Adverse Babyhood Experiences (ABEs) Increase Risk for Infant and Maternal Morbidity and Mortality, and Chronic Illness

Veronique P. Mead

Abstract: Adverse babyhood experiences (ABEs) identify 10 categories of negative events for mothers before they conceive, and for parents and babies from conception until a child's third birthday. ABEs identify preventable and reducible non-genetic factors that increase risk for infant morbidity and mortality, chronic illness, mental health conditions, and other symptoms in a child's life; morbidity and mortality in mothers; PTSD and depression in fathers, and more. Understanding, repairing, and reversing effects of ABEs decreases risk for adverse childhood experiences (ACEs), and for poor health outcomes in parents and children.

Keywords: Critical periods, fetal origins of adult disease, adverse babyhood experiences, ABEs, adverse childhood experiences, ACEs, trauma, postpartum depression, maternal morbidity, maternal mortality, maternal-infant bonding, asthma, type 1 diabetes, type 2 diabetes, heart disease

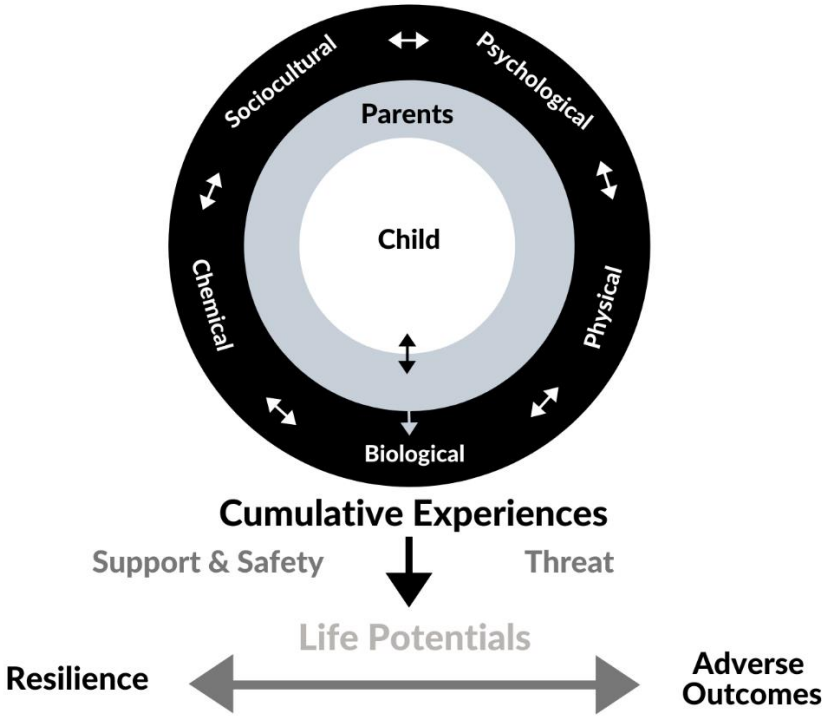
The science of epigenetics (Moore et al., 2017), traumatic stress (Lehrner et al., 2016), toxic stress (Shonkoff et al., 2012), bonding (Klaus & Kennell, 1976, 1982; Klaus et al., 1995), and more demonstrates that life experiences interact with genes to influence short and long-term emotional and physical health, including risk for chronic illness and mental illness. Life events and other environmental factors such as family, culture, and society also shape behavior, the capacity for physiological and emotional self-regulation, the ability to have and sustain satisfying relationships, and life potential (National Research Council and Institute of Medicine, 2000) (see Figure 1). Connection,

Veronique Mead is a former assistant professor and family physician with an obstetrics practice. She left medicine 20 years ago and has since been integrating existing research into a new model of disease and healing, focusing on how adverse life experiences influence risk for chronic illness. Her work is informed by a master's degree in somatic psychotherapy at Naropa University, as well as training in somatic trauma and pre- and perinatal therapies. Veronique can be contacted by email at veronique@chronicillnesstraumastudies.com. A free ebook, fact sheet, and more information are available on her blog: https://chronicillnesstraumastudies.com/aberesources/

communication, a sense of security, and support increase resilience and buffer the effects of adversity (Crandall et al., 2019; Racine et al., 2018). This understanding emphasizes opportunities for the prevention, reduction, and potential reversal of the many effects of adversity, including chronic disease (Mead, 2003, 2004, 2007).

Figure 1

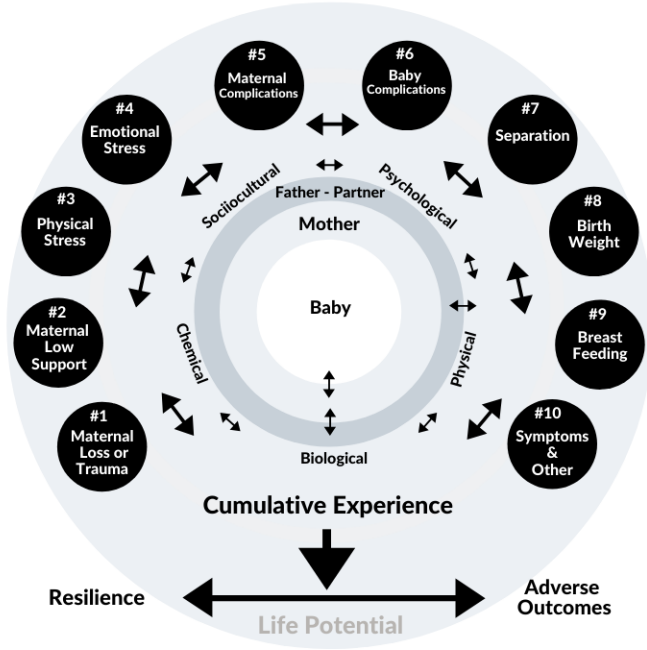
Health is Influenced by Cumulative Experiences



Note: *A child's health is influenced by the cumulative effects of safety and supportive life experiences, which buffer the effects of adversity and shape biology, psychology, and more through gene function and epigenetics. A child's health and outcomes are shaped by the environment, with examples of threat from biological (infections), chemical (toxins), physical (accidents, violence, medical procedures), and psychological sources (loss, emotional neglect or abuse, discrimination). For a child, however, one of the most important environmental influencers of life potential is the family, which is in turn affected by society and culture, among other factors.*

Figure 2

Ten Adverse Babyhood Experiences Influence Life Potential



Note: *Ten categories of adverse babyhood experiences (ABEs) that occur before a child's third birthday can have a profound influence on short- and long-term health in babies because they happen during critical periods of development. ABEs also affect parental health. For babies, the mother is the environment, and events that affect her also impact her baby. Fathers or partners are also an important part of a baby's environment. Interactions between supportive and threatening life experiences accumulate to shape one's life potential, including adverse outcomes, such as a baby's risk for developing a chronic illness at some point in life, of maternal morbidity and mortality, and for symptoms in fathers or partners. ABEs and their effects can be prevented, reduced, repaired, and reversed to a larger extent than has been recognized.*

ABEs do not occur in a vacuum. They also interact with one another. Symptoms in a baby and events that place a baby at risk affect parental behaviors, emotional states, and physiology. Parental states, in turn, influence and shape a baby's development, physiology and health.

Recognizing ABEs and their effects is based on an understanding of trauma. Knowing what to look for in risk factors, behaviors, and early symptoms makes it possible to prevent or reduce risk for poor outcomes

as well as to repair and potentially reverse the effects of adverse experiences in babies as well as parents.

ABEs highlight opportunities to support, develop, and promote resilience in everyone, at any age. Recognizing the many and varied faces of trauma invites the use of approaches and interventions, such as trauma-informed care, that can optimize life potential.

This article introduces ABEs and factors that increase risk for infant morbidity and mortality as well as for symptoms in babies, children, and adults. It draws on the large body of literature to also describe the effects of ABEs on mothers. Similar risks and effects are seen in fathers or partners (Charpak et al., 2016; Johansson et al., 2013; Klaus & Kennell, 1976, 1982; Koliouli et al., 2016; Wikander & Theorell, 1997). Mechanisms underlying the effects of ABEs and the potential for prevention and reversibility are presented. A future companion article describes approaches and interventions shown to prevent and reduce ABEs, and to decrease or repair effects of ABEs.

The 10 ABEs

The 10 ABEs build on psychologist Antonio Madrid's (2012) Maternal Infant Bonding Survey (MIBS), a questionnaire listing events that increase maternal emotional and physical separation, interrupt parent-infant bonding and coregulation, and increase risk for asthma and other symptoms. The 10 ABE categories also draw from Klaus and Kennell's work on bonding (1976, 1982) and from additional research, which is discussed and cited throughout the remainder of this article.

ABEs categorize adverse events into general areas rather than specific questions or types of trauma. The categories offer examples and are not all-inclusive. This is because what constitutes trauma is more common than recognized and is different for everyone. The 10 ABE categories are summarized below.

1. Maternal loss or trauma increases risk for all other ABEs and consequently, for many potential negative outcomes. This category includes events in a mother's life from before she conceives until her child's third birthday. ABE #1 includes maternal experiences of trauma throughout her life, such as: adverse childhood experiences (see Appendix); discrimination, such as for race, religion, sexual orientation, gender, and other reasons; and adverse events from previous pregnancies, such as stillbirth or miscarriage, preterm birth, preeclampsia, and other events and poor outcomes. Other examples of trauma or loss include accidents, violence, and other sources of trauma such as poverty; loss or death of a partner, parent, child, or other family member; difficulty conceiving; and more.

2. Low support or loss of support beginning two years before conception until the baby's third birthday reduces resiliency and the ability to cope with adversity. Low support for the mother increases risk for birth complications, bonding disruptions and other ABEs. Examples include a partner who becomes ill or leaves, disapproval of the pregnancy, having low family support such as for being very young or single, and more.

3. Maternal physical stress is a risk factor for low birth weight, premature birth, chronic illness, and other effects on the baby, and for complications and other ABEs in the mother. Examples of physical stress include being sick through much of the pregnancy, worrisome bleeding, gestational diabetes, excessive alcohol, smoking, illegal drugs, toxemia, getting hurt, significant vomiting, having to be medicated, getting too little or poor nutrition, and more.

4. Maternal emotional stress is a risk factor for outcomes similar to physical stress. Examples of emotional stress include feeling seriously depressed or scared. Emotional stress can also come from having a physical or mental illness, feeling unsafe, marital problems, conflict, financial worries, experiencing serious loss other than in ABE #1, and more. The common worries about pregnancy and the baby are not considered ABEs (Klaus & Kennell, 1976, 1982).

5. Complications in mothers during pregnancy, labor, birth, and beyond are risk factors for both baby and mother, as well as for bonding disruptions, difficulty breastfeeding, and other effects. Examples of maternal complications include hemorrhage, being put to sleep for delivery, toxemia, long labor, forceps extraction, vacuum extraction, induction, cesarean, and more. Maternal *near misses*, in which mothers experience serious difficulties and complications just short of death, are ABEs.

6. Complications in babies from conception until the third birthday are risk factors for bonding disruptions, difficulty breastfeeding and other ABEs, chronic illness, mental illness and more. Examples include: fetal illness or poor growth in the womb; events around birth, such as a tight cord around the neck, shoulder dystocia, being injured during birth, premature birth, breech birth, or trouble breathing; needing resuscitation, oxygen, a blood transfusion, incubator care, or intensive care; jaundice, having an infection or other illness, being a twin or other multiple birth, forceps extraction, vacuum extraction, cesarean, having a circumcision or other medical procedure, and later events such as accidents and more. Infant *near misses*, in which babies experience serious difficulties and complications just short of death, are ABEs.

7. Separation of baby from mother in particular, or of baby from either parent increases risk for symptoms in babies such as physiological and emotional dysregulation, poor growth, chronic illness, and mental illness. Separation also increases risk for maternal symptoms such as postpartum depression. Examples of separation include emotional separation due to trauma for the mother, father, or baby, and physical

separation, such as if the mother is given general anesthesia or has a cesarean, the baby is in newborn intensive care (NICU), or the baby stays in the hospital after the mother goes home. Other examples include foster care, adoption, or being hospitalized for illness, surgery, or other adverse events in the first two years, being separated for other reasons, such as a parent being hospitalized, parent travel, and more.

8. Birth weight is a reflection of experiences in the womb. Low birth weight is a risk factor for chronic illnesses and other symptoms later in life. Weighing more than 9 pounds or more at birth is also associated with increased risk in some studies.

9. Breastfeeding. Difficulty breastfeeding is a common symptom of ABEs and bonding disruptions. It indicates a need for greater support.

10. Early signs and symptoms in mother, baby, or father indicate a need for more support and repair. Many are indicators of exposure to ABEs. Examples include parental feelings of disconnection or lack of affection for their infant, postpartum depression or PTSD, and other symptoms in either parent. Examples of symptoms in the baby include low or poor eye contact (or gaze aversion), being sickly, easily upset, irritable or demanding, not growing well, not affectionate, not liking to be held, being difficult to calm or comfort, or having difficulty feeding, frequent respiratory infections, colic, trouble sleeping, coughing a lot, gagging often, wheezing, and more. Chronic illnesses in children or adults may also be indicators of ABEs.

Other adverse events that do not fit in the above list or in previous categories can be included as ABEs, such as unwanted pregnancy, a father or partner's experience of PTSD from witnessing the mother's birth experience, ABEs similar to #1 through #5 occurring for the father or partner, and more.

Many ABEs are already part of the routine history gathered by obstetricians, midwives, family physicians, pediatricians and others involved in prenatal and perinatal care. A more detailed list of ABEs can be obtained elsewhere (Mead, 2019).

Identifying and understanding ABEs can:

- Inform parents, health care professionals, teachers, and adults with chronic illness and other symptoms about identifiable, preventable, reversible, and treatable risk factors.
- Educate about common, underestimated risk factors for poor physical and emotional health in babies and parents, and other effects.
- Delineate the many symptoms and other effects of early adversity.

- Emphasize the potential for reversibility or reduction of symptoms and other effects of adversity.
- Identify interventions and treatment approaches.
- Reduce infant morbidity, mortality, near misses, and other complications.
- Reduce maternal morbidity, mortality, near misses, and other complications.
- Reduce symptoms in fathers or partners related to ABEs.
- Change the common perspective of blame to an understanding that emotional, behavioral, and physical symptoms reflect underacknowledged physiological effects of trauma.

ABEs Increase Risk for Babies

ABEs influence short- and long-term health in babies as well as risk for other symptoms. The effects of adversity can persevere throughout a baby's life and can affect future generations. Recognizing symptoms of exposure to adversity makes it possible to prevent and reduce risk as well as to repair and potentially reverse symptoms if they arise. ABEs also increase risk for premature death, including during infancy.

ABEs Increase Risk for Infant Mortality

Infant mortality rates are similar across most developed countries. However, the US is slower to improve than other countries (Kamal et al., 2019), and racial disparities are large with the highest rates of mortality in American Indian/Alaska Natives and African American infants (Singh & Yu, 2019).

Risk factors for infant mortality in developed countries are related to structural racism, income inequality, pregnancy under the age of 20, and maternal complications (National Center for Health Statistics, 2019). Examples of maternal complications include preeclampsia, infections, gestational diabetes, hemorrhage, and cesarean births. These risk factors all reflect trauma or potential effects of trauma younger age in pregnancy is greater with a history of maternal trauma and ACEs. (See Appendix) These risk factors are all ABEs.

Cesarean sections are an ABE because they are risk factors for neonatal mortality in low risk pregnancies (Black et al., 2015; MacDorman et al., 2006) and for miscarriage and stillbirth in subsequent pregnancies (Keag et al., 2018). Having a cesarean increases the risk of another cesarean in future pregnancies by 90% (ABE #6), even if future pregnancies are low risk (MacDorman et al., 2006).

Additional leading causes of infant death can also be ABEs and include:

- premature birth, which accounted for 17% of infant deaths in the US in 2017 (National Center for Chronic Disease Prevention and Health Promotion (NCCDPHP), 2019a)
- low birth weight
- sudden unexpected infant death
- congenital malformations (National Center for Health Statistics, 2019).

Adverse experiences, such as bereavement in the current pregnancy (ABE #1) due to a previous miscarriage, or other prenatal stress (ABE #3, #4), increase risk for premature birth (Mulder et al., 2002), stillbirth (Hogue et al., 2013; Keag et al., 2018; Laszlo et al., 2013), infection, and death in a baby's first year of life (Klaus & Kennell, 1982; Moore et al., 2012). Babies who are unwanted also have a greater risk of low birth weight, premature birth, and increased infant mortality (Bustan, 1993 as cited in Chamberlain, 2013, p. 103).

Prenatal stress also increases risk for congenital malformations (Carmichael et al., 2007; Feng et al., 2014). The type of malformation can be associated with the timing of exposure to environmental factors, including stress and trauma, during critical periods of development (King et al., 2009; Rice & Barone, 2000).

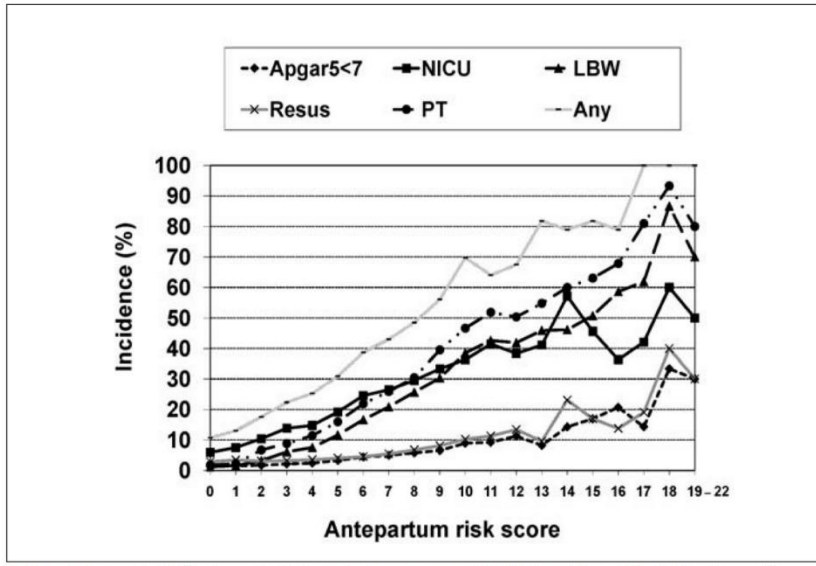
ABEs Increase Risk for Infant Morbidity

A series of antepartum assessment tools in Canada (Burstyn, 2010; Coopland et al., 1977; Goodwin et al., 1969) demonstrate the additive effect of maternal risk factors for adverse neonatal outcomes. These include preterm birth, low birth weight, five-minute APGAR score of seven or under, the need for invasive resuscitation, and admission to the NICU. The score is calculated from maternal factors that include maternal age, adverse events before pregnancy (ABE #1), adverse events and complications in past pregnancies (ABE #1) or in the current pregnancy (ABEs #2 to #5), as well as medical conditions (ABE #4).

Similar to what is seen with other types of trauma (Lehrner et al., 2016), risk for adverse neonatal outcomes increases with each adverse maternal event (see Figure 3). Risk derives from increasing exposures rather than specific events.

Figure 3

Antepartum risk score and measures of adverse pregnancy outcomes for singleton live births



NICU: admissions to NICU; Apgar 5 < 7: 5 minute Apgar score < 7; LBW: low birth weight < 2.5 kg; Resus: the need for invasive resuscitation measures; PT: preterm birth < 37 weeks of gestation; any: Any of these outcomes present.

Note. The antepartum risk score is calculated from maternal factors such as age below 17 or over 35 years, pre-pregnancy history, presence of medical conditions, as well as past and current obstetrical history and outcomes. Risk for adverse neonatal outcomes, such as admission to neonatal intensive care (NICU), an Apgar less than seven at five minutes, and low birth weight (LBW) increases with each additional maternal complication. Reprinted from the Journal of Obstetrics and Gynaecology Canada, 32(1), Burstyn, Antepartum risk score predicts adverse birth outcomes, 16-20, 2010, with permission from Elsevier.

ABEs Increase Risk for Chronic Illness

ABEs experienced by the baby are risk factors for the future development of heart disease, type 2 diabetes, cancer, chronic lung disease such as chronic bronchitis, and chronic obstructive pulmonary disease (COPD), stroke, and dementia (Barker et al., 1991; Calkins & Devaskar, 2011). These six chronic diseases are the leading causes of death in the US (Raghupathi & Raghupathi, 2018) and around the world (Ritchie & Roser, 2019).

The fetal origins of adult disease (FOAD) studies of prenatal stress, conducted with more than 20,000 participants and for multiple generations, find that prenatal emotional and physical stress increase risk for these and other chronic illnesses (summarized in Calkins & Devaskar, 2011). Prenatal stress also increases risk for low birth weight, which is an independent risk factor for many chronic illnesses. As Calkins and Devaskar (2011) describe, these effects of prenatal stress are independent of lifestyle factors such as smoking, dietary fat, or exercise. They are also distinct from family history and income levels, and influence health across multiple generations.

Two recently published cohort studies of adults born by cesarean have found increased risk for obesity and type 2 diabetes (Chavarro et al., 2020) and autoimmune diseases (Andersen et al., 2020). Chavarro and colleagues' (2020) Nurses' Health Study II, which evaluated risk only in women, noted that the association remained after adjustment for participant body mass index. The Denmark study (Andersen et al., 2020) used data from the national population registry for both genders. Risk was greater for all 4 diseases studied (type 1 diabetes, rheumatoid arthritis, inflammatory bowel disease, and celiac disease). Additional studies of cesarean sections and other ABEs, including prenatal stress and birth complications, have also been identified as risk factors for type 1 diabetes (Dahlquist & Kallen, 1992, 1997; McKinney et al., 1997; Mead, 2007; Patterson et al., 1994), asthma (Cookson et al., 2009; Keag et al., 2018; Madrid et al., 2004; Madrid & Schwartz, 1991; Mead, 2007; Nafstad et al., 2003; Oliveti et al., 1996; Turcotte-Tremblay et al., 2014; Xu et al., 2000), and many other chronic illnesses (Mead, 2003, 2004, 2007, 2019; Naviaux, 2014). According to David and colleagues (1988 as cited in Chamberlain, 2013, p. 103), babies who are unwanted also have more acute and long-term illnesses. The role of ABEs in risk for chronic illness will be presented in a future paper.

ABEs Increase Risk for Maternal Morbidity and Mortality

In addition to affecting risk for symptoms and chronic conditions in babies, ABEs are also risk factors for adverse maternal experiences and outcomes. This is in part because the maternal-fetal dyad is a tightly interconnected unit during pregnancy as well as in the first years of a child's life. It is also because events that increase risk for poor outcomes in babies are often traumatic for the mother.

Important risk factors for maternal morbidity and mortality in developed countries include structural racism, income inequality (Petersen et al., 2019b), pregnancy under 20 and over 35 years of age, and birth complications (Martin & Montagne, 2017; Petersen et al., 2019a), including cesarean sections (Liu et al., 2007). These types of adverse

events also contribute to risk for maternal morbidity and mortality around the world.

One of—if not the most important—causes of maternal mortality in the US is suicide (Palladino et al., 2011). Suicide is commonly triggered by postpartum depression (Martin & Montagne, 2017). Risk factors for postpartum depression include maternal trauma (ABE #1) such as adverse childhood experiences (see Appendix), low social support (ABE #2), prenatal stress (ABE #3, #4), preterm birth (ABE #5, 6), cesarean sections (Silverman et al., 2017) and other birth complications (Halbreich, 2005; NCCDPHP, 2019b; Silverman et al., 2017; Yim et al., 2015). A common feature of ABEs is that risk factors for one negative outcome often influence or compound risk for others. This is true for mothers as well as babies.

Cesarean sections provide an example of the additive effects of ABEs. Cesareans increase risk for postpartum depression (Silverman et al., 2017), and raise the risk of complications in future pregnancies such as antepartum hemorrhage, ectopic pregnancy, uterine rupture, placenta previa, placental abruption and placenta accreta (Keag et al., 2018). In addition, shorter durations from the decision to operate urgently until the delivery—referred to as a *crash cesarean section*—increase physiological markers of stress in babies even when newborns do not appear to be distressed (MacKenzie & Cooke, 2001). Mackenzie and Cooke (2001) hypothesize that "a crash attitude may in fact provoke increased maternal catecholamine release which may cause reduced perfusion of the placental bed leading to fetal acidosis," (p. 1335). This is a way of suggesting that emergency cesareans affect neonatal outcomes because they increase emotional and physiological states of fear and stress in mothers. Mackenzie and Cooke (2001) and Roy (2008) noted similar increases in fetal acidosis with assisted deliveries, such as with the use of forceps or vacuum extraction.

Roy (2008) and Mackenzie and Cooke's (2001) hypothesis is supported by other studies. Cesareans can be traumatizing for mothers (Fenwick et al., 2003; Ryding et al., 1997; Soderquist et al., 2009) and increase risk for serious intrusive thoughts and postpartum depression (Ryding et al., 1997) as well as posttraumatic stress and PTSD (Soderquist et al., 2009). Emergency cesareans, in particular, increase risk for PTSD in mothers more than six times compared with vaginal deliveries (Soderquist et al., 2002). Cesareans, whether planned or unplanned, also have three times greater mortality rates for mothers compared with vaginal deliveries (Kallianidis et al., 2018; Liu et al., 2007). As mentioned above, cesareans also increase risk for neonatal mortality as well as for the development of chronic illness, among other effects, in babies.

Mechanisms through which ABEs Affect Risk

The effects of trauma occur because adversity alters physiology. This has been observed whether the effects of trauma result in mental illness, increased sensitivity to stress, chronic illness, or other factors. This understanding provides opportunities to incorporate trauma awareness in medical care and to stop relegating the effects of adversity to the domains of psychiatric and psychological practice.

Understanding mechanisms through which trauma and other adverse events exert their effects increases the ability to identify ABEs as well as risk factors for ABEs. This also provides opportunities to prevent or decrease negative outcomes and intervene to reduce or repair effects when ABEs do occur. An understanding of trauma also emphasizes the potential for reversing effects of adversity at any age, which is one of the critical reasons for the construct of ABEs.

Characteristics of Trauma

Neurologist and traumatologist Robert Scaer (2006) defines trauma as:

> Any negative event that occurs in a state of relative helplessness—a car accident, the sudden death of a loved one, a frightening medical procedure, a significant experience of rejection—can produce the same neurophysiological changes in the brain as do combat, rape, or abuse. (p. 50)

What makes a negative life event traumatizing, according to Scaer (2005, 2006), isn't the life-threatening nature of the event, but rather the degree of helplessness it engenders and one's history of prior trauma.

While defense responses of sympathetic activation such as fight and flight typically resolve when a stressor goes away, the short- and long-term effects of trauma are different (Scaer, 2005; Yehuda et al., 2016). Negative events that occur during states of relative helplessness, such as painful or scary medical procedures, stimulate parasympathetic activation of freeze and immobilization responses. The elicitation of the freeze response increases the chances that threat signaling will remain and defensive states will continue even after the danger passes (Levine, 1997, 2010; Naviaux et al., 2016; Scaer, 2005; van der Kolk, 2014; van der Kolk et al., 1996). Repeated exposures and greater severity of perceived threat strengthen these pathways over time in a dose response (Yehuda et al., 2015). Persistent danger signaling that occurs even in the face of safety and support is a hallmark of an unresolved threat response (Naviaux, 2014) and trauma (Scaer, 2005).

The experience of trauma is influenced by perception, shaped by an individual's experiences of past and present adversity and support (Alonzo, 2000; Lehrner et al., 2016; Levine, 2010; McFarlane, 2015; Scaer, 2005; van der Kolk et al., 1996) and is much more common than previously

thought (Yehuda et al., 2016). The effects of trauma reflect severity, frequency, and timing of exposure, and are greater when there is a lower degree of perceived emotional or physical support (McFarlane, 2010). Studies of twins once thought to identify genetic risk for chronic illness and other symptoms can reflect individual differences in prenatal exposure to environmental factors, including stress and trauma (Yehuda et al., 2015).

Trauma increases sensitivity to stress as well as susceptibility to infections and other environmental factors that affect risk for disease (Dube et al., 2009; Naviaux, 2014). This heightened sensitivity can persist for more than one generation (Yehuda & Lehrner, 2018). The predominant cultural and medical views that all effects of trauma are psychological or "all in your head" is traumatizing to patients and no longer tenable (Burke, 2019).

Children are most vulnerable to trauma during prenatal life and in infancy by virtue of their complete dependence on others, and because organ systems undergoing periods of most rapid growth are the most sensitive to gene-environment interactions (Schore, 1994). Events in the earliest stages of life have a larger impact than at later stages (Shonkoff et al., 2012). Women are also inherently more vulnerable when protecting a child, such as during pregnancy, labor, birth, and the infant's early years.

While cesarean sections can be life-saving, they are also an example of medical interventions associated with risk for both infant and mother. As mentioned previously, cesareans can be traumatizing for mothers and babies, and increase risk for maternal as well as infant mortality. One contributing factor is that emergency cesareans are frequently settings of maternal loss of choice and control (Fenwick et al., 2003), which are risk factors for trauma. The graded dose-response relationship of increasing risk for asthma with assisted vaginal delivery (14% to 20%), planned cesareans (40%) and emergency cesareans (60%) in a Norwegian study (Tollanes et al., 2008) may reflect the increasing risk of adverse experiences as the invasiveness and urgency of the procedure rises.

Cesarean sections, preterm birth (Koliouli et al., 2016), and other adverse early experiences (NCCDPHP, 2019b) also increase risk for symptoms such as PTSD (Koliouli et al., 2016; NCCDPHP, 2019b) and depression (Shaw et al., 2009) in fathers.

Experiences of adversity vary for every mother, father, and baby and with every pregnancy and birth. They are influenced by the circumstances at the time of an intervention or procedure, the availability of support, past experiences such as previously traumatizing births, state of mind, and other factors (Horwitz et al., 2015; Madrid, 2005; Racine et al., 2018). One of the ways prenatal stress, preterm birth, interventions, birth complications, and other ABEs affect a prenate, infant, or child's short- and long-term health is that they are traumatizing for the baby (Chamberlain, 2013; Mate, 2003; Shonkoff et al., 2012; Verny, 2002), the

mother (Madrid, 2007; Soderquist et al., 2009) and the father or partner (Koliouli et al., 2016; Wells, 2016). Another mechanism through which trauma influences short- and long-term outcomes in parents and babies is through interruptions to the physiology of bonding.

Characteristics of Bonding

Bonding disruptions are under-recognized risk factors for babies and parents and are associated with most ABEs. Maternal-infant bonding occurs when parents fall in love with their babies (Bystrova et al., 2003; Kennell & Klaus, 1998; Klaus & Kennell, 1982; Welch et al., 2015). Bonding is a natural process of physical, emotional, and biological connection (Klaus & Kennell, 1976, 1982; Klaus et al., 1995; Madrid & Pennington, 2000) by which the vulnerable prenate and newborn invites proximity, psychobiological regulation, and protection from adults for survival and preparation for the environment they will encounter after birth (Porges, 2004; Schore, 1994). Bonding is almost guaranteed to be present, unless something interferes with it (Klaus & Kennell, 1976, 1982; Madrid et al., 2000).

The prenatal time and the first hours and days after birth are part of a sensitive period when babies and mothers are primed for bonding and are especially impacted by their environments (Widstrom et al., 2019). Bonding is orchestrated by the social nervous system branch of the autonomic nervous system. The social nervous system preferentially utilizes facial expressions, communication, and connection to optimize safety (Porges, 2004) over the less developed mechanisms of physical mobilization, and more energetically-costly strategies of fight and flight, driven by the sympathetic nervous system (Fredrickson, 2013). Bonding is facilitated through "hidden regulators" such as touch, eye contact, body temperature, tone of voice, smell, breastfeeding, hormone levels, and more (Hofer, 1994; Moore et al., 2012).

Prenatal communication between parents and their babies (Ikegawa, 2006; Schroth, 2010) fosters the process of bonding, which is also heightened by skin-to-skin contact and breastfeeding, particularly in the first hour after birth (Klaus & Kennell, 1982; Moore et al., 2012; Widstrom et al., 2019).

Parent-infant contact and bonding influence parental behaviors, such as gazing, holding, breastfeeding, and maintaining close physical proximity, as well as feelings such as love and protectiveness (Klaus & Kennell, 1976, 1982; Klaus et al., 1995). These parental states, in turn, shape a baby's brain development and physiology, sensitivity to stress, defense responses, and long-term health (Kennell & Klaus, 1998; Klaus & Kennell, 1982; Moore et al., 2012; Schore, 1994).

Characteristics of Early Separation

Bonding is most easily disturbed during sensitive periods in early life. In the 1970s, pediatricians Marshall Klaus and John Kennell (1976, 1982) discovered that traumatic events for the mother and hospital practices of routine separation contribute to maternal experiences of physical or emotional separation that can interfere with bonding. A recent study of maternal childbirth-related PTSD reveals similar effects on maternal behaviors (Dekel et al., 2019).

Events that are overwhelming for the mother are incompatible with bonding (Madrid & Schwartz, 1991). Emotional and physical separation affects the quality of engagement mothers have with their babies, decreases maternal feelings of love for the baby, and reduces bonding behaviors (Klaus & Kennell, 1976, 1982; Klaus et al., 1995). Events that can interfere with maternal bonding include a mild illness in the newborn, slight elevations in bilirubin levels, slow feeding, the need for oxygen for one or two hours, or separation, such as for incubator care in the first 24 hours (Klaus & Kennell, 1976). Klaus and Kennell (1976) found that such experiences affect the relationship between mother and infant and often alter a mother's behavior for the first year or longer. Cesarean sections are another example of ABEs (#5, #6) that commonly cause periods of parent-infant separation (ABE #7).

Columbia University professor and psychiatrist Myron Hofer (1984, 1994) discovered in the 1970s that rat pups separated from their dams suffered from decreases in blood pressure, temperature, and other physiological processes because proximity to the mother confers psychobiological regulation as well as safety. Babies also have slight alterations in blood pressure, temperatures, respiration, and other physiological markers when they are separated from their parents (Klaus & Kennell, 1976, 1982; Moore et al., 2012). Swedish researchers Dahlquist and Kallen (1992, 1997) also discovered that separation might be the most important underlying component among birth complications associated with risk for type 1 diabetes (Dahlquist & Kallen, 1997).

Madrid and Schwartz (1991) came to similar conclusions about the role of separation as a risk factor for asthma. Madrid's (2005) review of 60 years of the asthma literature revealed the common theme that children with asthma have conflicted relationships with their mothers. These conflicts, Madrid discovered, reflect interruptions in bonding caused by events that increase maternal experiences of emotional or physical separation in the two years before conception, during pregnancy and birth, and in the first two years of a child's life. Madrid and colleagues (2004) identified these risk factors from Klaus and Kennel's studies (1976, 1982) and found that 40% of mothers of asthmatic children have experienced at least one event that interferes with bonding compared with mothers of well children, and that 87% of these events involve emotional separation

(Madrid et al., 2004). In addition, children with asthma have experienced three times more bonding disruptions than healthy controls (Madrid, 2005; Madrid et al., 2011; Madrid & Schwartz, 1991).

Madrid and colleagues' understanding of trauma and its effects on bonding have led to treatment whereby healing the effects of adversity in mothers reduces or reverses asthma in most children under the age of nine years (Madrid et al., 2000; Madrid et al., 2011; Madrid et al., 2012). The intervention simultaneously resolves or decreases postpartum depression in mothers (Madrid et al., 2011).

Madrid's Maternal Infant Bonding Survey (2012) identifies non-bonding events as part of the initial phase of treatment. Examples of events that interfere with bonding include: maternal loss of a loved one, such as a parent, the father of the baby, or another child, and include previous miscarriage or stillbirth; maternal emotional stress, such as from marital conflict, financial worries, or worry about the baby's health; physical events, such as serious bleeding during pregnancy, severe vomiting, preeclampsia, or other illness; experiences of birth complications, such as a long or difficult labor, interventions and assisted deliveries, such as forceps or cesarean sections; lack of support, such as from stressful interactions with family members, indifference or harsh words from labor room staff, or not having her own doctor present for the birth; and physical separation after birth, such as when a baby is kept in the nursery as part of routine care or treated in an incubator or the NICU. The Maternal Infant Bonding Survey (MIBS) has served as an important and inspirational component for the construct of adverse babyhood experiences. ABEs expand on Madrid's time period of maternal trauma from two years before conception to a mother's lifetime to include the role of earlier trauma, such as adverse childhood experiences (Racine et al., 2018) and complications in previous pregnancies, which predict poor outcomes in future pregnancies (Burstyn, 2010; Coopland et al., 1977; Goodwin et al., 1969).

Epigenetic Changes in Babies

Epigenetics refers to the process by which life experiences influence the attaching and detaching of molecules to the surfaces of genes and alter how they function without changing genes themselves. A potent benefit to understanding the role of epigenetics and environmental factors in risk for maternal and infant morbidity and mortality, as well as for chronic illness and other symptoms and conditions, is that effects of adverse experiences are potentially treatable and reversible.

The science of epigenetics identifies how maternal experiences, feelings, and behaviors influence the health of the baby, and how preventing or healing such adverse events can potentially prevent or reverse morbidity and mortality in mothers as well as infants. These

studies suggest mechanisms through which Madrid's approach and other modalities for treating the effects of adverse babyhood experiences exert their effects.

The effects of bonding and bonding disruptions are expressed through epigenetics (Klaus & Kennell, 1976; Moore et al., 2017; Wright et al., 2018). In a landmark study, McGill scientists Weaver and colleagues (2004) showed that maternal behaviors influence defense responses and heightened sensitivity to stress in rat pups and that these shifts are conveyed epigenetically. For rats, effects occur following exposure to low maternal nurturing behaviors during a critical period in the first week of life. The affected areas regulate cortisol and stress responses and these changes can persist for multiple generations (Weaver et al., 2004). They can also be reversed if pups are returned to high-nurturing dams or through other means later in life (Weaver et al., 2004). This has profound implications for the prevention, reduction, and treatment of chronic diseases and other symptoms in babies, children, and adults.

Children who have been abused show the same epigenetic changes as rat pups who experience low nurturing contact (Romens et al., 2015). This threat response, occurring whether exposure is to low nurturing during infancy or to abuse in childhood, highlights common pathways for the many effects of trauma. Poor outcomes are increasingly understood to arise due to prolonged physiological responses to potential danger (Naviaux, 2014; Shonkoff et al., 2012). This emerging paradigm explains that effects of trauma, including chronic disease, reflect a physiology caught in different phases and configurations of threat responses. The type of disease or other symptoms a person develops may be based in part on genetics, but is perhaps even more importantly shaped by the timing and degree of exposure to threat, especially during critical periods of development (Naviaux, 2018; Shonkoff et al., 2012). This is because gene function is influenced by life experiences through epigenetics.

Epigenetic changes in babies mirror epigenetic changes in mothers and maternal experiences of stress (Wright et al., 2018). Furthermore, the amount of contact babies experience at five weeks is reflected in genome-wide epigenetic changes when they reach four years of age (Moore et al., 2017). As previously discussed, bonding behaviors influence the amount of contact parents express towards their babies. The quality of maternal engagement at five months also predicts epigenetic changes associated with oxytocin levels and sensitivity to stress at 18 months (Krol et al., 2019). Oxytocin facilitates the use of social engagement as the less energy-consuming way of interacting with the world, which involves connection, safety, and support through relationships. The social nervous system is able to inhibit threat responses such as fight, flight, and freeze to reduce the risk trauma will stimulate physiological states that get stuck in modes of defense (Schore, 1994). As clarified through ABEs, the quality of maternal engagement and the degree of contact a mother has with her baby can

reflect her degree of bonding, as well as trauma and other experiences of adversity she has experienced before, during, and after pregnancy.

Epigenetic research provides potential insights into Madrid's success in reducing or reversing asthma by treating mothers for adverse events occurring before her child's third birthday (Madrid et al., 2000; Madrid et al., 2011; Madrid et al., 2012). Yehuda's finding that some epigenetic changes reverse in combat veterans with PTSD when their symptoms resolve with trauma therapy (Yehuda et al., 2013) lends additional support and possible mechanisms. Similar interventions can also improve bonding (Madrid, personal communication, December 5, 2019) and may reduce or prevent risk for symptoms in fathers or partners. Such approaches provide important avenues to explore for the potential reduction or reversal of other chronic diseases and symptoms and will be discussed in more detail in a future article.

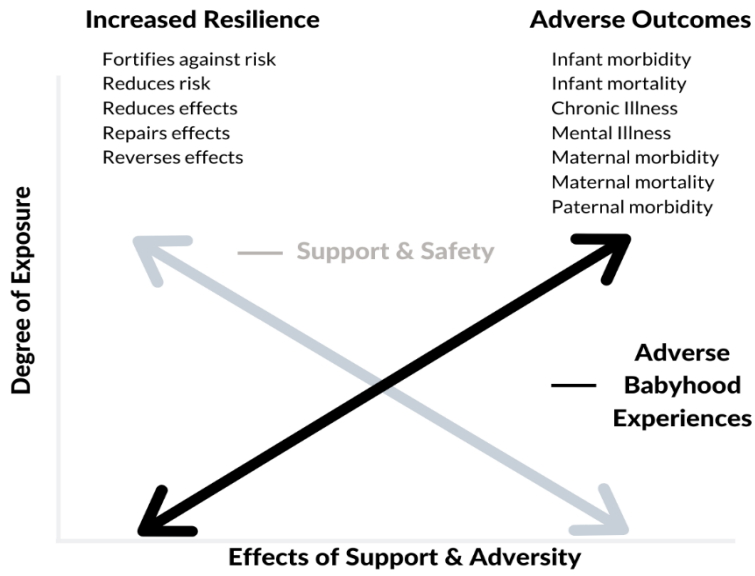
Discussion

The science of trauma demonstrates that interactions between life experiences and biology go beyond mental health conditions and behavioral changes. Adversity in childhood and during pregnancy, birth, and infancy affects parental feelings, behaviors, and physiology, influences psychobiological regulation and bonding during sensitive periods in early life, and increases risk for leading causes of death around the world from maternal and infant morbidity and mortality, chronic diseases, and beyond.

The effects of adversity are additive, increase risk through multiple exposures and dose over time, and are multigenerational. These effects of trauma are physiological, epigenetic, and to a larger extent than has been recognized, reversible and preventable. Understanding trauma demonstrates how safety, support, communication, and other tools buffer the effects of adversity. Outcomes are influenced by the degree of support in relation to adversity (see Figure 4).

Figure 4

Health is Shaped by Balance Between Safety & Adverse Babyhood Experiences



Note. Health is influenced by the balance between experiences of safety and support, and experiences of adversity, such as adverse babyhood experiences (ABEs). The greater the amount of support and safety and the lower the amount of adversity, the higher the resilience and possibilities for optimal outcomes. Support and trauma-informed interventions can also buffer the effects of adversity to prevent, reduce, repair, or reverse effects of ABEs.

The Importance of Recognizing and Treating ABEs

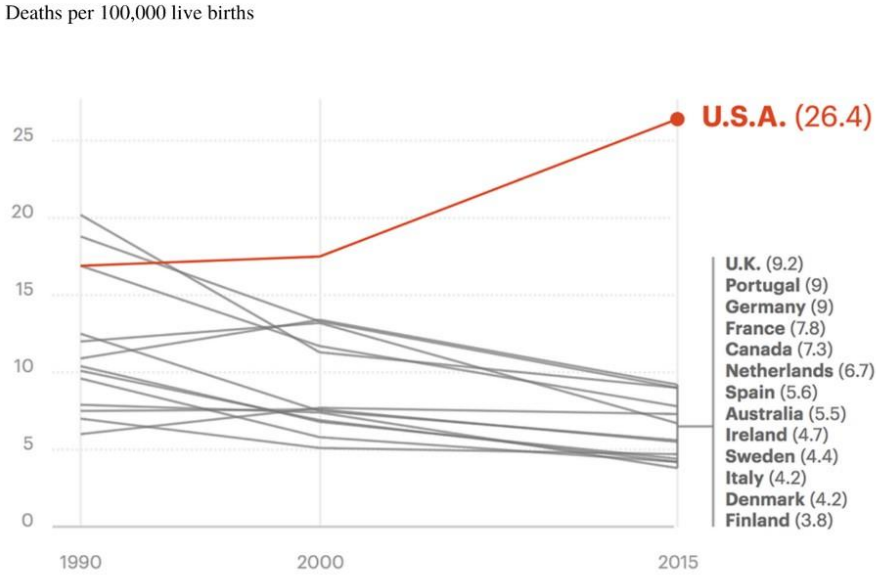
The need for an understanding of ABEs and trauma is seen with the example of maternal mortality and morbidity. While rates are improving in much of the world, preventable deaths continue to be unacceptably high, especially in low and lower-middle income countries where 95% of deaths occur (Roser & Ritchie, 2019). In addition, many countries have not achieved goals for reductions in maternal mortality (Kassebaum et al., 2014).

The United States, as another example, has the highest rate of maternal morbidity and mortality among developed countries (see Figure 5), with two to three women dying every day and 175 women almost dying daily (the Lancet's Global Burden of Disease Study 2015 as cited in Martin

& Montagne, 2017). Risk is more than four times greater for women of color and from other minority groups (G.B.D. Maternal Mortality Collaborators, 2016; Martin & Montagne, 2017). According to the Central Intelligence Agency's World Factbook (2019), the US ranks 55th in the world for maternal mortality, and rates are still rising (CDC, 2019). As National Public Radio (NPR) states, these facts reflect a public health catastrophe (Martin & Montagne, 2017). At least 60% of maternal deaths in the US are believed to be preventable (Petersen et al., 2019a). An understanding of trauma, such as through the construct of ABEs, is an important means to better understand risk factors. It also provides opportunities for prevention, repair, and intervention.

Figure 5

Maternal Mortality Is Rising in the U.S. As It Declines Elsewhere



Note. Maternal mortality is rising in the U.S. as it declines elsewhere: Deaths per 100,000 live births. From Martin, "The Last Person You'd Expect to Die in Childbirth" citing "Global, regional, and national levels of maternal mortality, 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. *Only data for 1990, 2000, and 2015 was made available in the journal. Source: The Lancet Credit: Rob Weychert/ProPublica. Published with permission from ProPublica.*

Cesareans are an important contributor to maternal morbidity and mortality. Rates of cesareans are rising around the world and are

increasingly performed without medical or obstetrical indications (Keag et al., 2018; Roy et al., 2008). ABEs emphasize the need for doctors and patients, among others, to learn about the risks associated with cesareans and other obstetrical interventions.

Reducing maternal morbidity and mortality decreases infant morbidity and mortality as well as chronic illness and other effects of ABEs. Understanding, recognizing, and using ABEs provides opportunities to recognize the multi-layered impact of interventions on babies as well as parents. It also offers guidance and tools for preventing, repairing and minimizing the negative effects of cesareans and other complications, such as when interventions are truly needed or when they have already happened. This will be explored in a separate article.

ABEs Affect Risk for Adverse Childhood Experiences (ACEs)

ABEs further the science of understanding Adverse Childhood Experiences (see Appendix). Adverse Childhood Experiences (ACEs) refer to 10 kinds of trauma that occur before a child's 18th birthday. These 10 items—which include abuse, neglect, mental illness in a parent, and the loss of a parent—represent a fraction of the kinds of trauma that affect short- and long-term health. Dr. Vincent Felitti, principal co-investigator for the first and other ACE studies, has added an 11th question to the 10 ACEs: "Are there any adverse childhood experiences in your life that should be added to the above list?" (personal communication, March 15, 2018).

The construct of ABEs addresses this question with a set of distinct risk factors in the earliest period of development, when effects have a disproportionate impact unlike at any other time of life. In addition to other effects mentioned throughout this article, ABEs increase risk for many of the types of trauma in childhood that are known to affect long-term health and other outcomes. As previously discussed, for example, ABEs increase risk for postpartum depression and PTSD. Mental illness in a parent is an Adverse Childhood Experience that influences a child's life potential. The death of a mother, such as from birth complications, is another Adverse Childhood Experience. ABEs also increase risk for abuse and neglect because they affect the ability of parents to connect emotionally with their infants (Klaus & Kennell, 1976; Madrid & Pennington, 2000). Abuse and neglect are two additional types of ABEs that shape a child's potential (Felitti et al., 1998). Reducing ABEs decreases risk for abuse and neglect and other Adverse Childhood Experiences because they provide a separate set of tools to prevent and reduce adverse experiences in early life and their impacts.

Conclusion

Parents are a critical component of their child's environment. Parental states of emotional and physiological self-regulation have a large influence on a child's short and long-term health and other outcomes. Opportunities for prevention, treatment, and reversal are among the vital reasons for recognizing ABEs in particular, and the many different types of overt and covert trauma in general.

Trauma science demonstrates that nurturing, supportive, social connections are a critical component in health, healing, and in healing relationships. Understanding common characteristics of trauma provides opportunities for doctors, nurses, midwives, doulas, and other care professionals, who are in positions of relative power due to their knowledge and training, to reduce trauma that can be inadvertently caused through attitudes, behaviors, treatments, and interventions. It also validates concerns that many health care professionals and others already have about medical care, which is not yet incorporated into most training programs. Such understanding introduces strategies to optimize outcomes, such as through emotional regulation in care providers, parents, and babies during pregnancy, birth, and afterwards, including in the event of complications and interventions.

Experiences of adversity and negative outcomes cannot all be predicted or prevented. ABEs are therefore not about despairing when a "perfect" pregnancy or birth does not occur. Instead, ABEs help recognize indicators of adversity in order to provide opportunities for prevention of symptoms and other adverse events, as well as for healing and repair.

Not everyone who experiences adversity develops symptoms. Risk for maternal and infant morbidity and mortality, chronic illness, and other symptoms arises when there is too much adversity in the face of too little support and repair. As shall be discussed in more depth in a future article, understanding ABEs provides hope. Many inexpensive, easily accessible tools exist that buffer the effects of trauma to reduce or prevent ABEs such as preterm birth, low birth weight, postpartum depression, infant illness, maternal and infant mortality, chronic illness, and more.

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Appendix

Adverse Childhood Experiences (ACEs)

The 10 ACEs are as follows (Dube et al., 2009; Felitti et al., 1998):

1. Loss of a parent through divorce or separation
2. Having a parent with a mental illness, such as anxiety or depression
3. Physical abuse
4. Emotional abuse
5. Sexual abuse
6. Emotional neglect
7. Physical neglect
8. Having a household member who has problems with substance abuse
9. Having a household member who has been incarcerated
10. Witnessing domestic violence

Each ACE contributes one point to an ACE score. The effects of ACEs are additive and each additional ACE increases risk regardless of which ACE it is (Felitti et al., 1998).