implications and potential solutions to toxic stress, these findings have not been widely disseminated to the many people whose actions are critical to achieving breakthrough progress in addressing the problem.

Strategy 2, therefore, would focus on conveying key information relating to brain science, toxic stress, and the positive story that continues to unfold in biological science about resilience and human potential to a wide range of audiences that have the potential to help advance solutions. This includes education and medical service providers to children and families, researchers, philanthropists, parents, policymakers, nonprofits, and members of the media.

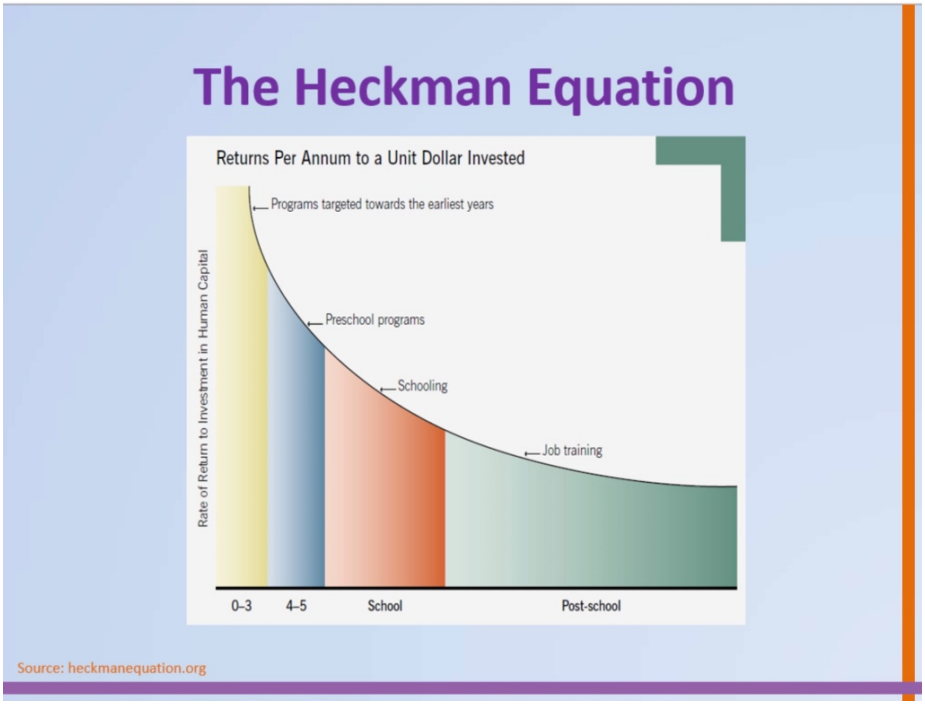
Although the primary objective is to broaden general awareness of these issues on the part of relevant individuals and groups, an important secondary objective is to reduce or eliminate significant barriers that currently inhibit effective collaboration between the critical fields of health and education.

Part of this is the development and communication of the primary issues, as well as potential solutions, in a common language to the appropriate audiences. In addition to conveying the economic benefits of prevention, relative to the expense of late-stage intervention, the fields of education and medicine are – similar to nature and nurture – inseparable, engaged in a dynamic and continuous process throughout childhood, adolescence, and the life span.

Our growing understanding of the damaging effects of toxic stress on the brain and immune system speaks to the need for public education – particularly for our most vulnerable children – to be considered through a public health lens.

However, as noted previously, federal law in the form of HIPAA and FERPA impedes the efficient flow of information between the fields of health and education. While these regulations were designed, appropriately, to protect privacy, some level of permeability must be built in, allowing key information to reach those who touch the lives of children within our system.

In line with Figure 6, shown below, developing long-term metrics substantiating the ROI of integrating medicine and education at or before birth may be a key lever for the improved public resource allocation necessary for our at-risk community members to have the best opportunity to live the futures they choose and deserve.



Activities of the Past Year

The principal vehicles for building awareness will be speeches and publications, undertaken by Dr. Walker on her own and also in collaboration with synergistic co-authors and presentation partners. In all cases, efforts will be made to leverage content developed under Strategy 1, especially regarding materials specific to toxic stress and its antidotes. The potential power of Strategy 2 has been demonstrated through activities that Dr. Walker undertook in the past year, which included several high-visibility speeches and papers that were well-received and stimulated much on-going interest and discussion.

These include the following:

- South by Southwest Education Conference. *Transforming Schools Using Brain Science.* Presented with Dr. Pamela Cantor - Turnaround for Children, Katherine Bradley and Reverend Dwight Davis – Assistant Principal Wheatley Elementary School. Austin, TX, March 2015.
- New Profit Gathering of Leaders. *Opportunity and Neurobiology*. Presented with Dr. Pamela Cantor and Dr. Nadine Burke Harris – Center for Youth Wellness. Pebble Beach, CA, March 2015.
- Children's Aid Society Staff Summit Keynote. *Poverty, Adversity and Toxic Stress: Consequences and Solutions*. New York, NY, June 2015. (~1000 in attendance)
- Martha's Table: "Casseroles and Conversations". Patty Stoneseifer and team orchestrated event for major donors and board members. Discussion on the science of toxic stress, clinical solutions, and public policy perspectives. Presented with Dr. Matt Biel – Chief of Child and Adolescent Psychiatry, Medstar Georgetown University Hospital and Dr. Wendy Ellis, George Washington University Milken School of Public Health. Washington, DC, September 2015.
- Illuminate JP Morgan event. *The Adversity Epidemic: Science, Schools and Social Equity.* Presented with Dr. Pamela Cantor, Katherine Bradley, Dr. Todd Rose –

Director, Mind, Brain and Education program at Harvard University, Jim Shelton – Executive Director, Chan Zuckerberg Initiative and Reverend Dwight Davis. Washington, DC, October, 2015.

- Children's Law Center. Conversation about the effects of toxic stress, solutions, and need for system-level collaborative solution to optimize opportunity for children to reach their full potential. Washington, DC, October, 2015.
- Inter-American Development Bank event: "*Little Scientists and Mathematicians*". Gave TED talk to inspire children to follow their hearts into science, even if the path is circuitous, and for parents, teachers and policymakers to ensure a strong pipeline of future scientists by making science fun (https://vimeo.com/151711270). Washington, DC, November, 2015.
- Johns Hopkins Bloomberg School of Public Health. *Interrupting the School-to-Prison Pipeline.* Organized and assembled a panel conversation about the School to Prison Pipeline with actress Anna Deavere Smith, the Johns Hopkins Bloomberg School of Public Health, Johns Hopkins School of Education, the Baltimore Police Department, and the Maryland Family Network. Baltimore, MD, December, 2015.
- The Community School. *Neuroscience, Stress and Schools*. Presentation on the effects of chronic stress on student health, behavior and academic achievement in high-competition, high-pressure school contexts. Sun Valley, ID, February, 2016.
- Children's National Medical Center. *Transforming Children's Health*. Presentation with Dr. Lee Beers (co-director of Early Childhood Innovation Network) and Dr. Marcee White (Chief pediatrician at TheARC in Ward 8) on toxic stress, solutions, and CNMC's initiatives in both practice and advocacy to help at-risk children thrive. Washington, DC, February 2016 / Palm Beach, FL, March, 2016 / Washington, DC, June 2016.
- Vanderbilt University, Annual Barbara Gay Lecture. *Neurobiology, Adversity and Resilience: Leveraging Science to Promote Student Health and Well-being.* Lecture with Reverend Dwight Davis to students and practitioners from the fields of psychiatry, medicine and education. Nashville, TN, April, 2016.
- Op Ed published in the Washington Post – co-authored with Melissa Steel King, Associate Partner at Bellwether Education Partners. Title: "Toxic stress' in the classroom: How a public health approach could help". June, 2016. https://www.washingtonpost.com/news/education/wp/2016/06/06/toxic-stress-in-the-classroom-how-a-public-health-approach-could-help/
- Teaching "Schools and Health" spring term of 2016: Graduate course at Johns Hopkins Bloomberg School of Public Health with Masters of Public Health, offered to PhD, Master of Public Health, School of Education and medical students. Dr. Walker delivered the first-ever lecture in this class on toxic stress and its implications for education. The remainder of the curriculum was synergistic in offering ways in which to support vulnerable students and families by employing the Whole School, Whole Community, Whole Child model. The majority of students, in their final policy briefs, focused on strategies to alleviate toxic stress in high-poverty schools via interventions focused on executive function, behavior, new models of chronic disease management, mindfulness meditation, and school gardens. These students are highly motivated, mission-oriented, energetic and dynamic, and will employ this knowledge base and holistic prism in their future studies and careers changing lives in the U.S. and abroad.
- Radio Interview: *Growing Up in America.* Dr. Robert Sanborn (CEO and President of "Children at Risk") and Mandi Kimball (public policy expert) moderated the interview, which focused on early childhood development, chronic stress, and the neurobiology of resilience.

Academic Research Papers published during the period of the Dr. Kuno Fellowship:

1. **Walker, S.O.**, Mao, G., Caruso, D., Hong, X., Pongracic, J.A., Wang, X. "Cardiovascular Risk Factors in Parents of Food Allergic Children". *Medicine, 2016, 95(5), 1-10.*
2. Li, M., Fallin, M.D., Riley, A., Landa, R., **Walker, S.O.**, Silverstein, M., Caruso, D., Pearson, C., Kiang, S., Dahm, J.L., Hong, X., Wang, G., Wang, M-C, Zuckerman, B., Wang, X. "Combined effects of maternal obesity and diabetes on developmental disabilities including autism". *Pediatrics,* 2016 Feb;137(2):1-10. doi: 10.1542/peds. 2015-2206. ***Pediatrics issued a policy statement based on this research paper.*
3. Yeung, E.W., Place, R., Gordish-Dressman, H., Visich, P. Hoffman, E., **Walker, S.O.**, Granger, D.A. "Salivary Latent Trait Cortisol (LTC): Relation to Lipids, Blood Pressure, and Body Composition in Middle Childhood". *Psychoneuroendocrinology,* 2016, May 18;71:110-118. doi: 10.1016/j.
4. Hong, H., Hao, K., Ladd-Acosta, C., Hansen, K.D., Tsai, H.J., Liu, X., Xu, X., Thornton, T.A., Caruso, D., Keet, C.A., Sun, X., Wang, G., Luo, W., Kumar, R., Fuleihan, R., Singh, A.M., Kim, J.S., Story, R.E., Gupta, R.S., Gao, P., Chen, Z., **Walker, S.O.**, Bartell, T.R., Beaty, T.H., Fallin, M.D., Schleimer, R., Holt, P.G., Nadeau, K.C., Wood, R.A., Pongracic, J.A., Weeks, D.E., Wang, X. "Genome-wide Association Study of Food Allergy Identifies Peanut Allergy-Specific Susceptibility Loci and Evidence of Epigenetic Mediation in U.S. Children of European Ancestry". *Nature Communications,* 2015, Feb 24;6:6304. doi: 10.1038/ncomms7304
5. Collaborated with New York Times best-selling author Paul Tough on his new book "*Helping Children Succeed*".

Plan Details

Strategy 2 is currently being advanced on several fronts. Key details are as follows:

- Financial requirements: Dr. Walker is the primary writer and producer of materials for public speaking, and any incremental costs – anticipated to be minimal – will be folded into research assistant (RA) / fixed staff responsibilities as described below. Variable costs of these events, especially travel and lodging, are typically reimbursed by the host/organizer of the event. Some events will involve honoraria so may generate offsetting revenue.
- Outcomes indicators and metrics: Direct feedback from organizations and institutions where speaking events take place, and communication from fellow academics following publication of research papers.
- Timetable for implementation: Dr. Walker is currently doing speaking engagements and building the schedule for 2016 as noted below. The intention is to accelerate new content development in early 2017 and beyond.
- Current Status: the following events are potential upcoming speaking engagements:
  - Children's National Medical Center, Washington, DC, June 2016
  - Aspen Ideas Festival, June 2016
  - Clinton Global Initiative, winter 2016 / spring 2017

Strategy 3: Build Practical Knowledge

The third strategy is to proactively undertake and support research projects that provide fertile settings for advancing the knowledge base about toxic stress in very practical ways. To date, Dr. Walker has identified two discrete efforts that represent high-potential opportunities to significantly advance our understanding of toxic stress in specific ways. These efforts are concentrated in the Washington, D.C. metro area, which will bolster the

expected ROI of these efforts by both leveraging Dr. Walker's time and energy and also enabling the identification and exploitation of possible synergies amongst the projects.

Initiative A: Early Childhood Innovation Network (ECIN)

Dr. Walker will collaborate with two distinguished researchers, Dr. Matthew Biel, Ph.D., and Dr. Lee Savio Beers, M.D., on the Early Childhood Innovation Network (ECIN), a $6 million 5-year project that will be undertaken in Washington, D.C.'s Wards 5, 6, 7 and 8. Dr. Biel is the Division Chief of Child and Adolescent Psychiatry at Medstar Georgetown University Medical Center, while Dr. Beers is an Assistant Professor of Pediatrics**,** Diana L. and Stephen A. Goldberg Center for Community Pediatric Health Medical Director for Municipal and Regional Affairs, Child Health Advocacy Institute; and Director, DC Mental Health Access in Pediatrics, Children's National Health Center.

The program will focus on providing effective, sustained interventions for children and families to equip them with the skills and stability needed to succeed. In addition to a science/research aspect, there is a specific arm designed to leverage lessons learned to develop best practices and share knowledge regarding "what works". Finally, there is an arm of the ECIN that has been designed to inform policy and propose both interventions and strategies to benefit our most vulnerable children and families.

ECIN aims to take a systemic and transformative approach to improving the long-term health and well-being of children and families in Washington DC. Grounded in the science of early childhood development and the promise of collective impact, the ECIN will leverage the infrastructure of a core innovation team to mobilize stakeholders and the community around four key activities to promote the development of young children into healthy, thriving adults:

- Education. The ECIN is a platform to educate service providers and the public about adversity, stress, resilience, and promotion of mental health in children.
- Action. The ECIN is a driving force for community engagement through the successful implementation of interventions in collaboration with key partners, aimed at reaching very young children (ages 0-5) and their families, with common themes of mitigating the biological impacts of adversity, promoting resilience, and driving positive outcomes in physical health, mental health, and education.
- Research. The ECIN is an investigation team dedicated to designing and conducting longitudinal studies of childhood outcomes among families living in highly stressed neighborhoods of Washington, D.C. The research team will support and energize community stakeholders to design and participate in relevant and promising community-based research activities, and will create the infrastructure necessary to understand the long-term health, education and economic impact of interventions delivered in early childhood.
- Advocacy. The ECIN is a vehicle to drive local policy changes relevant to understanding factors that support optimal health, educational, and social outcomes. These policy targets will have local focus and national significance, with the potential to advance systems' capacities to prioritize policies that advance childhood outcomes.

Despite significant progress over the last decade, considerable disparities in the educational and health statuses of children living in the District of Columbia continue to separate rich and poor. Children in the most disadvantaged communities of Washington live in highly

stressed environments and demonstrate markedly poorer health and educational outcomes compared with children living in more privileged settings.

Meanwhile, as discussed above, the science of childhood development has made marked strides forward across the same decade, with converging streams of evidence from neuroscience, developmental psychology, and education confirming several crucial factors:

1. Experiences in the first five years of life, both positive and negative, have a critical and enduring impact upon individuals' outcomes across the lifespan;
2. These lifespan impacts are linked to significant economic repercussions for society in areas including healthcare costs, work productivity, and incarceration;
3. Individual vulnerabilities evident in the first five years of life tend to persist across development into adulthood;
4. Adverse and traumatic experiences occurring in early childhood negatively impact biological development and mental as well as physical health;
5. Daily or routine severe adversity, known commonly as "toxic stress," may exert a particularly pernicious effect upon biological development and health; and
6. Exciting interventions in both clinical and educational settings offer tantalizing hope that these effects might be mitigated or reversed on a population-wide scale.

As in many urban settings, the efforts to bring this emerging science to bear in the programs and agencies that work directly with children and families in Washington have been scattered and under-coordinated. This poorly integrated approach to addressing the specific challenges of highly stressed families and their young children is exacerbated by structural barriers that separate service delivery systems in the domains of physical health, mental health, and early childhood education.

These barriers persist despite glaring evidence from the scientific literature that child development observes no such separation: children living in highly stressed environments struggle to control their behavior, regulate their biology, and attend to relevant information in ways that impact learning, mental and physical health, and emotional stability.

Nationwide, there are increasing appeals for bold new initiatives that take wholly integrated, evidence-based but locally grounded strategies to identify and address the impacts of toxic stress upon young children and their families. There is a clear need to take on this challenge in the nation's capital, where effective interventions may have particular potential to emerge as national models.

The mission and goals of the ECIN are broad-reaching and transformative. In order to effect meaningful and sustainable change, two underlying constructs will guide and inform all activities. First, all activities will be grounded in evidence-based, clear and measurable short- and long-term goals, which will be reevaluated on a regular basis. Second, ECIN will meaningfully engage key partners and stakeholders through a collective impact approach to identify, address and prevent the impact of toxic stress in early childhood. Collective impact initiatives mobilize and facilitate strategic partnerships between organizations with a shared vision, and utilize a structured process, centralized infrastructure and dedicated staff to develop a shared agenda with measurable outcomes.

At a minimum, Dr. Walker's role in ECIN will entail collaboration around the integration of biological sciences into the intervention protocols. Her past research experience includes

leading a bio-social research study in high-risk, high-poverty D.C. Public School (DCPS) 4th grade classrooms. This line of research was the first approved across DCPS to integrate salivary bioscience into an elementary school-based study protocol, which allowed for the examination of biological markers of stress such as cortisol and alpha amylase, as well as markers of immune system function such as secretory immunoglobulin A (sIgA).

The study protocol enhanced the more traditional self-report survey measures provided by both students and teachers and allowed for an examination of data both "above and below the skin". In this capacity, Dr. Walker has brought unique value-added expertise to the ECIN research team, and also serves as a member of the Scientific Advisory Board, contributing to ongoing operations as well as the strategic direction of the initiative. As discussed above, ECIN is in the process of building a strong research and administrative team and aims to begin the first series of interventions in the Fall of 2016.

In addition, Dr. Walker is exploring, possibly within the footprint of the ECIN project, embedding an innovative, bio-social, multi-modal, longitudinal research study capable of quantifying the comprehensive long-term ROI for investing early in the mental health, physical health and education of our children. This effort would be led by a to-be-determined team of researchers and would address key questions such as: what is the impact of early investment in children on not only educational outcomes, but also on key metrics such as job productivity, incarceration and healthcare costs over a child's life?

The study will be unique in its' focus on the "whole", rather than multiple small "effect sizes" that can be difficult to detect due to survey methods and timing. Moreover, the study will be grounded in the WSCC model – as it "takes a village" to raise a healthy and happy child. Our overarching aim is to provide data supporting the long-term economic benefit of taking a more holistic approach to the implementation of programs benefiting children and families living in poverty.

Critical to the success of ECIN is the relationship with the local community – to build trusted, authentic relationships and partnerships with the individuals who have lived and raised their children in these communities for generations. A powerful quote that emerged from the October collective impact meetings was that "change moves at the pace of trust".

In other words, without buy-in, genuine respect and a shared vision, our ambitious aims simply are not possible. We want to provide a solution that the community itself articulates and puts its own personal momentum behind.

We believe strongly that at the top of the priority list for parents in the aforementioned communities are good mental, emotional, behavioral and physical health, foundational for a comprehensive education for their children - hence we envision strong relationships with all families engaged in the study. To this end, the October 2015 meetings involved many important members of the academic, educational, medical, and government communities, as well as other key parties interested in these issues and motivated to contribute to sustainable solutions. The attendee list is displayed in Appendix IV.

Initiative B: Prep Matters

Throughout the spring of 2016, Dr. Walker engaged in a collaboration with Dr. Doug Granger, PhD (Foundation Professor and Director, Institute for Interdisciplinary Salivary Bioscience Research at the University of California, Irvine) and Ned Johnson (President and Founder, Prep Matters Inc.) to conduct a follow-up to a feasibility study completed by Drs. Walker and Granger in the Spring of 2015.

The prior study, also done with Prep Matters, focused on using salivary biomarkers to evaluate the relationship between biological-level stress, anxiety and test performance. Prep Matters is one of the leading and most highly respected academic test preparation / tutoring organizations in the Washington, D.C. area and has supported this effort in many ways: provided assistance in recruiting subjects, donated tutor staff time to conduct the study (collecting biomarkers and administering questionnaires) and provided additional staff to ensure the research protocol was followed in a manner consistent with the rules and regulations on ethical treatment of human subjects.

To our knowledge, this will be the first study to examine biological level stress prevalent in high-stakes testing for students in competitive high-pressure school contexts.

Rationale:

College entrance exams are a stress-provoking experience for most high school students, and perhaps even more so for those in high-stakes, high-performance, high-expectations settings. Within this group of elite students, there are significant individual differences in perceived stress and anxiety surrounding test taking. These differences are rooted in a combination of self-imposed performance pressure, difficulty of the test material for the individual, and also proper management of negative emotion and physiological arousal: e.g. test anxiety and perceived stress.

To date, efforts directed towards optimal scholastic performance have consisted of targeted curricular preparation, the teaching of targeted strategies, and concerted "mindset" coaching. Recent research suggests that a personalized combination of curricular training, anxiety reduction techniques, and physiological regulation may facilitate optimal performance.

This complex relationship is reflected at a biological level in well-known markers of perceived stress such as cortisol, which is known to influence learning and memory. Our study aims to further examine this question, and discover whether having an understanding of what is happening below the "behavioral surface" can complement supplemental test preparation to optimize performance.

Although the term "stress" is often considered a negative force, stress in and of itself is an intricate and necessary factor in human development. Individual differences in stress-performance trajectories are represented by an inverted U-shaped curve (see Figure 7), which depicts the relationship between cognitive anxiety and performance.

The figure suggests that individuals have a Peak Performance Stress Level (PPSL) associated with maximum performance. This relationship is shaped by an individual's genetics, behavior, and life experience, a dynamic highlighted in an attention-garnering 2013 New York Times magazine article titled "Why Can Some Kids Handle Pressure While Others Fall Apart"? The inverted U-curve can shift left or right, and the peak can be higher or lower, depending on the individual's reactivity and response to stress.

This nature-nurture dynamic is supported by twin studies, which suggest that about half of a person's response and reactivity to stress is due to genetics, and half of it to the environment. Recent innovations in "salivary bioscience" (the measurement and analysis of saliva) have presented the opportunity to extend on the inverted U-curve model, providing insight into what is happening at a biological level in addition to what is visible to parents and tutors (see Figure 8). In short, using both biological and behavioral indicators may be a powerful combination capable of fine-tuning the mix of curricular training and test anxiety

management in a way not possible at present, giving us greater insight into when stress becomes a negative rather than a positive force for the student.

Figure 7: Inverted U-shaped Stress Cure

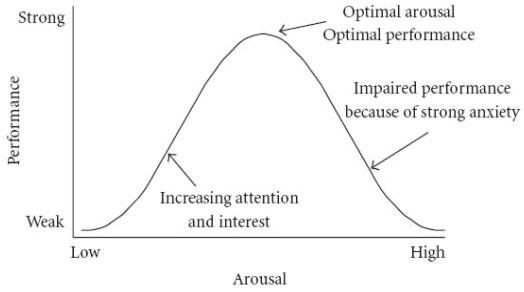
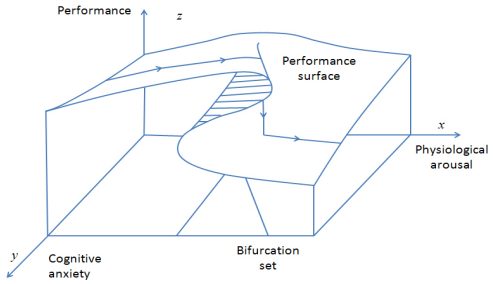


Figure 8: 3-way Model: Cognitive, Physiological and Performance



More broadly, our study may also provide information about how targeted approaches to the management of specific stressors (in this case, test preparation for students) can serve to reduce stress at both psychological and biological levels in non-test settings. For example, strategies for healthy management of test anxiety may have implications for how to more generally neutralize stress in everyday life, enhancing resiliency in the process. Given the growing body of research connecting chronic stress with adverse health and cognitive outcomes, this is important not only at an individual level, but also at the level of the population.

In addition, research suggests that biological sensitivity to the environment, genetically or otherwise, does not in and of itself confer risk – in fact - such individuals may benefit disproportionately from well-timed support or interventions. This topic was highlighted in a recent Wall Street Journal article describing the concept of "orchid" children (who require perfect conditions to perform), and "dandelion" children (who can thrive just about anywhere).

Measuring salivary biomarkers for stress hormones in real time (e.g.: directly before and after a stress-inducing event) will offer insight into the optimum level of stress hormones for peak cognitive performance at all points along the continuum between biological sensitivity and hardiness. As well, this information may complement existing proactive measures (e.g. mindset coaching) allowing for more tailored interventions, academic or otherwise, for a truly comprehensive evaluation of the "whole child".

In short, having an objective understanding of individual differences in these processes has the potential to provide parents with subtle yet valuable information with which to make informed decisions about a broad range of life pursuits in which their child and family engage.

At present, the PrepMatters research team has recruited 6 study participants, and is aiming for a total of 20-30.

Plan Details

Both major initiatives encompassed in Strategy 3 are well underway on all fronts:

- Financial requirements:
  - Initiative A, the ECIN has received $6 million in funding commitment from the Marriott Foundation over a 5-year period. While the Principal Investigators have deemed this amount adequate to fund the core project, they are seeking additional funding for specific research studies to be conducted within the ECIN framework. Dr. Walker may design and oversee a supplementary project, most likely a longitudinal study, which would require incremental funding in an amount not yet determined. Development of a grant proposal with a team of academic collaborators is currently under discussion.
  - Initiative B, Prep Matters. Current phase is funded.
- Timetable for Implementation:
  - ECIN – TBA
  - PrepMatters – ongoing at present.
- Outcome Indicators and Metrics:
  - ECIN – TBA
  - PrepMatters – hypothesized relationship between anxiety, test- and trait-specific stress and anxiety, and cortisol levels. Data collection is underway.
- Current Status:
  - Initiative A, the ECIN, is already underway, with key activities now focused on staffing the new organization. Participant recruitment will commence in the Fall of 2016.
  - The earliest possible start date for the research study within ECIN would be Fall of 2018. https://www.ecin.org

.

APPENDICES

Appendix I: ACE Score and Resilience Questionnaires

Adverse Childhood Experiences (ACEs - Centers for Disease Control & Kaiser Permanente)

Prior to your 18th birthday:

1. Did a parent or other adult in the household often or very often… Swear at you, insult you, put you down, or humiliate you? or Act in a way that made you afraid that you might be physically hurt?
   No___If Yes, enter 1 __

2. Did a parent or other adult in the household often or very often… Push, grab, slap, or throw something at you? or Ever hit you so hard that you had marks or were injured?
   No___If Yes, enter 1 __

3. Did an adult or person at least 5 years older than you ever… Touch or fondle you or have you touch their body in a sexual way? or Attempt or actually have oral, anal, or vaginal intercourse with you?
   No___If Yes, enter 1 __

4. Did you often or very often feel that … No one in your family loved you or thought you were important or special? or Your family didn't look out for each other, feel close to each other, or support each other?
   No___If Yes, enter 1 __

5. Did you often or very often feel that … You didn't have enough to eat, had to wear dirty clothes, and had no one to protect you? or Your parents were too drunk or high to take care of you or take you to the doctor if you needed it?
   No___If Yes, enter 1 __

6. Were your parents ever separated or divorced?
   No___If Yes, enter 1 __

7. Was your mother or stepmother:
   Often or very often pushed, grabbed, slapped, or had something thrown at her? or Sometimes, often, or very often kicked, bitten, hit with a fist, or hit with something hard? or Ever repeatedly hit over at least a few minutes or threatened with a gun or knife?
   No___If Yes, enter 1 __

8. Did you live with anyone who was a problem drinker or alcoholic, or who used street drugs?
   No___If Yes, enter 1 __

9. Was a household member depressed or mentally ill, or did a household member attempt suicide? No___If Yes, enter 1 __

10. Did a household member go to prison?
    No___If Yes, enter 1 __

Now add up your "Yes" answers: ____ This is your ACE Score

Addendum: Below are specific additional questions for child and adolescent ACE scores as delineated in the 2016 paper "Screening for Adverse Childhood Experiences in an Integrated Pediatric Care Model"[10], published by the Center for Youth Wellness, a leader in developing a model of care for preventative treatment of / early intervention for children and adolescents who are at-risk due to ACEs.

Child:

11. Foster Care
12. Bullying
13. Parent/guardian death
14. Separation due to deportation / immigration
15. Serious medical procedure / illness
16. Neighborhood violence
17. Discrimination

Adolescent:

18. Intimate partner violence
19. Youth arrest / incarceration

American Academy of Pediatrics: Resilience Questionnaire

Please answer the questions below using the following scoring guide:

0	1	2	3	4
Definitely Not True	Probably Not True	Not Sure	Probably True	Definitely True

1. I believe my mother loved me when I was little.
2. I believe that my father loved me when I was little.
3. When I was little, other people helped my parents take care of me and they seemed to love me.
4. I've heard that when I was an infant, someone in my family enjoyed playing with me and I enjoyed it too.
5. When I was a child, there were relatives in my family who helped me feel better when I was sad or worried.
6. When I was a child, neighbors or my friends' parents seemed to like me.
7. When I was a child, teachers, coaches, youth leaders or ministers were there to help me.
8. Someone in my family cared about how I was doing in school.
9. My family/friends/neighbors talked about making our lives better.
10. We had rules in our house and were expected to keep them.
11. When I felt really bad, I could almost always find someone I trusted to talk to.
12. As a youth, people noticed that I was capable and could get things done.
13. I was independent and a go-getter.
14. I believe that life is what you make it.
15. There are people I can count on now in my life.

Total Score: _____

Appendix II: Preliminary Module Structure and Content, On-Line Teacher PD

Module I: Mind, Brain, and Education Science in the Classroom

Themes:

- Teachers are researchers and brain changers
- Learning Differences
- Individual differences in educationally relevant student characteristics
- Neuromyths and Neuro-truths

75% of teachers in classrooms today have no formal training in how the brain, learns, works and changes. Considering that the organ of learning is the brain, teachers and school leaders need to better know the science behind learning and to develop the mindsets and tools to inform, validate, and transform their instructional decisions and practices based on robust research in Mind, Brain, and Education Science.

Module II: Mental and Physical Health: The Foundation for all Learning

Themes:

- Healthy Lifestyles 101 (basics of importance of nutrition, sleep, exercise, social support). We can go into detail on each of these items - especially sleep!! Particularly for adolescents!)
- Individual differences in mental health
- Individual differences in physical health
- Teaching children about the importance of health (from a young age)
- Conveying to teachers the importance of their OWN health – mental and physical

Module III: The architecture of the brain: What do teachers and students really need to know

Themes:

- Early brain development 101
- Nature via Nurture (epigenetics)
- Brain Plasticity

Module IV: Stress and Learning

Themes:

- Not all stress is bad: Relationship between stress & performance
- Orchids and dandelions (biological sensitivity to context)
- Toxic stress and its effects on the brain and immune system
- Solutions to Stress: Awareness (Student/teacher); Nurturing human relationships; Healthy active lifestyle; Mindfulness meditation (neurobiology and research on effects on behavior, mental health and academic performance)

Module V: Poverty, Trauma and Toxic Stress:

Themes:

- Impact of toxic stress on brain and immune system (in which case we would not go into this in the module above)
- Fortified Environments: Special considerations for high-poverty classrooms / schools; Importance of a caring, trusted adult

- Promising interventions: Trauma Informed Schools; Cognitive Behavioral Intervention for Traumatized Schoolchildren; Mindfulness meditation

Module VI: "Non-Cognitive" Skills: Growth Mindset and Character Traits

Themes:

- The involvement of emotion in all meaningful learning: Importance of SEL for academic performance due to cross-wiring of brain
- Neurobiology of the growth mindset
- Character skills: grit, resilience, perseverance
- Mindsets, Essential Skills, & Habits | MESH / Transforming Education)
- fMRI
- The 3 M's: Meaningful, Measurable, Malleable

Module VII: Attention and Engagement

Themes:

- Neurobiology of attention and engagement (importance of novelty / dopamine in classroom instruction)
- Importance of using multiple modalities (see, hear, touch/sensory) for fortification of student learning
- Differentiated instruction
- Intrinsic vs. Extrinsic Motivation
-

Module VII: Memory

Themes:

- Different types of memory (Active Working, Short and Long-Term)
- Make it Stick through Formative Assessments

Module VIII: Self-Reflection and Meta-Cognition (for both teacher and student)

Themes:

- Me and My Brain (for students – colleagues at Beauvoir have shared some info with me here – it is in development – to bolster meta-cognition / self-understanding and reflection / what kind of content students "get" are "good at"…often these are areas they also "like"…builds basis for intrinsically motivated learning)
- Start-of-year (and at subsequent intervals) self-reflection exercise: Building the basis for understanding between student and teacher.

Module X: Putting it all together

Themes:

- Mind, Brain, and Science Integration Action Plan
- What are the optimal outcomes: Educating the "Whole Child" for a lifetime of good health, love of learning, productivity, and quality of life
- Module dissemination/placement: primarily via partnerships with existing education/training/professional development providers

Appendix III: Syllabus for Johns Hopkins "Schools and Health" Course

3/21/16	Relationship between Schools and Health; Whole School Whole Child Whole Community Framework
3/23/16	The Whole School Whole Child Whole Community Model; Working across health and education agencies
3/28/16	Health Services: School Nursing
4/4/16	Health Services: School-Based Health Services
4/6/16	Toxic Stress
4/11/16	Nutrition Services
4/13/16	School Wellness Policies
4/18/16	Physical Education and Physical Activity
4/20/16	Health Education
4/25/16	Physical Environment
4/27/16	Family Involvement
5/2/16	Community Involvement
5/4/16	Social and Emotional Climate
5/9/16	Counseling and Psychological Services
5/11/16	Staff Wellness

Appendix IV: Attendees at the Ward 7/8 Collaborative Community Project Meeting

This series of meetings was held at Halcyon House in October 2016 and invitees / attendees are as follows:

Dr. Bruno Anthony- Georgetown University, Professor of Pediatric and Psychiatry, Director of research and Evaluation, Center for Child and Human Development
Expertise- Children's mental health services, mental health in primary care, family involvement, family to family support, early childhood mental health consultation
Bja28@georgetown.edu

Gail Avent- Director, Total Family Care Coalition
Expertise- nonprofit
totalfamilycarecoalition@gmail.org

Dr. Lee A. Savio Beers- Children's National Health System; Assistant Professor of Pediatrics**,** Diana L. and Stephen A. Goldberg Center for Community Pediatric Health
Medical Director for Municipal and Regional Affairs, Child Health Advocacy Institute
Director, DC Mental Health Access in Pediatrics (DC MAP)
Expertise- Pediatric medicine, pediatric emergency medicine
lbeers@cnmc.org/ lbeers@childrensnational.org

Dr. Nathaniel Beers – Chief Operating Officer, District of Columbia Public Schools
Expertise - General and developmental behavioral pediatrics
Nathaniel.beers@dc.gov
Assistant: Joyce McNeil, joyce.mcneil@dc.gov

Dr. Matthew Biel- Georgetown University Medical Center, Assistant Professor of Clinical Psychiatry
Director of Child and Adolescent Psychiatry
Expertise - Child, adolescent, and adult psychiatry; Child and adolescent development; Mood and anxiety disorders; Trauma and PTSD;
Psychosomatic illness and psychiatric care of the medically ill child
mgbielmd@gmail.com

Dr. Christy Bethell - Johns Hopkins University Bloomberg School of Public Health; Professor, Population, Family, and Reproductive Health
Expertise - Healthy development of children, population health, childhood trauma and resilience, maternal health, child and adolescent health
cbethell@jhu.edu

Deitra Bryant- Mallory - District of Columbia Public Schools, School Mental Health Director
Expertise - DCPS, Mental Health
deitra.bryant-mallory@dc.gov

Mr. Dan Cardinali - Communities in School, President
Expertise- dropout prevention
cardinalid@cisnet.org
Assistant: Eliza Duquette, duquetteE@cisnet.org

Dr. Michael Cordell - KIPP, Chief Academic Officer
Expertise- DCPS, "turnaround schools", High Jump program for high-performing low-income students
michael.cordell@kippdc.org

Ms. Michelle Derr - Mathematica, Senior Researcher
Expertise - adult skill building, executive function
mderr@mathematica-mpr.com

Dr. William (Bill) Dietz - George Washington University; Director, Sumner M. Redstone Global Center for Prevention Wellness
Expertise - Obesity
dietzwcd4@gmail.com

Derwin Dubose - Fellow, Halcyon House
Expertise-Community approach to problem solving and data gathering
derwin.dubose@newmajoritylabs.com

Wendy Ellis – Milken Scholar, George Washington University
Expertise – Public policy research, child health advocacy
Wendy.Ellis@nemours.org

Dr. Arthur Fields - District of Columbia Public Schools, Deputy Chief of Youth Engagement
Expertise-Student attendance and truancy reduction, Health and wellness, Student discipline and school climate, including response and intervention, Student placement, Policy and compliance
arthur.fields@dc.gov

Lanre Falusi- President, DC Chapter of the AARP
lanre.falusi@gmail.com

Molly Greene - Peer Health Exchange: National division; Vice President of Programs
Expertise - Development, growth, management, and evaluation of PHE's programs, also oversight of strategic programmatic investments
molly@peerhealthexchange.org

Sharra Greer - Policy Director, Children's Law Center
Expertise - Children's Law
sgreer@childrenslawcenter.org

Wendy Goldberg - Raise DC
wendygldbrg@gmail.com

Elizabeth Groginsky – Office of the State Superintendent for Education, Director of Early Learning
Expertise - Early childhood
Elizabeth.groginsky@dc.gov

Dr. Carla Henke- Community of Hope; Chief Medical Officer
Expertise - Family medicine
chenke@cohdc.org

Yair Inspektor - Office of the Deputy Mayor for Education; Senior Policy Advisor
Expertise - Public policy, D.C. government
yair.inspektor@dc.gov

Dr. Sara Johnson - Johns Hopkins University; Director of General Academic Pediatrics Fellowships, Associate Professor of Pediatrics
Expertise - Child and adolescent health, self-regulation, neurodevelopment, stress and health
sjohnson@jhsph.edu

Dr. Tim Kautz - Mathematica
Expertise – economics (graduate student of James Heckman @ University of Chicago)
tkautz@chicago.edu/ tdkautz@gmail.com

Aria Kirkland-Harris -The Expectations Project; Regional Director
Expertise - Non-Profit, Faith, Trauma Informed Schools
aria@theexpectationsprojects.org

Sherry Lachman - Fellow, Halycon House
Expertise - Foster child welfare focus, navigating cross-agency communication issues
sherry.lachman@gmail.com

Mr. Michael Lamb - Turnaround for Children: Washington, D.C.; Executive Director
Expertise - Public Policy
mlamb@tfcusa.org

Dr. Matt Levy - Georgetown University
Expertise- academic research
mdl2@gunet.georgetown.edu

Ms. Kirsten Lodal - LIFT Communities; President and CEO
Expertise - poverty, policy, child development, public service accessibility
klodal@liftcommunities.org
Assistant: Erin Ridgeway, eridgeway@liftcommunities.org

Ms. Ellen London - Communities in Schools; Executive Director
Expertise - community connectedness / school site coordinators
ELondon@cisnationscapital.org

Ms. Mireille Lopez-Humes - District of Columbia Public Schools; Principal, Moten Elementary School
Expertise - Ward 8, Grades PS-5, D.C.P.S.
mireille.lopez@dc.gov

Ms. Kimberly McNatt – Executive Director, Hawn Foundation (Mind Up)
Expertise- mindfulness and wellness interventions in schools
kimberly.mcnatt@thehawnfoundation.org

Mrs. Kelly Sweeney McShane - Community of Hope; President and CEO
Expertise - Homeless and low-income families, housing and medical care
kmcshane@cohdc.org

Mr. Bill Milliken - Communities in School; Founder and Vice Chairman
Expertise - Community connectedness with schools, public service, dropout prevention
millikenb@cisnet.org
Assistant: Jonathan Hayden, jonathan.hayden@leadercomm.org

Chaya Merrill - Children's National Hospital; Director of Child Health Data Lab
Expertise - Child health, data collection
cmerrill@childrensnational.org

Dr. LaDonna Pavetti - Center on Budget and Policy Priorities; Vice President for Family Income Support Policy
Expertise - Adult skill building, executive function
pavetti@cbpp.org

Mr. Scott Pearson - Peer Health Exchange
Expertise - Medication/Education – peer health education in schools
spearson@dcpcsb.org

Dr. Olga Acosta Price - George Washington University; Milken Institute School of Public Health;
Director of the Center for Health and Health Care in Schools
Associate professor in the Department of Prevention and Community Health
Expertise - Women's and Girls Education
oaprice@gwu.edu

Mr. Michael Regnier - Turnaround for Children; Head of Organizational Learning and Impact
Expertise - Organizational learning and data-driven decision-making
mregnier@tfcusa.org

Dr. Katy Roche- George Washington University
Expertise – academic research
kroche@email.gwu.edu

Judith Sandalow - Executive Director, Children's Law Center
Expertise – Law and policy regarding vulnerable children and youth
jsandalow@ChildrensLawCenter.org

Nancy Schoenfeld - Executive Director, DC Chapter of the AAP
Expertise – pediatric medicine
nancy.schoenfeld@dcaap.org

Mrs. Lauren Shweder Biel - Executive Director and Co-Founder, DC Greens
Expertise- Nutrition, farmer's markets
lauren@dcgreens.org

Dr. Satira S. Streeter – Asuncion Community Services, Inc.
Expertise - Community organization, medical care
satira@juno.com

Ms. Patty Stonesifer - CEO, Martha's Table
Expertise - Strategies for reducing inequity
pstonesifer@marthastable.org
Assistant: Tanya Hales, thales@marthastable.org

Desiree de la Torre - Children's National Hospital; Director of Community Affairs and Population Health Improvement
Expertise - Community, population health
ddelatorre@childrensnational.org

Dr. Sheila Ohlsson Walker - Johns Hopkins University Bloomberg School of Public Health: Center for the Childhood Origins Diseases, Assistant Scientist; JH School of Education: Assistant Professor
Expertise- Behavioral genetics, epigenetics, education, healthy schools, stress, nutrition, exercise, sleep, chronic disease
Swalke46@jhu.edu / sheila@walkersdc.com
Assistant: Hilary Kulig, Hilary.kulig@gmail.com

Janée Walsh - Peer Health Exchange; Washington, D.C. division; Program Director
Expertise- diabetes and youth education programs, combining health education and income generation activities in Guatemala
janee@peerhealthexchange.org

Mark Weissman - Children's National Hospital; Vice President of Community Pediatric Health
Expertise – pediatric community medicine
mweissma@childrensnational.org

Marcee White - THEARC and Mobile Programs; Director of the Children's Health Center
Expertise - Children's community health
mwhite@childrensnational.org

Laurie Wingate - Raise DC; Executive Director
Expertise - collective impact
lauriewingate@gmail.com

Dr. Larry Wissow - Johns Hopkins University Bloomberg School of Public Health; Professor, academic research
Expertise - Primary care, mental health, patient-doctor communication
lwissow@jhmi.edu

Dr. Travis Wright - District of Columbia Public Schools; Deputy Chief of Early Childhood
Expertise - Early Childhood education
travis.wright@dc.gov

Ms. Laura Zeilinger - Director, District of Columbia Department of Human Services
Expertise – public policy, homelessness
Laura.zeilinger@dc.gov
Assistant: Quameice Harris, quameice.harris2@dc.gov

Appendix V: References

1. American Psychiatric Association., American Psychiatric Association. DSM-5 Task Force. *Diagnostic and statistical manual of mental disorders : DSM-5.* 5th ed. Washington, D.C.: American Psychiatric Association; 2013.
2. The Center for Youth Wellness. http://www.centerforyouthwellness.org/.
3. McEwen BS. Stress, adaptation, and disease. Allostasis and allostatic load. *Annals of the New York Academy of Sciences.* 1998;840:33-44.
4. Borrell LN, Crawford ND. Social disparities in periodontitis among US adults: the effect of allostatic load. *Journal of epidemiology and community health.* 2011;65(2):144-149.
5. Cicchetti D. Allostatic load. *Development and psychopathology.* 2011;23(3):723-724.
6. Blair C, Raver CC, Granger D, Mills-Koonce R, Hibel L, Family Life Project Key I. Allostasis and allostatic load in the context of poverty in early childhood. *Development and psychopathology.* 2011;23(3):845-857.
7. Boardman JD. Stress and physical health: the role of neighborhoods as mediating and moderating mechanisms. *Social science & medicine.* 2004;58(12):2473-2483.
8. National Center for Children in Poverty: Childhood Poverty Statistics. 2016; http://www.nccp.org/topics/childpoverty.html.
9. Felitti VJ, Anda RF, Nordenberg D, et al. Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults. The Adverse Childhood Experiences (ACE) Study. *American journal of preventive medicine.* 1998;14(4):245-258.
10. Purewal SP, Bucci, M., Gutiérrez, Wang, L., Koita, K., Silvério Marques, S., Oh, D., Burke Harris, N. *Screening for Adverse Childhood Experiences (ACEs) in an Integrated Pediatric Care Model.* 2016.
11. Burke NJ, Hellman JL, Scott BG, Weems CF, Carrion VG. The impact of adverse childhood experiences on an urban pediatric population. *Child abuse & neglect.* 2011;35(6):408-413.
12. Johnson SB, Riley AW, Granger DA, Riis J. The science of early life toxic stress for pediatric practice and advocacy. *Pediatrics.* 2013;131(2):319-327.

13. Slopen N, McLaughlin KA, Shonkoff JP. Interventions to improve cortisol regulation in children: a systematic review. *Pediatrics.* 2014;133(2):312-326.
14. Hart H, Rubia K. Neuroimaging of child abuse: a critical review. *Front Hum Neurosci.* 2012;6:52.
15. Kelly PA, Viding E, Wallace GL, et al. Cortical thickness, surface area, and gyrification abnormalities in children exposed to maltreatment: neural markers of vulnerability? *Biological psychiatry.* 2013;74(11):845-852.
16. Carballedo A, Lisiecka D, Fagan A, et al. Early life adversity is associated with brain changes in subjects at family risk for depression. *The world journal of biological psychiatry : the official journal of the World Federation of Societies of Biological Psychiatry.* 2012;13(8):569-578.
17. Sheridan MA, Sarsour K, Jutte D, D'Esposito M, Boyce WT. The impact of social disparity on prefrontal function in childhood. *PloS one.* 2012;7(4):e35744.
18. Holz NE, Laucht M, Meyer-Lindenberg A. Recent advances in understanding the neurobiology of childhood socioeconomic disadvantage. *Curr Opin Psychiatry.* 2015;28(5):365-370.
19. Shonkoff JP. Leveraging the biology of adversity to address the roots of disparities in health and development. *Proceedings of the National Academy of Sciences of the United States of America.* 2012;109 Suppl 2:17302-17307.
20. Garner AS, Shonkoff JP, Committee on Psychosocial Aspects of C, et al. Early childhood adversity, toxic stress, and the role of the pediatrician: translating developmental science into lifelong health. *Pediatrics.* 2012;129(1):e224-231.
21. Shonkoff JP, Boyce WT, McEwen BS. Neuroscience, molecular biology, and the childhood roots of health disparities: building a new framework for health promotion and disease prevention. *JAMA : the journal of the American Medical Association.* 2009;301(21):2252-2259.
22. Noble KG, Houston SM, Brito NH, et al. Family income, parental education and brain structure in children and adolescents. *Nature neuroscience.* 2015.
23. Carrion VG, Haas BW, Garrett A, Song S, Reiss AL. Reduced hippocampal activity in youth with posttraumatic stress symptoms: an FMRI study. *Journal of pediatric psychology.* 2010;35(5):559-569.
24. Carrion VG, Weems CF, Reiss AL. Stress predicts brain changes in children: a pilot longitudinal study on youth stress, posttraumatic stress disorder, and the hippocampus. *Pediatrics.* 2007;119(3):509-516.
25. McEwen BS. The neurobiology of stress: from serendipity to clinical relevance. *Brain research.* 2000;886(1-2):172-189.
26. McEwen BS. Plasticity of the hippocampus: adaptation to chronic stress and allostatic load. *Annals of the New York Academy of Sciences.* 2001;933:265-277.
27. Hodel AS, Hunt RH, Cowell RA, Van Den Heuvel SE, Gunnar MR, Thomas KM. Duration of early adversity and structural brain development in post-institutionalized adolescents. *NeuroImage.* 2015;105:112-119.
28. Weems CF, Scott BG, Russell JD, Reiss AL, Carrion VG. Developmental variation in amygdala volumes among children with posttraumatic stress. *Developmental neuropsychology.* 2013;38(7):481-495.
29. Blair RJ, Leibenluft E, Pine DS. Conduct disorder and callous-unemotional traits in youth. *The New England journal of medicine.* 2014;371(23):2207-2216.
30. Carrion VG, Kletter H. Posttraumatic stress disorder: shifting toward a developmental framework. *Child and adolescent psychiatric clinics of North America.* 2012;21(3):573-591.
31. McEwen BS. Mood disorders and allostatic load. *Biological psychiatry.* 2003;54(3):200-207.
32. Aust S, Stasch J, Jentschke S, et al. Differential effects of early life stress on hippocampus and amygdala volume as a function of emotional abilities. *Hippocampus.* 2014;24(9):1094-1101.

33. Aupperle RL, Morris AS, Silk JS, et al. Neural responses to maternal praise and criticism: Relationship to depression and anxiety symptoms in high-risk adolescent girls. *Neuroimage Clin.* 2016;11:548-554.
34. Doll A, Holzel BK, Mulej Bratec S, et al. Mindful attention to breath regulates emotions via increased amygdala-prefrontal cortex connectivity. *NeuroImage.* 2016;134:305-313.
35. Laufer O, Israeli D, Paz R. Behavioral and Neural Mechanisms of Overgeneralization in Anxiety. *Curr Biol.* 2016;26(6):713-722.
36. Krishnan V, Han MH, Graham DL, et al. Molecular adaptations underlying susceptibility and resistance to social defeat in brain reward regions. *Cell.* 2007;131(2):391-404.
37. Hosking J, Winstanley CA. Impulsivity as a mediating mechanism between early-life adversity and addiction: theoretical comment on Lovic et al. (2011). *Behavioral neuroscience.* 2011;125(4):681-686.
38. Wei Q, Fentress HM, Hoversten MT, et al. Early-life forebrain glucocorticoid receptor overexpression increases anxiety behavior and cocaine sensitization. *Biological psychiatry.* 2012;71(3):224-231.
39. Lovic V, Belay H, Walker CD, et al. Early postnatal experience and DRD2 genotype affect dopamine receptor expression in the rat ventral striatum. *Behav Brain Res.* 2013;237:278-282.
40. Brenhouse HC, Lukkes JL, Andersen SL. Early life adversity alters the developmental profiles of addiction-related prefrontal cortex circuitry. *Brain Sci.* 2013;3(1):143-158.
41. Wade R, Jr., Cronholm PF, Fein JA, et al. Household and community-level Adverse Childhood Experiences and adult health outcomes in a diverse urban population. *Child abuse & neglect.* 2016;52:135-145.
42. Giovanelli A, Reynolds AJ, Mondi CF, Ou SR. Adverse Childhood Experiences and Adult Well-Being in a Low-income, Urban Cohort. *Pediatrics.* 2016.
43. Wade R, Jr., Shea JA, Rubin D, Wood J. Adverse childhood experiences of low-income urban youth. *Pediatrics.* 2014;134(1):e13-20.
44. Mersky JP, Topitzes J, Reynolds AJ. Impacts of adverse childhood experiences on health, mental health, and substance use in early adulthood: a cohort study of an urban, minority sample in the U.S. *Child abuse & neglect.* 2013;37(11):917-925.
45. PTSD in our nation's classrooms. 2015; http://www.examiner.com/article/ptsd-our-nation-s-classrooms-1.
46. Jimenez ME, Wade R, Jr., Lin Y, Morrow LM, Reichman NE. Adverse Experiences in Early Childhood and Kindergarten Outcomes. *Pediatrics.* 2016.
47. Luby JL. Poverty's Most Insidious Damage: The Developing Brain. *JAMA pediatrics.* 2015.
48. Cicchetti D. Neural plasticity, sensitive periods, and psychopathology. *Development and psychopathology.* 2015;27(2):319-320.
49. Wright RJ, Rodriguez M, Cohen S. Review of psychosocial stress and asthma: an integrated biopsychosocial approach. *Thorax.* 1998;53(12):1066-1074.
50. Wright RJ, Cohen RT, Cohen S. The impact of stress on the development and expression of atopy. *Current opinion in allergy and clinical immunology.* 2005;5(1):23-29.
51. Maynard BR, Salas-Wright CP, Vaughn MG. High school dropouts in emerging adulthood: substance use, mental health problems, and crime. *Community Ment Health J.* 2015;51(3):289-299.
52. Barry M, Reschly AL. Longitudinal predictors of high school completion. *School psychology quarterly : the official journal of the Division of School Psychology, American Psychological Association.* 2012;27(2):74-84.
53. Legters N, Balfanz R. Do we have what it takes to put all students on the graduation path? *New Dir Youth Dev.* 2010;2010(127):11-24.

54. Milliken B. *The last dropout : stop the epidemic!* Carlsbad, Calif.: Hay House; 2007.
55. Centers for Disease Control: Leading Causes of Death in the U.S. 2016; http://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm.
56. Centers for Disease Control: Chronic Disease Prevention and Health Promotion. 2016.
57. Slomski A. Chronic mental health issues in children now loom larger than physical problems. *JAMA : the journal of the American Medical Association.* 2012;308(3):223-225.
58. Tardif ED, P.A. & Meylan, N. Neuromyths among teachers and student teachers. *Mind, Brain, and Education.* 2015;9(1):50-59.
59. Howard-Jones PA. Neuroscience and education: myths and messages. *Nature reviews. Neuroscience.* 2014;15(12):817-824.
60. Stafford-Brizard KB. *Building Blocks for Learning: A Framework for Comprehensive Student Development.* 2016.
61. Plomin R, DeFries JC, Knopik VS, Neiderhiser JM. *Behavioral genetics : a primer.* Sixth edition. ed. New York: Worth Publishers; 2013.
62. Coyle D. *The talent code : greatness isn't born. It's grown. Here's how.* New York: Bantam Books; 2009.
63. Weaver IC. Integrating early life experience, gene expression, brain development, and emergent phenotypes: unraveling the thread of nature via nurture. *Adv Genet.* 2014;86:277-307.
64. McEwen BS. In pursuit of resilience: stress, epigenetics, and brain plasticity. *Annals of the New York Academy of Sciences.* 2016.
65. Singh-Taylor A, Korosi A, Molet J, Gunn BG, Baram TZ. Synaptic rewiring of stress-sensitive neurons by early-life experience: a mechanism for resilience? *Neurobiol Stress.* 2015;1:109-115.
66. Turecki G, Meaney MJ. Effects of the Social Environment and Stress on Glucocorticoid Receptor Gene Methylation: A Systematic Review. *Biological psychiatry.* 2016;79(2):87-96.
67. Meaney MJ, Aitken DH, Bodnoff SR, Iny LJ, Tatarewicz JE, Sapolsky RM. Early postnatal handling alters glucocorticoid receptor concentrations in selected brain regions. *Behavioral neuroscience.* 2013;127(5):637-641.
68. DeVries AC, Craft TK, Glasper ER, Neigh GN, Alexander JK. 2006 Curt P. Richter award winner: Social influences on stress responses and health. *Psychoneuroendocrinology.* 2007;32(6):587-603.
69. Champagne FA. Early environments, glucocorticoid receptors, and behavioral epigenetics. *Behavioral neuroscience.* 2013;127(5):628-636.
70. Zhang TY, Labonte B, Wen XL, Turecki G, Meaney MJ. Epigenetic mechanisms for the early environmental regulation of hippocampal glucocorticoid receptor gene expression in rodents and humans. *Neuropsychopharmacology : official publication of the American College of Neuropsychopharmacology.* 2013;38(1):111-123.
71. Reiss D, Leve LD, Neiderhiser JM. How genes and the social environment moderate each other. *American journal of public health.* 2013;103 Suppl 1:S111-121.
72. Shahrokh DK, Zhang TY, Diorio J, Gratton A, Meaney MJ. Oxytocin-dopamine interactions mediate variations in maternal behavior in the rat. *Endocrinology.* 2010;151(5):2276-2286.
73. Samuel S, Hayton B, Gold I, Feeley N, Carter CS, Zelkowitz P. Maternal Mental Health Moderates the Relationship between Oxytocin and Interactive Behavior. *Infant Ment Health J.* 2015;36(4):415-426.
74. Rault JL. Effects of positive and negative human contacts and intranasal oxytocin on cerebrospinal fluid oxytocin. *Psychoneuroendocrinology.* 2016;69:60-66.
75. Feldman R, Gordon I, Zagoory-Sharon O. Maternal and paternal plasma, salivary, and urinary oxytocin and parent-infant synchrony: considering stress and affiliation components of human bonding. *Developmental science.* 2011;14(4):752-761.

76. Steeger CM, Cook EC, Connell CM. The Interactive Effects of Stressful Family Life Events and Cortisol Reactivity on Adolescent Externalizing and Internalizing Behaviors. *Child Psychiatry Hum Dev.* 2016.
77. Philbrook LE, Hozella AC, Kim BR, Jian N, Shimizu M, Teti DM. Maternal emotional availability at bedtime and infant cortisol at 1 and 3 months. *Early Hum Dev.* 2014;90(10):595-605.
78. Flannery JE, Beauchamp KG, Fisher PA. The role of social buffering on chronic disruptions in quality of care: evidence from caregiver-based interventions in foster children. *Social neuroscience.* 2016:1-6.
79. Badanes LS, Dmitrieva J, Watamura SE. Understanding Cortisol Reactivity across the Day at Child Care: The Potential Buffering Role of Secure Attachments to Caregivers. *Early Child Res Q.* 2012;27(1):156-165.
80. Lester BM, Conradt E, Marsit C. Introduction to the Special Section on Epigenetics. *Child development.* 2016;87(1):29-37.
81. Fraga MF, Ballestar E, Paz MF, et al. Epigenetic differences arise during the lifetime of monozygotic twins. *Proceedings of the National Academy of Sciences of the United States of America.* 2005;102(30):10604-10609.
82. Chiarella J, Tremblay RE, Szyf M, Provencal N, Booij L. Impact of Early Environment on Children's Mental Health: Lessons From DNA Methylation Studies With Monozygotic Twins. *Twin research and human genetics : the official journal of the International Society for Twin Studies.* 2015;18(6):623-634.
83. Parade SH, Ridout KK, Seifer R, et al. Methylation of the Glucocorticoid Receptor Gene Promoter in Preschoolers: Links With Internalizing Behavior Problems. *Child development.* 2016;87(1):86-97.
84. Keating DP. Transformative Role of Epigenetics in Child Development Research: Commentary on the Special Section. *Child development.* 2016;87(1):135-142.
85. Gershon NB, High PC. Epigenetics and child abuse: Modern-day darwinism - The miraculous ability of the human genome to adapt, and then adapt again. *Am J Med Genet C Semin Med Genet.* 2015;169(4):353-360.
86. Wang G, Walker SO, Hong X, Bartell TR, Wang X. Epigenetics and early life origins of chronic noncommunicable diseases. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine.* 2013;52(2 Suppl 2):S14-21.
87. Hardiman MM. *The brain-targeted teaching model for 21st-century schools.* Thousand Oaks, Calif.: Corwin; 2012.
88. Fields RD. A new mechanism of nervous system plasticity: activity-dependent myelination. *Nature reviews. Neuroscience.* 2015;16(12):756-767.
89. Karpova NN, Sales AJ, Joca SR. Epigenetic Basis of Neuronal and Synaptic Plasticity. *Curr Top Med Chem.* 2016.
90. Swingler MM, Perry NB, Calkins SD. Neural plasticity and the development of attention: Intrinsic and extrinsic influences. *Development and psychopathology.* 2015;27(2):443-457.
91. Tognini P, Napoli D, Pizzorusso T. Dynamic DNA methylation in the brain: a new epigenetic mark for experience-dependent plasticity. *Front Cell Neurosci.* 2015;9:331.
92. Fuhrmann D, Knoll LJ, Blakemore SJ. Adolescence as a Sensitive Period of Brain Development. *Trends Cogn Sci.* 2015;19(10):558-566.
93. Daack-Hirsch S. The International Society of Nurses in Genetics (ISONG) 2015 World Congress: Epigenetics Across the Life Span. *Biological research for nursing.* 2016;18(2):125-126.
94. Cassilhas RC, Tufik S, de Mello MT. Physical exercise, neuroplasticity, spatial learning and memory. *Cell Mol Life Sci.* 2016;73(5):975-983.

95. Jeste DV, Palmer BW. A call for a new positive psychiatry of ageing. *Br J Psychiatry.* 2013;202:81-83.
96. Li X, Xiao YH, Zhao Q, Leung AW, Cheung EF, Chan RC. The neuroplastic effect of working memory training in healthy volunteers and patients with schizophrenia: Implications for cognitive rehabilitation. *Neuropsychologia.* 2015;75:149-162.
97. Morimoto SS, Wexler BE, Liu J, Hu W, Seirup J, Alexopoulos GS. Neuroplasticity-based computerized cognitive remediation for treatment-resistant geriatric depression. *Nat Commun.* 2014;5:4579.
98. Vance DE, Kaur J, Fazeli PL, et al. Neuroplasticity and successful cognitive aging: a brief overview for nursing. *J Neurosci Nurs.* 2012;44(4):218-227.
99. Bronfenbrenner U, Morris, P. The Bioecological Model of Human Development. *Theoretical Models of Human Development.* Vol 1. 5th ed. New York: Wiley; 2006.
100. Sameroff A. A unified theory of development: a dialectic integration of nature and nurture. *Child development.* 2010;81(1):6-22.
101. Oberle E, Schonert-Reichl KA. Stress contagion in the classroom? The link between classroom teacher burnout and morning cortisol in elementary school students. *Social science & medicine.* 2016;159:30-37.
102. Houts RM, Caspi A, Pianta RC, Arseneault L, Moffitt TE. The challenging pupil in the classroom: the effect of the child on the teacher. *Psychological science.* 2010;21(12):1802-1810.
103. Walker SO, Mao G, Caruso D, Hong X, Pongracic JA, Wang X. Cardiovascular Risk Factors in Parents of Food-Allergic Children. *Medicine (Baltimore).* 2016;95(15):e3156.
104. Initiative MAfCTaLP. *Helping Traumatized Children Learn: Creating and Advocating for Trauma-Sensitive Schools.* 2005.
105. Waasdorp TE, Bradshaw CP, Leaf PJ. The impact of schoolwide positive behavioral interventions and supports on bullying and peer rejection: a randomized controlled effectiveness trial. *Arch Pediatr Adolesc Med.* 2012;166(2):149-156.
106. Bethell CD, Newacheck P, Hawes E, Halfon N. Adverse childhood experiences: assessing the impact on health and school engagement and the mitigating role of resilience. *Health affairs.* 2014;33(12):2106-2115.
107. Bethell C, Gombojav N, Solloway M, Wissow L. Adverse Childhood Experiences, Resilience and Mindfulness-Based Approaches: Common Denominator Issues for Children with Emotional, Mental, or Behavioral Problems. *Child and adolescent psychiatric clinics of North America.* 2016;25(2):139-156.
108. Mendelson T, Tandon SD, O'Brennan L, Leaf PJ, Ialongo NS. Brief report: Moving prevention into schools: The impact of a trauma-informed school-based intervention. *Journal of adolescence.* 2015;43:142-147.
109. Strand V, Popescu M, Abramovitz R, Richards S. Building Agency Capacity for Trauma-Informed Evidence-Based Practice and Field Instruction. *J Evid Inf Soc Work.* 2016;13(2):179-197.
110. Yoshikawa H, Leyva D, Snow CE, et al. Experimental impacts of a teacher professional development program in Chile on preschool classroom quality and child outcomes. *Developmental psychology.* 2015;51(3):309-322.
111. Paulson S, Davidson R, Jha A, Kabat-Zinn J. Becoming conscious: the science of mindfulness. *Annals of the New York Academy of Sciences.* 2013;1303:87-104.
112. Sibinga EM, Perry-Parrish C, Thorpe K, Mika M, Ellen JM. A small mixed-method RCT of mindfulness instruction for urban youth. *Explore (NY).* 2014;10(3):180-186.
113. Sibinga EM, Webb L, Ghazarian SR, Ellen JM. School-Based Mindfulness Instruction: An RCT. *Pediatrics.* 2016;137(1).

114. Perry-Parrish C, Copeland-Linder N, Webb L, Sibinga EM. Mindfulness-Based Approaches for Children and Youth. *Current problems in pediatric and adolescent health care.* 2016.
115. Flook L, Goldberg SB, Pinger L, Davidson RJ. Promoting prosocial behavior and self-regulatory skills in preschool children through a mindfulness-based Kindness Curriculum. *Developmental psychology.* 2015;51(1):44-51.
116. Schonert-Reichl KA, Oberle E, Lawlor MS, et al. Enhancing cognitive and social-emotional development through a simple-to-administer mindfulness-based school program for elementary school children: a randomized controlled trial. *Developmental psychology.* 2015;51(1):52-66.
117. Rose T. *The end of average : how we succeed in a world that values sameness.* First Edition. ed. New York: HarperOne; 2016.
118. Kidger J, Brockman R, Tilling K, et al. Teachers' wellbeing and depressive symptoms, and associated risk factors: A large cross sectional study in English secondary schools. *J Affect Disord.* 2016;192:76-82.
119. Sandilos LE, Cycyk LM, Hammer CS, Sawyer BE, Lopez L, Blair C. Depression, Control, and Climate: An Examination of Factors Impacting Teaching Quality in Preschool Classrooms. *Early Educ Dev.* 2015;26(8):1111-1127.
120. Hamre BK, Pianta RC. Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child development.* 2005;76(5):949-967.
121. Sabol TJ, Pianta RC. Recent trends in research on teacher-child relationships. *Attachment & human development.* 2012;14(3):213-231.
122. Williford AP, Maier MF, Downer JT, Pianta RC, Howes C. Understanding how children's engagement and teachers' interactions combine to predict school readiness. *J Appl Dev Psychol.* 2013;34(6):299-309.
123. Ahnert L, Harwardt-Heinecke E, Kappler G, Eckstein-Madry T, Milatz A. Student-teacher relationships and classroom climate in first grade: how do they relate to students' stress regulation? *Attachment & human development.* 2012;14(3):249-263.
124. Zee M, Koomen HM, Van der Veen I. Student-teacher relationship quality and academic adjustment in upper elementary school: the role of student personality. *Journal of school psychology.* 2013;51(4):517-533.
125. Elledge LC, Elledge AR, Newgent RA, Cavell TA. Social Risk and Peer Victimization in Elementary School Children: The Protective Role of Teacher-Student Relationships. *Journal of abnormal child psychology.* 2016;44(4):691-703.
126. Shan SL, C.; Shi, J.; Wang, L.; Cai, H. . Impact of effective communication, achievement sharing and positive classroom environments on learning performance. *Systems Research and Behavioral Science.*Vol 31(3):471-482.
127. Konstantopoulos S. Teacher effects in early grades: Evidence from a randomized study. *Teachers College Record.* 2011;113(7):1541-1565.
128. Goyal M, Singh S, Sibinga EMS, et al. *Meditation Programs for Psychological Stress and Well-Being*. Rockville (MD)2014.
129. Elder C, Nidich S, Moriarty F, Nidich R. Effect of transcendental meditation on employee stress, depression, and burnout: a randomized controlled study. *Perm J.* 2014;18(1):19-23.
130. Ricard M, Lutz A, Davidson RJ. Mind of the meditator. *Sci Am.* 2014;311(5):38-45.
131. Khalsa SS, Rudrauf D, Davidson RJ, Tranel D. The effect of meditation on regulation of internal body states. *Frontiers in psychology.* 2015;6:924.
132. Rosenkranz MA, Lutz A, Perlman DM, et al. Reduced stress and inflammatory responsiveness in experienced meditators compared to a matched healthy control group. *Psychoneuroendocrinology.* 2016;68:117-125.

133. Araujo T, Jarrin DC, Leanza Y, Vallieres A, Morin CM. Qualitative studies of insomnia: Current state of knowledge in the field. *Sleep Med Rev.* 2016.
134. Archer SN, Oster H. How sleep and wakefulness influence circadian rhythmicity: effects of insufficient and mistimed sleep on the animal and human transcriptome. *J Sleep Res.* 2015;24(5):476-493.
135. Khanijow V, Prakash P, Emsellem HA, Borum ML, Doman DB. Sleep Dysfunction and Gastrointestinal Diseases. *Gastroenterol Hepatol (N Y).* 2015;11(12):817-825.
136. Magee CA, Reddy P, Robinson L, McGregor A. Sleep Quality Subtypes and Obesity. *Health psychology : official journal of the Division of Health Psychology, American Psychological Association.* 2016.
137. Pemberton R, Fuller Tyszkiewicz MD. Factors contributing to depressive mood states in everyday life: A systematic review. *J Affect Disord.* 2016;200:103-110.
138. Watling J, Pawlik B, Scott K, Booth S, Short MA. Sleep Loss and Affective Functioning: More Than Just Mood. *Behav Sleep Med.* 2016:1-16.
139. Bunketorp Kall L, Malmgren H, Olsson E, Linden T, Nilsson M. Effects of a Curricular Physical Activity Intervention on Children's School Performance, Wellness, and Brain Development. *The Journal of school health.* 2015;85(10):704-713.
140. Resaland GK, Moe VF, Aadland E, et al. Active Smarter Kids (ASK): Rationale and design of a cluster-randomized controlled trial investigating the effects of daily physical activity on children's academic performance and risk factors for non-communicable diseases. *BMC Public Health.* 2015;15:709.
141. Mullender-Wijnsma MJ, Hartman E, de Greeff JW, Doolaard S, Bosker RJ, Visscher C. Physically Active Math and Language Lessons Improve Academic Achievement: A Cluster Randomized Controlled Trial. *Pediatrics.* 2016;137(3):1-9.
142. Maher C, Lewis L, Katzmarzyk PT, Dumuid D, Cassidy L, Olds T. The associations between physical activity, sedentary behaviour and academic performance. *J Sci Med Sport.* 2016.
143. Lopes L, Santos R, Mota J, Pereira B, Lopes V. Objectively measured sedentary time and academic achievement in schoolchildren. *J Sports Sci.* 2016:1-7.
144. Steinert Y, Mann KV. Faculty development: principles and practices. *J Vet Med Educ.* 2006;33(3):317-324.
145. Schubert T, Sussenbach P, Schafer SJ, Euteneuer F. The effect of subjective social status on depressive thinking: An experimental examination. *Psychiatry Res.* 2016;241:22-25.
146. Garg A, Dworkin PH. Surveillance and Screening for Social Determinants of Health: The Medical Home and Beyond. *JAMA pediatrics.* 2016;170(3):189-190.
147. Basch CE. Healthier students are better learners. *The Journal of school health.* 2011;81(10):591-592.
148. Rooney LE, Videto DM, Birch DA. Using the Whole School, Whole Community, Whole Child model: implications for practice. *The Journal of school health.* 2015;85(11):817-823.
149. Campbell F, Conti G, Heckman JJ, et al. Early childhood investments substantially boost adult health. *Science.* 2014;343(6178):1478-1485.
150. Heckman J, Moon SH, Pinto R, Savelyev P, Yavitz A. Analyzing social experiments as implemented: A reexamination of the evidence from the HighScope Perry Preschool Program. *Quantitative economics.* 2010;1(1):1-46.
151. Heckman JJ, Moon SH, Pinto R, Savelyev PA, Yavitz A. The Rate of Return to the High/Scope Perry Preschool Program. *Journal of public economics.* 2010;94(1-2):114-128.
152. Grannis KSS, I. *Improving Children's Life Chances: Estimates from the Social Genome Model.* Center on Children and Families: Brookings Intitute;2013.

153. Duckworth A, Gross JJ. Self-Control and Grit: Related but Separable Determinants of Success. *Curr Dir Psychol Sci.* 2014;23(5):319-325.
154. Dweck CS. Mindsets and human nature: promoting change in the Middle East, the schoolyard, the racial divide, and willpower. *The American psychologist.* 2012;67(8):614-622.
155. Paunesku D, Walton GM, Romero C, Smith EN, Yeager DS, Dweck CS. Mind-set interventions are a scalable treatment for academic underachievement. *Psychological science.* 2015;26(6):784-793.
156. Rattan A, Savani K, Chugh D, Dweck CS. Leveraging Mindsets to Promote Academic Achievement: Policy Recommendations. *Perspectives on psychological science : a journal of the Association for Psychological Science.* 2015;10(6):721-726.
157. Duckworth AL, Peterson C, Matthews MD, Kelly DR. Grit: perseverance and passion for long-term goals. *Journal of personality and social psychology.* 2007;92(6):1087-1101.
158. Dweck CS. *Mindset : the new psychology of success.* Ballantine Books trade pbk. ed. New York: Ballantine Books; 2008.
159. Gambone MA, Klem, A.M., & Connell, J.P. *Finding out what matters for youth: Testing key links in a community action framework for youth development.* Philadelphia, PA2002.
160. Shonkoff JP, Garner AS, Committee on Psychosocial Aspects of C, et al. The lifelong effects of early childhood adversity and toxic stress. *Pediatrics.* 2012;129(1):e232-246.
161. Shonkoff JP, Levitt P. Neuroscience and the future of early childhood policy: moving from why to what and how. *Neuron.* 2010;67(5):689-691.
162. Eskreis-Winkler L, Shulman EP, Beal SA, Duckworth AL. The grit effect: predicting retention in the military, the workplace, school and marriage. *Frontiers in psychology.* 2014;5:36.
163. Visek AJ, Achrati SM, Mannix H, McDonnell K, Harris BS, DiPietro L. The fun integration theory: toward sustaining children and adolescents sport participation. *J Phys Act Health.* 2015;12(3):424-433.
164. Balchin R, Linde J, Blackhurst D, Rauch HL, Schonbachler G. Sweating away depression? The impact of intensive exercise on depression. *J Affect Disord.* 2016;200:218-221.
165. de Souza Moura AM, Lamego MK, Paes F, et al. Comparison Among Aerobic Exercise and Other Types of Interventions to Treat Depression: A Systematic Review. *CNS & neurological disorders drug targets.* 2015;14(9):1171-1183.
166. de Souza Moura AM, Lamego MK, Paes F, et al. Effects of Aerobic Exercise on Anxiety Disorders: A Systematic Review. *CNS & neurological disorders drug targets.* 2015;14(9):1184-1193.
167. Holton KF, Nigg JT. The Association of Lifestyle Factors and ADHD in Children. *J Atten Disord.* 2016.
168. McPhee JS, French DP, Jackson D, Nazroo J, Pendleton N, Degens H. Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology.* 2016.
169. Nascimento H, Alves AI, Medeiros AF, et al. Impact of a School-Based Intervention Protocol - ACORDA Project - On Adipokines in an Overweight and Obese Pediatric Population. *Pediatr Exerc Sci.* 2016.
170. Segalowitz SJ. Exercise and Pediatric Brain Development: A Call to Action. *Pediatr Exerc Sci.* 2016;28(2):217-225.
171. Shaw J. The Deadliest Sin. *Harvard Magazine.* 2004;March-April, 2004. http://harvardmagazine.com/2004/03/the-power-of-exercise.
172. Berry D, Blair C, Ursache A, Willoughby MT, Granger DA, Family Life Project Key I. Early Childcare, Executive Functioning, and the Moderating Role of Early Stress Physiology. *Developmental psychology.* 2013.
173. Zhai F, Raver CC, Jones SM. Social and Emotional Learning Services and Child Outcomes in Third Grade: Evidence from a Cohort of Head Start Participants. *Child Youth Serv Rev.* 2015;56:42-51.

174. Gazelle H. Class climate moderates peer relations and emotional adjustment in children with an early history of anxious solitude: a Child X Environment model. *Developmental psychology.* 2006;42(6):1179-1192.
175. McCormick MP, O'Connor EE, Cappella E, McClowry SG. Teacher-child relationships and academic achievement: a multilevel propensity score model approach. *Journal of school psychology.* 2013;51(5):611-624.
176. Doumen S, Verschueren K, Buyse E. Children's aggressive behaviour and teacher-child conflict in kindergarten: is teacher perceived control over child behaviour a mediating variable? *The British journal of educational psychology.* 2009;79(Pt 4):663-675.
177. Pianta RC, Mashburn AJ, Downer JT, Hamre BK, Justice L. Effects of Web-Mediated Professional Development Resources on Teacher-Child Interactions in Pre-Kindergarten Classrooms. *Early Child Res Q.* 2008;23(4):431-451.
178. Wilson SM. Professional development for science teachers. *Science.* 2013;340(6130):310-313.
179. Sheridan SM, Edwards CP, Marvin CA, Knoche LL. Professional Development in Early Childhood Programs: Process Issues and Research Needs. *Early Educ Dev.* 2009;20(3):377-401.
180. Center CsL. *Addressing Trauma in DC Schools.* 2015.
181. Ngo V, Langley A, Kataoka SH, Nadeem E, Escudero P, Stein BD. Providing evidence-based practice to ethnically diverse youths: examples from the Cognitive Behavioral Intervention for Trauma in Schools (CBITS) program. *Journal of the American Academy of Child and Adolescent Psychiatry.* 2008;47(8):858-862.
182. Network NCTS. Structured Psychotherapy for Adolescents Responding to Chronic Stress (SPARCS). http://www.nctsnet.org/nctsn_assets/pdfs/promising_practices/SPARCS_General.pdf.
183. University of California SF. Healthy Environments and Response to Trauma in Schools (HEARTS program). http://coe.ucsf.edu/coe/spotlight/ucsf_hearts.html.
184. Medicine NYUSo. Trauma Systems Theory. http://www.med.nyu.edu/child-adolescent-psychiatry/research/institutes-and-programs/trauma-and-resilience-research-program/trauma-systems-therapy.
185. Initiative MAfCTaLP. Creating and Advocating for Trauma Sensitive Schools. 2013.
186. Blodgett C, Harrington, R., Lohan, J., Short, R., Turner, N., Winikoff, J. *Adverse Childhood Experience and Developmental Risk in Elementary Schoolchildren.* 2014.
187. Turnaround for Children. http://www.turnaroundusa.org/.
188. Desimone LS, T.; Ueno, K. Are teachers who need sustained, content-focused professional development getting it? An administrator's dilemma. *Educational Administration Quarterly.* 2006;42(2):179-215.