Effects of Childhood Experiences on Pregnancy and Birth Outcomes

Submitted to the Faculty of the
College of Health Sciences
University of Indianapolis

In partial fulfillment of the requirements for the degree
Doctor of Health Science
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Acknowledgements

I am thankful for the support that I have consistently received from family, my research committee at the University of Indianapolis (UIndy), the University of California at San Diego Health (UCSD Health), and my colleagues at the Rady Children's Institute Genomics for Medicine (RCIGM). I thank my family, my husband Si Chi and daughter Caroline, for their endless love, understanding, and encouragement throughout my learning years at the Interprofessional Health & Aging Studies (IHAS), UIndy.

My great thanks extend to my research committee, Dr. Elizabeth Moore, Dr. Gretchen Bandoli, and Dr. Lochana Siriwardena. Each advisor generously offered collective expertise, sagacious wisdom, and steady guidance to help me complete my Doctoral project. I am deeply thankful to Dr. Karen Garman, Dr. Tina Chambers, Dr. Charlotte Hobbs, and Dr. Stephen Kingsmore at RCIGM and UCSD Health for supporting my participation in the MotherToBaby study for this project.

My great appreciations also extend to Dr. Laura Santurri and the IHAS dedicated professors and staff, who equip me with the skills and knowledge for a doctorate health professional. Finally, I am grateful to collaborate and continue to share learning experiences with my colleagues at the UIndy throughout this program and for the time to come.

With deepest gratitude,
Jennie M. Le, MS, ASCP(MB), CGMBS

Abstract

A growing body of research reports an association between adverse childhood experiences (ACEs) and severe physiological and psychological health problems. Recent studies suggested that positive childhood experiences (PCEs) may bestow a protective buffer against the negative impacts of ACEs. The current study examined the effect of ACEs/PCEs on pregnancy outcomes, including unhealthy gestational weight gain (UWG), gestational diabetes (GD), preterm birth, and small or large birth weight for gestational age (SGA or LGA). The study sample included 556 women who enrolled in the MotherToBaby, delivered a live singleton from 2015-2021, and completed the Positive and Adverse Childhood Experiences survey between September 2020 and February 2021. Women who reported ≥ 3 ACEs or physical/emotional abuse had increased aOR = 1.68, 95% CI [1.12, 2.51]) or aOR = 1.79, 95% CI [1.24, 2.59] for UWG. Although sexual abuse or household dysfunction had elevated point estimates with increased odds for GD, SGA, and LGA or UWG, preterm birth, and LGA, the associations were not statistically significant with large confidence intervals. Additionally, due to the small sample size within stratified outcomes, we were unable to assess the effect modification of PCEs. Further research may advance an understanding of associations between timing, frequency, and types of ACEs/ PCEs and pregnancy health which could facilitate ACE awareness, reduce medical costs in maternal health care, and provide a better beginning for infant development.

Keywords: adverse childhood experiences, positive childhood experiences, MotherToBaby, pregnancy health, gestational diabetes, gestational weight gain, gestational age, preterm birth, birth weight for gestational age.

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Adverse and Positive Childhood Experiences on Pregnancy Health and Birth Outcomes

More than half of Americans have at least one adverse childhood experience (ACE) which approximately 1 in 6 people report experiencing four or more ACEs during childhood (Centers for Disease Control and Prevention [CDC], 2020). ACEs relate to both psychological and physical experiences that occur before the age of 18 years. As defined in early ACE research, these experiences included physical abuse, emotional abuse, sexual abuse, neglect, household dysfunction, exposure to domestic violence, mental illness, substance abuse, incarceration, and parental divorce or separation (Felitti et al., 1998; Hughes et al., 2017). Females and individuals of certain racial and ethnic minority groups in the United States (U.S.) are more likely to experience four or more ACEs (CDC, 2020). ACEs are considered risk factors for many severe health problems in the U.S. that cost families, the economy, and society a total of hundreds of billions of dollars each year (CDC, 2020; Felitti et al., 1998; Hughes et al., 2017).

Research suggests that ACEs may have direct physiological alterations of the brain's architecture, functions, and development, activation of the neural endocrine stress response and inflammation, and disruption of the autoimmune and metabolic function (Buss et al., 2017; Teicher et al., 2016). Moreover, ACEs may act on adverse outcomes through behavioral pathways including smoking, alcohol binge drinking, sexual risk-taking, drug-using, and violence perpetrating (Currie et al., 2020; Hughes et al., 2017; Mersky et al., 2018; Pear et al., 2017; Petruccelli et al., 2019). Preventing or mitigating the impacts of ACEs could potentially reduce as many as 1.9 million cases of heart diseases and 21 million cases of depression in the U.S. (CDC, 2020).

ACEs may also negatively impact pregnancy and birth outcomes (Berrens et al., 2017; Bethell et al., 2019; Cao-Lei et al., 2016; Hughes et al., 2017; Ranchod et al., 2016; Smith et al.,

2016). ACEs can deleteriously affect pregnancy through complications such as perinatal unhealthy weight gain, gestational diabetes, high blood pressure, and preeclampsia (Olsen, 2018). Adverse pregnancy outcomes, such as preterm birth, small birth size, low birth weight, and fetal death, were reported with greater frequency among pregnant women exposed to a high level of ACEs (Appleton et al., 2019; Nerasi et al., 2018; Olsen, 2018; Selk et al., 2016).

Positive childhood experiences (PCEs) may modify the effects of ACEs in a dose-response manner (Appleton et al., 2019; Bethell et al., 2019). Individuals who experienced four or more ACEs yet were nurtured in a safe and supportive environment that enhanced their sense of security and belongingness had lower odds of developing depression and poor mental health relative to individuals without a supportive environment (Bethell et al., 2019, Beutel et al., 2017; Crouch et al., 2019; Howell et al., 2020).

Problem Statement

Over the past two decades, studies have reported effects of ACEs on the physiological and psychological health of children and adults (Felitti et al., 1998; Hughes et al., 2017; Olsen et al., 2018), yet there are gaps in the research of ACEs and PCEs. First, most studies of ACEs and PCEs examined the impact of childhood experiences on the health outcomes of adults but did not study the prevalence of ACEs and PCEs among pregnant women. Second, it is unclear whether individual ACEs or types of ACEs differentially predict adverse pregnancy and birth outcomes, or whether a cumulative ACE score best summarizes the effects of childhood exposures (Merrick et al., 2017). Finally, among a few studies examining the effects of ACEs on women, little research has focused on PCEs that may modify the effects of ACEs on pregnancy health risks and birth outcomes. The current dissertation aims to address the research gaps by analyzing

preexisting data collected through the MotherToBaby (MTB) Pregnancy studies and MTB-PACE addendum study.

Purpose Statement

The purpose of this study is to examine the prevalence of childhood experiences (ACEs and PCEs) and the associations between ACEs/PCEs and adverse pregnancy and birth outcomes among a sample of women who enrolled in the MTB pregnancy studies and later participated in the MTB-PACE study. The current study addressed the following research questions:

1. What is the prevalence of childhood experiences (ACEs and PCEs) self-reported by pregnant women who participated in the MTB-PACE study?
2. What are the associations between ACEs scores, individually and cumulatively, and adverse pregnancy (i.e., unhealthy weight gain and gestational diabetes), and birth outcomes (i.e., gestational age at delivery, and birth weight for gestational age) in the MTB-PACE participants?
3. Do PCEs modify the associations between ACEs scores and adverse pregnancy (i.e., unhealthy weight gain and gestational diabetes) or birth outcomes (i.e., gestational age at delivery, and birth weight for gestational age)?

To answer the research questions, we examined the following objectives:

1. a) To calculate frequencies and percentages of self-reported childhood experiences (ACEs and PCEs) by women who participated in the MTB-PACE study.

   b) To analyze subtypes of the ACEs questionnaire results using factor analysis.
2. To determine associations between subtype ACEs/total ACEs scores and adverse pregnancy and birth outcomes using factor analysis of ACEs results to categorize ACEs subtypes and multivariate logistic regression to analyze the associations.

3. To determine whether PCEs scores modify the associations between ACEs and adverse pregnancy and birth outcomes using multivariate logistic regressions on two stratified samplings of MTB-PACE participants, one with cumulative PCEs scores of 5 or higher and another with PCEs scores of 4 or lower.

Significance of the Study

A conceptual clarification of complex factors associated with ACEs, examining from different levels and subtypes, with and without PCE modifiers, that influence the risks of maternal and intergenerational health through adverse pregnancies and poor childbirth outcomes, may effectively contribute to the scientific and clinical knowledge in maternal and child medicine. A better understanding of the associations between ACEs/PCEs and perinatal outcomes facilitates clinical implications in the care of pregnant women. The ACEs/PCEs-related findings also improve the standard prenatal care involving routine screening, counseling, and personalized medical treatment of pregnant women's conditions. The results help enhance self-efficacy and social support to mitigate adverse effects on the health and well-being of the mothers-to-be and their babies. Additionally, ACEs/PCEs' awareness may directly affect the resource allocations in implementing early detection and a pragmatic intervention to improve health outcomes among maternal and pediatric patients who suffered from ACEs. Identifying ACEs early in life and during prenatal care can reduce medical costs of perinatal and postnatal complications and effectively improve maternal health and birth outcomes, thus providing a better beginning for infant development (Narayan et al., 2018).

Literature Review

Adverse childhood experiences (ACEs) are among pervasive, unaddressed public health issues in the U. S. categorized by a high prevalence rate across 25 states (CDC, 2020a; Hughes et

al., 2017). Before 18 years old, 61% of children in the U.S. have experienced one or more ACEs (CDC, 2020a; Hughes et al., 2017). Adverse childhood trauma includes experiences of physical, emotional, sexual abuse; physical, emotional neglect; exposures to household dysfunction such as domestic violence, mental illness, substance abuse, incarceration, and parental divorce or separation (Felitti et al., 1998; Petruccelli et al., 2019).

Researchers developed models to plausibly explain the long-lasting effects of ACEs on the psychological, physiological health, and adverse health behaviors of individuals (Buss et al., 2017; Cameranesi et al., 2019; Teicher et al., 2016; Wong et al., 2018). ACEs exposures may endure neurobiological changes, alter the epigenetic variants, increase biological stress to the autoimmune system, and disrupt the metabolic regulations causing serious health problems (Buss et al., 2017; Teicher et al., 2016). Further, individuals with ACEs may engage in adverse health behaviors, substance abuse, and perpetration of violence (Currie et al., 2020; Hughes et al., 2017; Mersky et al., 2018; Pear et al., 2017; Petruccelli et al., 2019).

In addition to the enduring effect on the health and well-being of the individual, the impact of ACEs propagated to the next generation through pregnancy and birth outcomes (Berrens et al., 2017; Bethell et al., 2019; Cao-Lei et al., 2016; Hughes et al., 2017; Racine et al., 2018a; Racine et al., 2018b; Ranchod et al., 2016; Smith et al., 2016). A growing number of studies reported that pregnancy complication and poor delivery outcomes were disproportionately related to pregnant women experiencing ACEs (Appleton et al., 2019; Campbell et al., 2018; Diesel et al., 2014; Huffhines et al., 2016; Mason et al., 2016; Ranchod et al., 2016; Schoenake et al., 2019).

Childhood Experiences Theory and Model

The Life Course Theory

In the early 20th century, pioneer psychologists utilized the Life Course Theory (LCT) in studies of young people who experienced enormous social changes during the Great Depression, World Wars I and II, the Cold War, the Vietnam War, and the Civil Rights movements (Elder, 1998; Shanahan et al., 2003). The emergence of LCT marked a new era for the longitudinal, prospective, and retrospective studies of the life history of individuals in social psychological research (Elder, 1998; Shanahan et al., 2003). LCT reflects the nature of the interconnection between the socio-historical experiences and biographical context through five principles: lifespan development, human agency, time and place, life sensitivity, and social relationships (Black et al., 2009; Elder, 1998; Shanahan et al., 2003). The authors articulated that human development is dynamic as people live and make choices within the historic and social context of their times and places (Black et al., 2009; Elder, 1998; Shanahan et al., 2003). Individuals shape the trajectories of development and behaviors through personal experiences to remarkable events or traumatic occurrences during sensitive periods across the lifespan; however, these trajectories are influenced by the dependence and relationships of social networks (Black et al., 2009; Elder, 1998; Shanahan et al., 2003). In longitudinal studies of human development, LCT also examined the life consequences as a result of the accumulation of disadvantages (Elder, 1998). Early transitional experiences followed by subsequent trauma, even years later in life, can have an enduring and long-lasting effect on the health and well-being of individuals (Elder, 1998). LCT has opened a new perspective that challenges researchers to properly account for the effects of experiences throughout the lifespan of an individual (Elder, 1998).

Developmental Psychopathology Model

Developmental Psychopathology (DP) is a coherent model that integrates developmental science and psychopathology in studying human development (Eme, 2017). Drawn from multidisciplinary findings, DP focuses on four interrelated principles considering normality and abnormality: the reciprocal and transactional processes, the psychopathological pathways, and the multiple-level aspect of human development (Eme, 2017). Considering abnormality as a deviation from normality due to adverse exposures, Eme (2017) emphasized the importance of mutual inclusion of normal and abnormal pathways in the pathological study. The reciprocal and transactional factors contributing to the developmental cascades further explain the cumulative and long-lasting effects of childhood adversity into adulthood (Eme, 2017). Sequential and timing effects of adverse and positive environments on development may involve multiple pathways and outcomes; DP conveys a framework of various pathways leading to the same effect while a single developmental factor can associate with different outcomes (Eme, 2017). Moreover, Eme (2017) examined human development via multilevel analyses including the neurobiological, psychological, and socio-environmental contexts. Like LCT, DP provides an expansive approach for researchers to examine the pathological and psychological effects of adversity throughout an individual's lifespan.

Adverse Childhood Experiences and Adult Outcomes

Although there are different definitions of what may constitute childhood adversity among researchers, Felitti and colleagues (1998) are the pioneers who introduced an ACEs measure using metrics of abuse (physical, emotional, sexual), neglect (physical and emotional), and household dysfunction (such as mental illness, substance abuse, incarceration, parental divorce or separation). In further research, experiences of racism, financial hardship, being

bullied, serious childhood illness or injury, exposures to household criminality, and environmental criminality expanded the metrics used to measure ACEs (Hughes et al., 2017; Kim et al., 2019; Lydsdottir et al., 2017). A preliminary study of ACEs prevalence in pregnant women in the Southern U.S. estimated that one-fourth of ACEs is associated with abuse, one-fourth with neglect, and approximately half relates to household dysfunction (Nguyen et al., 2019).

Research studies have consistently found that ACEs are associated with increased risks of many adverse health outcomes in adults. A systematic review of 199 papers, published from 1990 to 2014 conducted by Li et al. (2016), estimated the pooled odds ratio of 2.03 to 2.70, 95% CIs [1.37, 3.01] and [2.10, 3.47] between any type of abuse/neglect endured during childhood and depression/anxiety disorder in adults. In one study, having four or more ACEs was associated with a 2 to 5-fold increased risk of experiencing an adverse physical or psychological effect in adulthood (Madigan et al., 2017). Overall, ACEs were frequently reported on a wide array of adversities such as abuse, neglect, household dysfunction, and socioeconomic factors.

Physical, Sexual, and Emotional Abuse

Abuse can occur in various forms and a wide range of family dynamics. Abuse can involve physical harm or injury (physical abuse), exposure to sexual material or situations (sexual abuse), and harmful verbiage that can severely affect one's mental health or social development (emotional abuse) (HelpGuide, n.d.). Rich-Edwards and colleagues (2011) studied two large cohorts of 2,128 pregnant women in urban and suburban areas in Boston, Massachusetts, and found associations between prenatal depression and either physical abuse (OR = 1.48, 95% CI [1.15, 1.90]) or sexual abuse (OR = 1.68, 95% CI [1.24, 2.28]). Childhood sexual abuse was associated with risks for physical and psychological problems during

pregnancy including a high frequency of hospitalization due to complications of premature contractions, cervical insufficiency, and premature birth (Leeners et al., 2010). Also, findings of a longitudinal study conducted by Choi and colleagues (2017) indicated that childhood emotional abuse was associated with a risk of having prenatal distress and postpartum depression in a prospective cohort of 150 South African women.

Physical and Emotional Neglect

Neglect is a common type of child abuse that is not always easily identified. Parents who physically neglect their child fail to adequately provide basic needs including food, clothing, hygiene, or supervision while those who emotionally neglect their child fail to provide a safe, nurtured, and loving environment (HelpGuide, n.d.). In a large cohort study of the Kaiser Health Plan members in California, Dong et al. (2004) found the prevalence of childhood physical and emotional neglect was 24.7% among adults. In addition to physical, emotional, and sexual abuses, physical and emotional neglect was among common experiences in cohort studies of women with ACEs (Choi et al., 2017; Hughes et al., 2017; Kim et al., 2019; Merrick et al., 2017).

Household Dysfunction

Children living in a dysfunctional household with parental mental illness, substance abuse, incarceration, divorce, or separation experience a high level of ACEs (Felitti et al., 1998). In a longitudinal study of a cohort of 3,389 pregnant Swedish women with ACEs, Angerud and colleagues (2018) found that parental separation, household substance abuse, or household mental illness was among the most prevalent (18.6% to 28.5%), and was associated with a high risk of having prenatal and postnatal depression in these women. There is still a research gap in

examining the association between ACEs-related household dysfunction and adverse pregnancy and birth outcomes.

Socioeconomic and Demographic Factors

Childhood adversities are commonly experienced by people from diverse backgrounds, races, and ethnicities. Previous studies indicated people who have low childhood socioeconomic status (SES) or belong to demographic subgroups were more likely to experience ACEs (Danielson et al., 2018; Kim et al., 2019; Zarse et al., 2019). In a longitudinal study of approximately 1,800 women who lived at or below 200% of the federal poverty line in Wisconsin, U.S., Mersky and Lee (2019) found an association between a high level of ACEs and adverse pregnancy health. The authors concluded that cumulative ACEs scores were associated with a slightly increased odds of pregnancy loss (OR = 1.12, 95% CI [1.08, 1.17]), preterm birth (OR = 1.07, 95% CI [1.01, 1.12]), and low birth weight (OR = 1.08, 95% [1.03, 1.15]) among the low SES women in this population (Mersky & Lee, 2019).

In a cohort study of Mother-Baby Minnesota, 79% of 133 pregnant women who self-identified as Black reported four-fold higher odds of having physical abuse, five-fold higher odds of experiencing childhood sexual abuse, and seven-fold higher odds of witnessing domestic violence as a child, compared to White and other ethnic groups (Kim et al., 2019). Gillespie and colleagues (2017) supported a well-established discrepancy in preterm birth rates between different racial groups, with approximately 1 in 11 White women having a preterm birth compared to 1 in 7.5 non-Hispanic African American women. When further queried, they found that childhood stresses (abuse, neglect, household dysfunction, serious childhood illness, and adverse environmental experience) were associated with birth timing in the sample, and elevated levels of cortisol mediated the association (Gillespie et al., 2017). Additionally, in a nearly four-

year prospective cohort study on 9470 women with singleton gestations from eight clinics across the U.S., Grobman and colleagues (2017) found that non-Hispanic Black women, compared to non-Hispanic White counterparts, experienced an association between ACEs and a significantly higher risk for hypertension-related pregnancy, preterm birth, and delivering a small-for-gestational-age infant (Grobman et al., 2017). These findings indicate SES and race/ethnicity are among important factors for consideration in ACEs research and health-related policy-making (Walsh et al., 2019).

Genetic and Biological Factors of Childhood Experiences

Researchers have examined the enduring effects of ACEs on psychological and physiological functions and the impact of ACEs across the lifespan of individuals (Buss et al., 2017; Cameranesi et al., 2019; Teicher et al., 2016; Wong et al., 2018). The pathways on which ACEs modulate can be viewed through the dynamic effects of genetics, the architecture and function of the brain, the neuroendocrine responses, the metabolism regulation, and the inflammatory and autoimmune functioning in the body (Buss et al., 2017; Dieckmann et al., 2020; Luiz et al., 2018; Monk et al., 2016; Rubinstein et al., 2020; Teicher et al., 2016).

Epigenetic Effect

A growing body of epigenetic research indicates many genetic variants are likely to be susceptible to methylation of the deoxyribonucleic acid (DNA) with trauma exposures. ACEs may impair the early psychosocial environment during sensitive periods of development through epigenetic signatures (Argentieri et al., 2017; Blacker et al., 2019; Bush et al., 2018; Brodsky et al., 2018; Cao-Lei et al., 2016; Frach et al., 2020; Gouin et al., 2017; Kaufman et al., 2018; Kertes et al., 2016; Monk et al., 2016). Methylation of the cytosine nucleotide alters gene-expression regulations without changes to the DNA sequence for many genes involved in the

stress response pathways (Cao-Lei et al., 2016). It was also reported that elevated global placental DNA methylation was associated with large births for gestational age (Dwi Putra et al., 2020), and childhood physical abuse correlated with modestly increased DNA methylation of placental genes FKBP5, one of the glucocorticoid-related genes associated with fetal movement and heart rate (De Castro-Catala et al., 2017). However, limited research studies have focused on the intergenerational effects of ACEs propagated through an epigenetic modification that affects pregnancy health risks and birth outcomes.

Neurobiological and Metabolic Functioning

There is evidence that ACEs affect adverse health outcomes through neurological and metabolic pathways in humans. Buss and colleagues (2017) articulated that childhood trauma and ACEs may cause enduring neurobiological damages that irreversibly change the trajectories of the brain's function and development. Alterations in the brain can elevate a biological stress response, interfere with the autoimmune system, and disrupt metabolic regulations leading to psychological and physiological effects (Buss et al., 2017; Teicher et al., 2016). Additionally, autonomic responses, pain, and mood are significantly associated with increased ACEs scores among affected individuals, particularly back pain, migraines for adults, and post-traumatic stress disorder (PTSD) in adult women (Zarse et al., 2019).

Inflammatory and Autoimmune Functioning

Research results indicated ACEs affect health outcomes in children and adults through interconnected inflammatory and autoimmune functions. Hantsoo et al. (2019) also found that high levels of ACEs were associated with alterations in the composition of the gut microbiota and these changes elevated stress responses through the acute inflammatory and immune pathways. Other research studies suggested ACEs increased disruption to the adaptive stress

response leading to susceptibility of diseases such as rheumatoid arthritis (RA) and systemic lupus erythematosus (SLE) regardless of age and SES (Luiz et al., 2018; Rubinstein et al., 2020). Further, Bandoli and Chambers (2017) found an increased risk of preterm birth among women with RA (risk ration [RR] = 2.10, 95% CI [1.54, 2.87]) and Crohn's disease (RR = 1.87, 95% CI [1.25, 2.81]) in a cohort study of 3034 pregnant women. Later, the authors found RA, SLE, and inflammatory bowel disease (IBD) associated with preterm birth and small for gestational age (SGA) in a birth cohort of 2,963,888 Californian women (Bandoli et al., 2020). However, to our knowledge, no one has assessed whether there is a differential effect of chronic conditions and adverse pregnancy outcomes by ACEs exposure.

Health Behaviors Associated with Adverse Childhood Experiences

Smoking

Tobacco use including smoking, heavy smoking, and early smoking initiation has a strong relationship with ACEs (Anda et al., 1999; Bellis et al., 2014). Compared to individuals without ACEs, those with ACEs score of four or higher had an adjusted odds ratio of 3.96, 95% CI [2.74-5.73] for smoking (Bellis et al., 2014). A respective cohort study by Anda et al. (1999) surveying 9,215 adults in a primary care setting in Southwestern U.S. indicated that individuals with ACEs score of five or higher were associated with a substantially high odds of 5.4, 95% CI [4.1, 7.1] for early smoking initiation before age of 14 years, and the OR = 2.8, 95% CI [1.9, 4.2] for heavy smoking with 20 cigarettes per day. Furthermore, Pear and colleagues (2017) found in a U.S. National Longitudinal study of 2,999 mothers from diverse races and ethnicities that ACEs were significantly associated with increased risks of prenatal smoking in household alcoholism (RR = 1.25, 95% CI [1.13, 1.38]).

Drinking

Maternal ACEs were also associated with alcohol use and increases fetus health risk (Currie et al., 2020). In a prospective cohort study of 1,663 pregnant women in a Canadian community, Currie and colleagues (2020) found that maternal ACEs accounted for two to three-fold increased odds of binge drinking of five or more drinks among middle and upper-middle-income women. The authors found maternal ACEs accounted for a two to three-fold increase in the odds of binge drinking that may put the infant at a high risk of being born with fetal alcohol spectrum disorders (Currie et al., 2020). The likelihood of binge drinking is highest among first-time expectant mothers who lack social support. Alcohol use by pregnant women was also strongly linked with delivering small babies-for-gestational-age, even among infants who had not met full criteria for fetal alcohol spectrum disorders (Myers et al., 2018).

Drug Use

Illicit drug use and adverse drug-related health problems associated with ACEs have been examined in research. Currie and Tough (2020) indicated a greater level of illicit drug use was reported by pregnant women with higher ACEs scores compared to those with less illicit drug use. In a secondary analysis of prospective cohort data from a three-year study of 1,680 pregnant women in Canada, Currie and Tough (2020) found that women with two to three ACEs had more than a two-fold increase in illicit drug use, while those with four or higher ACEs had an approximately four-fold increase in illicit drug use during pregnancy. The authors articulated that exposures to childhood abuses were more consistently associated with illicit drug use than exposures to household dysfunction among the women in this sample (Currie & Tough., 2020). Although researchers have studied antidepressant use during pregnancy (Campagne, 2019;

Currie & Tough, 2020), little is known about the prevalence of antidepressant use among pregnant women affected by ACEs.

Sexual Risk

Previous studies indicated that ACEs were associated with sexual risk behaviors and increased odds of reproductive health problems. In a three-year study of a cohort of 5,060 women in the Southwestern U.S., Hillis and colleagues (2001) found risks of engaging in sexual activity before the age of 15 years were associated with a high ACEs score in abuses (OR = 2.8, 95% CI [2.1, 4.0]) and household dysfunction (OR = 2.5, 95% CI [1.8, 3.6]). Risky sexual behaviors including early sexual activity and engaging in unprotected sex were elevated in individuals who had high ACE scores and strongly connected to unplanned pregnancy among adolescents (Bellis et al., 2014). Consistently, in a cross-sectional study of 1,500 British adults from a diverse population, Bellis et al. (2014) found that women with ACE scores of four or higher were at higher risk (OR = 4.46, 95% CI [2.73, 7.30]) for unplanned pregnancy before 18 years of age compared to those with ACE scores of three or lower.

Summary

The neuroendocrine and autonomic effects caused by ACEs tend to be impactful during the sensitive period of childhood development. The effects are strongly connected to a wide array of adverse health behaviors through adulthood including smoking, binge drinking, sexual risk-taking, and illicit drug abuse (Currie et al., 2020; Hillis et al., 2001; Hughes et al., 2017; Mersky et al., 2018; Pear et al., 2017; Petruccelli et al., 2019; Strathearn et al., 2019). The health risk behavior of women suffering from ACEs is important in the study of the effects of ACEs on adverse pregnancy and birth outcomes.

Effects of Positive Childhood Experiences

Supportive Environment

Research studies showed PCEs provided a protective buffer against the deleterious effects of ACEs (Bethell et al., 2019; Beutel et al., 2017; Jaffee et al., 2017). Individuals with four or more ACEs, who were nurtured in a safe, secure, and engaging environment reported relatively lower odds of developing depression or poor mental health (Bethell et al., 2019, Beutel et al., 2017; Crouch et al., 2019). In a cohort study of 101 low-income pregnant U.S. women from various racial/ethnic groups, Narayan and colleagues (2017) found high levels of PCEs related to receiving basic needs and feeling safe and belonging were associated with lower prenatal stress and psychopathology. Furthermore, Merrick et al. (2020) studied another cohort of 101 low-income, pregnant women, using ACE and PCE surveys and reported that benevolent experiences in early childhood tend to have a stronger effect against the impact of ACEs on psychopathological health compared to those occurring in later childhood. Further studies are in need to examine the effective and sufficient support provided to women with ACEs at critical timing in life (Malat et al., 2017).

Resilience

Several researchers showed that resilience can be a positive factor that buffers the adverse impact of ACEs on affected individuals (Bellis, et al., 2018; Beutel et al., 2017; Howell et al., 2020; Young-Wolff et al., 2019; Youssef et al., 2017). While women with low social support or coping abilities tend to be negatively affected by ACEs, resilient individuals are more likely to overcome adverse behaviors and improve ailments from undiagnosed somatoform symptoms (Howell et al., 2020; Young-Wolff et al., 2019). Youssef and colleagues (2017) examined the dose-response relationship between ACEs, depressive symptoms, and resilience and found young adults with medium and high levels of resilience had experienced less

depressive symptoms associated with ACEs. In a cross-sectional study of a cohort of 101 low-income women at 3 to 39-weeks of pregnancy who participated in the Women, Infant, and Children (WIC) program in the Midwestern U.S., Howell and colleagues (2020) found cumulative ACEs were associated with depression and inversely associated with resilience in these women. These findings encourage further research to effectively improve resilience in people who suffer from severe ACEs (Howell et al., 2020; Youssef et al., 2017).

Summary

A growing body of research has conveyed a positive impact of PCEs on protecting individuals against the adverse effects of ACEs. Living in a supportive environment or experiencing social supportive relationships may reduce stress responses, facilitate the adaptation to childhood trauma experiences, and improve maternal health and birth outcomes among ACEs-affected women. However, there is little evidence as to what extent the association between ACEs and adverse pregnancy outcomes among pregnant women is modified by PCEs.

Health Effects Associated with Adverse Childhood Experiences

Pregnancy Health

As briefly mentioned in previous sections, research studies have proliferated in examining the adverse impact of ACEs on pregnancy outcomes. Gestational diabetes and excessive gestational weight gain are among pregnancy-related complications frequently reported in women with ACEs (Campbell et al., 2018; Center for Child Counseling.,2020; Diesel et al., 2014; Hollingsworth et al., 2012; Huffhines et al., 2016; Mason et al., 2016; Ranchod et al., 2016; Schoenaker et al., 2019).

Unhealthy Gestational Weight Gain. Ranchod and colleagues (2016) found an association between ACEs and the risk of unhealthy gestational weight gain in the data analysis

of 2,873 women participating in the National Longitudinal Survey of Youth from 1979 to 2012. The authors found physical abuse was associated with a 20% increased risk (RR = 1.2, 95% CI [1.1, 1.4]) of excessive gestational weight gain; while household dysfunction such as mental illness and alcoholism was associate with a 30% (RR = 1.3, 95% CI [1.0, 1.7]) and 60% (RR = 1.6, 95% CI [1.1, 2.2]) increased risk of prenatal obesity (Ranchod et al., 2016). Notably, Diesel et al. (2014) found no association between ACEs score and maternal excessive weight gain in a retrospective cohort study of 472 low-income pregnant women, aged 23 years, from a prenatal clinic in Northeastern U. S.

Gestational Diabetes. In a longitudinal cohort study of 45,550 registered nurses from 14 states in the U.S., Mason et al. (2016) indicated that sexual and physical abuse was associated with 30% to 42%, 95% CIs [1.14, 1.49] and [1.21, 1.66] greater risk of GD. Additionally, cumulative exposure to both severe sexual and physical abuse in childhood was associated with an increased risk of GD compared to a single abuse (Mason et al., 2016). However, Mason and colleagues (2016) found no association between these abuses and prenatal obesity among these women. Consistently, in another longitudinal population-based cohort study of 6,317 Australian women, aged 18 to 23 years, Schoenaker et al. (2019) showed an association between abuse and household dysfunction and gestational diabetes mellitus. The relative risk of having GD was 1.73 to 1.76, 95% CIs [1.02, 3.01] and [1.04, 2.99] among the women with ACEs scores of three or higher (Schoenaker et al., 2019). Finally, Madigan and colleagues (2017) indicated that a cumulative ACEs score of four or higher was associated with two folds increased risk of having prenatal diabetes among a cohort of 501 urban women.

Birth Outcomes

In addition to the description in previous sections about the intergenerational effects of ACEs, a growing body of research has focused on the adverse impact of ACEs on childbirth outcomes. Poor birth outcomes including preterm birth and low birth weight are frequently reported among pregnant women with a high level of ACEs (Appleton et al., 2019; Gillespie et al., 2017; Nerasi et al., 2018; Olsen, 2018; Selk et al., 2016; Smith et al., 2016).

Preterm Birth. Sexual abuse was associated with increased odds (OR = 1.22, 95% CI [1.10, 1.35]) for preterm birth in a large cohort of 51,434 pregnant women (Selk et al., 2016). Margerison-Zilko et al. (2016) found childhood sexual abuse and violence experiences were associated with preterm delivery at 35-36 weeks of pregnancy in another cohort study of 3,019 mothers with singletons at 52 clinics in the Midwestern U.S. Gillespie et al. (2017) also found physical and emotional abuses or household dysfunction (interpersonal loss) were inversely associated with gestational age at birth in a cohort of 89 pregnant African American women at two Ohio, U.S. hospitals.

Additionally, a study that examined 75 cases of mothers with singleton and 148 controls in Edmonton, Canada indicated that exposure to two or more ACEs was associated with a two-fold higher risk of preterm birth (Christiaens et al., 2015). Also, Madigan and colleagues (2017) found a two-fold increased risk of preterm birth among a cohort study of hundreds of women with a cumulative ACEs score of four or higher. Further, in a study of a larger cohort of 2,303 women with a singleton pregnancy, Smith and colleagues (2016) estimated that each additional ACEs score was associated with a decrease of 0.06 weeks of gestational age among pregnant women from clinics in Northeastern U.S.

Moreover, researchers identified multiple pathways interconnected in the associations between ACEs and adverse pregnancy outcomes (Bublitz et al., 2017; McDonnell et al., 2016; Salah et al., 2019). A connection was demonstrated by McDonnell et al. (2016) from the WIC cohort study of 398 pregnant women aged 16 to 46 years in the Midwestern U.S. The authors indicated that childhood household dysfunction was significantly negatively associated with gestational age at first pregnancy, while gestational age was positively associated with infant birth weight (McDonnell et al., 2016). Furthermore, Salah et al. (2019), from a one-year cohort study of 593 pregnant women in Tunisia, found that collective childhood exposures to violence were associated with the risk of preterm birth as well as low birth weight among these women. Finally, the plausible mechanism explaining the link between GD and the risk of preterm birth through elevated interleukin-15 was suggested by Bublitz et al. (2017).

Birth Weight. Appleton et al. (2019) found that maternal ACEs with sexual abuse, emotional abuse, and household dysfunction also significantly and inversely correlated with the infant birth weight of 100 female New Yorkers. Consistently, Madigan et al. (2017) indicated a cumulative ACE score of four or higher was associated with a two-fold increased risk of low birth weight in a cohort study of 501 mother-infant dyads. In a larger cohort study of more than 2,000 women at many clinics in the Northeastern U.S., Smith and colleagues (2016) found that each additional ACE score in pregnant women was associated with a decrease of 16.33 grams in infant's birth weight.

Additionally, research studies sought to understand the interaction effects of ACEs and PCEs on birth outcomes. Appleton and colleagues (2019), in a prospective birth cohort study of 126 mothers at around 27-week gestation at the Albany Medical center in New York, U.S., examined the main and interaction effects between ACE categories (i.e., sexual abuse, emotional

abuse, and parental divorce/separation) and social support concerning infant cephalization. Infant cephalization is defined as the ratio between the head circumference of an infant at birth and the birth weight as well as the infant's birth size at delivery. According to Appleton et al. (2019), positive social support can be tangible support (e.g., financial or transportation help), belonging support (e.g., social activities or emotional expression), or appraisal support (e.g., advice and information). The authors found that maternal ACEs can deleteriously increase infant cephalization index; however, social support (tangible and belonging) during pregnancy may provide a protective buffer against its enduring effects (Appleton et al., 2019; Holdsworth & Appleton, 2019).

Summary

Childhood trauma and ACEs have a lasting effect on the health and well-being of the individual; moreover, the impact of ACEs may pass on to the next generation through adverse pregnancy and poor childbirth outcomes. Adverse conditions in pregnancy, such as GD and UWG can contribute to poor birth outcomes including preterm birth, low birth weight, and SGA. Nevertheless, childhood positive experiences and social support may provide some protective buffer promoting a trauma adaptation to improve maternal health outcomes. However, there remains a research gap to examine whether ACE subtypes differently associate with adverse pregnancy and birth outcomes, or whether a cumulative ACE score better predicts the adverse pregnancy and birth outcomes of childhood exposures.

Instruments for Childhood Experiences Study

The Positive and Adverse Childhood Experience questionnaire (PACE-Q) is the instrument used to collect PACE data from the MotherToBaby participants. PACE combines the Positive Childhood Experience questionnaire (PCEs-Q) and the Adverse Childhood Experience

questionnaire (ACEs-Q) in one measure to collect information about participants' childhood experiences.

The Positive Childhood Experiences Questionnaire

The PCEs-Q, a 7-item assessment tool, is used to capture the positive experiences that a person feels when supported by family and society (Bethell et al., 2019). PCEs-Q adapts questions from validated subscales including the Child and Youth Resilience Measure-28, the Psychological Caregiving subscale, the Education subscale, the Culture subscale, and the Peer Support subscale (Bethell et al., 2019; Liebenberg et al., 2013). In the cross-sectional cohort study of 6,188 Wisconsin, non-institutionalized adults in 2015 using PCE-Q, Bethell and colleagues (2019) found PCEs-Q having reliable consistency, Cronbach's alpha of .77, and an adequate convergent and divergent validity when using individual and cumulative scores (with a single Eigenvalue of 2.95 and factor loading across seven items ranges from 0.57 to 0.72). The authors suggested PCEs-Q can be used to assess the positive childhood experiences in individuals associated with resilience and cultural sensitivity (Bethell et al., 2019). The questionnaire records the degree and frequency a child felt able to talk to family about feelings, felt family support during a difficult time, enjoyed joining community events, felt belong to the school, and felt safe and protected at home (Bethell et al., 2019). Researchers have increasingly utilized PCEs-Q together with ACEs-Q in studies to examine the modifying effects of PCEs that may protect against the deleterious impact of ACEs on affected individuals (Appleton et al., 2019; Bethell et al., 2019; Jaffee et al., 2017).

The Adverse Childhood Experience Questionnaire

Based on published surveys, the ACEs questionnaire (ACEs-Q) has adapted into the current universally used survey to advance the clinical implication of ACEs in public health

promotion (Behell, 2017; Mersky et al., 2017; Zarse et al., 2019). The questionnaires consist of three parts: core questions, optional modules, and state-added questions (Behell, 2019). The ACEs-Q has 11 items assessing the collective information, in cumulative score 0, 1, 2-3, or 4-8 ACEs, of childhood exposures including physical, sexual, emotional abuse, and household dysfunctions such as mental illness, domestic violence, substance abuse, and parental incarceration, divorce, or separation (Behell, 2019). After two decades of using ACEs-Q for studies on large, diverse population samplings across the U.S. and around the world, it has demonstrated high internal consistency (Cronbach's alpha = .77 to .81), test-retest reliability of r = .90 to .91, and strong convergent validity, r = .73, when compared to the validated Childhood Trauma Questionnaire (Mersky et al., 2017; Schmidt et al., 2020). ACEs-Q has been a simple and quick tool for use to quantify the types and the convergence of individual adverse exposures (Mersky et al., 2017; Zarse et al., 2019). Although limited in the assessment of the duration, severity, and timing of personal ACEs in affected individuals, the ACEs-Q has been widely used as the core-risk assessment of ACEs-related mental health, health behaviors, medical illness, and premature death in children and adults worldwide (Zarse et al., 2019).

Summary

ACEs pose long-lasting effects on psychological, biological, and physiological health, along with adverse health behaviors for individuals. However, the negative effect of ACEs is beyond the lifespan of individuals. ACEs have the potential to affect intergenerational health through adverse pregnancy and poor childbirth, from the women's mental and gestational health to birth outcomes. The impact of ACEs on pregnancy and birth outcomes may be associated with multiple complex factors, individually and cumulatively, from genetics, environmental factors, demographic characteristics, health behavior, medical condition, and SES of pregnant women.

Early detection of ACEs before and during pregnancy may provide opportunities for mitigation, whereby successful intervention could reduce the medical cost due to complications, improve maternal health, and childbirth outcomes thus provide a better beginning for the health and development of the infants (Narayan et al., 2018).

Method

Study Design

The current study analyzed data that were collected as part of the MTB-PACE study. MTB-PACE study is an addendum of the MTB Pregnancy Studies which is a research program under the largest conductor of pregnancy registries in North America focusing on factors that may affect pregnancy (MotherToBaby, 2021). Mothers-to-be enroll in one of the MTB-Pregnancy Studies via the program website after which data are collected through telephone interviews and medical records of participants. After delivering a baby, the mothers are invited to participate in the MTB-PACE study in which data are collected through a web-based survey. The purpose of the current study was to examine the prevalence of childhood experiences (ACEs and PCEs), the associations between ACEs/ PCEs and pregnancy and birth outcomes, and the potential effect modification of PCEs on pregnancy health and birth outcomes among a sample of MTB-PACE participants who completed the PACE addendum between September 1, 2020 to February 15, 2021.

Participants

Pregnant women who enrolled in the MTB Pregnancy Studies and delivered a live born singleton infant between 2015 and 2021were offered participation in the MTB-PACE study. For the MTB Pregnancy Studies, the population of interest was expecting women 18 years or older who lived in the U.S. and Canada. For the MTB-PACE addendum study, participants were MTB

women who had delivered a live birth within the past five years, who signed informed consent and completed the PACE survey. Women who did not provide informed consent, who consented but did not complete the PACE questionnaire, or who had multiplex infants were excluded from the current study's data analyses.

A minimum study sample size was estimated using G* Power, version 3.1.9.7 (Faul et al., 2007). The data were extracted from literature including studies by Mason et al. (2016), Selk et al. (2016), and Ranchod et al. (2016). Using *z* tests, logistic regressions with a priori alpha level of .05, and a power level of .80, an estimated sample for each pregnancy/birth outcome and ACE type were calculated, ranging from 74 to 354. Based on the expected prevalence of particular outcomes, the appropriate number of participants enrolled in the study was recommended for the data analysis to be sufficiently powered (Appendix C, Table 8).

Procedures

The MTB Pregnancy Studies and MTB-PACE study met the requirements defined by federal regulation of human subject research (National Institute of Health, n.d.). The MTB-Pregnancy Studies received approval from the Institutional Review Board (IRB), the MTB-PACE study was approved by the IRB as the addendum of MTB Pregnancy Studies, and the current study was exempt from IRB human research (Appendix D). Informed consent documents were prepared in various languages for both verbal and written formats: oral consent was employed in MTB Pregnancy Studies for phone interviews and signature consent was included in the data collection surveys of the MTB-PACE study.

Data Collection and Management

The current study was affiliated with a research facility within the MotherToBaby network located in Southwestern U. S., the Center for Better Beginnings at the University of

California at San Diego, California (UCSD Health). Data on participants' demographics, characteristics, health conditions, and selected pregnancy and birth outcomes were retrieved from the MTB-Pregnancy Studies. Self-reported data and health records of the MTB-Pregnancy Studies participants were collected prenatally, while data related to birth outcomes were collected following delivery, and ACEs and PCEs data were collected post-delivery for the MTB-PACE addendum study using PACE-Q.

Study participants' demographics, health information, and PACEs responses were confidentially managed using a secure, online, and password-protected data collection portal of MTB database and only accessible to authorized personnel approved by IRB and MTB Research. Collected data were assigned unique, independently de-identified codes. Missing, unclear, or incomplete responses alerted researchers to contact responders for confirmation using the secured link between de-identified data and contact information. For the current study, a web-data dictionary workbook describing MTB Pregnancy Studies and MTB-PACE study (with links to projects, worksheets, tables, codes, measure units, variables) and limited-use, de-identified datasets in Excel files were provided by the UCSD Health research management. The data strictly complied with the UCSD Health retention policy and participants' consent upon completion of the research study.

Study Data

Data collected on maternal demographics and characteristics of MTB-Pregnancy Studies participants included age (younger than 30, 30-35, 36-40, and older than 40 years), race (White, Black, Asian, Indian/Native American, and Other), ethnicity (Hispanic / Latina, NonHispanic / NonLatina), education (high school or less, college, and above college degree), SES (low and high), and location (provinces in Canada and states in the U.S., from Midwest, Northeast,

Southeast, Southwest, and West U. S.). Data collected on health conditions of MTB-Pregnancy Studies participants included preexisting diabetes type I or II (yes, no), hypertension (yes, no), asthma (yes, no), rheumatoid arthritis (RA) (yes, no), systemic lupus erythematosus (SLE) (yes, no), and inflammatory bowel disease (IBD) such as Crohn's disease and ulcerative colitis (yes, no). Additionally, MTB-Pregnancy Studies data collection included participants' health information such as prenatal body mass index (BMI) in kg/m^2 and categorized as weight status (underweight/normal weight, overweight, and obese), passive and active smoking (yes, no), recreational drug use (yes, no), alcohol use (yes, no), and anxiety/depression (yes, no). Collected pregnancy and birth outcomes data from the MTB-Pregnancy Studies included unhealthy gestational weight gain (yes, no), GD (yes, no), preterm birth babies born before 37 weeks of gestation (yes, no), and birth weight for gestational age in percentile including SGA (yes, no), and LGA (yes, no). Finally, collected data on ACEs and PCEs of the MTB-PACE participants consisted of responses to questions in the PACE survey.

Operational Variables

The operational variables in the current study comprised both the independent variable (ACEs and PCEs) and dependent variables (adverse pregnancy and birth outcomes). The current study examined the psychological and physiological trauma which MTB-PACE participants experienced before the age of 18 years. These experiences included eight categories: physical, sexual, emotional, substance abuse, domestic violence, mental illness, incarceration, and parental divorce or separation (Felitti et al., 1998; Hughes et al., 2017). The SES of participants was determined based on the Hollingshead four-factor index including four domains of marital, employment, educational, and occupational status (Hollingshead, 1975). Participants with a total score of 3 or less for four domains were considered to have high SES, while those with a score

higher than 3 were of low SES (Appendix D). Prenatal BMI, calculated by the ratio of weight in kg and height in meter square, was categorized by underweight/ normal weight, overweight, and obese. According to CDC (2019b), depending on their pre-pregnancy BMI, women in a particular weight category should gain a specific amount of weight for a singleton or multiplex pregnancy to be considered having a healthy gestational weight gain. UWG was identified as "yes" if maternal weight gain was out of the range or "no" if it was within the range recommended by CDC guidelines (CDC, 2019b). Preterm birth was defined as gestational age less than 37 weeks at delivery. Based on CDC growth curves of boy and girl infants delivered by study participants (CDC, 2009), SGA is the birth weight of the baby for gestational age < 10th percentile while LGA is the infant's birth weight > 90th percentile for gestational age.

Instruments for MTB-PACE Study

The PACE-Q was used to collect data for the MTB-PACE study. PACE-Q combined the 7-item Positive Childhood Experience Questionnaire (PCEs-Q) and the 11-item Adverse Childhood Experience Questionnaire (ACEs-Q) in one measure to collect information about participants' childhood experiences (Bethell et al., 2017; Bethell et al., 2019; CDC, 2020b). ACEs-Q and PCEs-Q have been widely used by researchers across the U.S. to study childhood exposures (Bethell et al., 2017; Bethell et al., 2019; CDC, 2020b; Liebenberg et al., 2013; Mersky et al., 2017).

Assessment of Positive Childhood Experiences

The childhood experiences that a person felt supported by family and society were assessed by the PCEs-Q (Bethell et al., 2019). PCEs-Q measures positive childhood experiences in individuals associated with resilience and cultural sensitivity (Bethell et al., 2019). The questionnaires assessed the degree and frequency of positive experiences through a 5- point

Likert scale including “never”; “rarely”; “sometimes”; “often”; or “very often” that an individual felt able to talk to family about feelings, felt family support during a difficult time, enjoy joining community traditions, felt belong to the school, and obtained genuine interest from at least two adults other than parents. The PCEs-Q also assessed the likelihood as “never”; “a little of the time”; “some of the time”; “most of the time”; or “all of the time” that an individual felt safe and protected at home. The PCEs-Q score ranged from 0-7 in which the answers “never”, “rarely”, “sometimes”, “a little of the time”, or “some of the time” to an item gave a PCEs score of 0 while the answers of “often”, “very often”, or “all of the time” gave a PCEs score of 1 to the item (Bethell et al., 2019). The response “preferred not to answer” was considered a missing value in PCEs-Q data. Finally, responses to PCEs-Q were summarized by the number of PCEs (0-2, 3-4, 5, 6-7), and PCEs variables in the stratification analysis were categorized by high (≥ 5) versus low (≤ 4) cumulative PCEs scores.

Assessment of Adverse Childhood Experience

The ACEs-Q is a measure widely used across the U.S to assess the collective information of childhood exposures prior to age 18 years. ACEs-Q has 8 subtypes including physical abuse, sexual abuse, emotional abuse, and household dysfunction (substance abuse, incarceration, mental illness, violence, divorce or separation) (Behell, 2017; CDC, 2020b; Mersky et al., 2017). ACEs-Q is a simple tool with a “yes” or “no” response to identifying individual adverse exposures such as living with a depressed, mentally ill, suicidal, alcoholic, or incarcerated household member. ACEs-Q also queries whether or not an individual has experienced parental divorce or separation. The questionnaires assess the level and frequency of physical abuse or emotional abuse as “never”; “once”, or “more than once” that an individual got a slap, hit, kick, beat, or physically hurt; swear, insult, or emotionally put down by a parent or adult. The same 3-

point Likert scale was used to assess sexual abuse experiences as to how often an individual was sexually touched, forced to touch, or have sex with anyone at least 5 years older (Behell, 2017; CDC, 2020b). ACEs-Q total score ranged from 0-8 in which the answers "no" and "never" had an ACEs score of 0 while the responses "yes", "once", and "more than once" had an ACEs score of 1 to the item (Bethell et al., 2017). The summation of items 2 and 3 had a score of 0 with the answer "no" and a score of 1 with the answer "yes" to alcoholism, illegal street drug, or abused prescription medications. Additionally, the score of the sexual abuse subtype was 0 with negative responses ("no" or "never") to all items 9-11 in the ACEs-Q, or else, it had a score of 1. Finally, the response "preferred not to answer" was considered a missing value in the subsequent data analyses. Finally, responses to ACEs-Q were categorized by the number of ACEs as 0-1, 2, 3, and 4-8, and ACEs variables in the association analyses were total ACEs score (0-8) (Bethell et al., 2019; CDC, 2019), or cumulative ACEs scores of 3 or higher with ACEs scores of 2 or less as a reference (Schoenaker et al., 2019).

Data Analysis

IBM SPSS Statistics for Window, Version 27.0 (IBM Corp., Armonk, NY) was used to statistically analyze data for research questions 1, 2, and 3 following methods described by Field (2018). All tests were two-tailed and an alpha level less than .05 was considered statistically significant.

Research Question 1

What is the prevalence of childhood experiences (ACEs and PCEs) self-reported by pregnant women who participated in the MTB-PACE study?

For research question 1, descriptive statistics were used to describe the demographics, characteristics, health conditions, health information, and the prevalence of ACEs and PCEs

among MTB-PACE participants. The demographic data categorized age, race/ethnicity, education, and SES. Health conditions and health information included prenatal BMI, preexisting diabetes, depression and anxiety, smoking, alcohol, and recreational drug use. Other chronic health conditions included asthma, RA, SLE, and IBD such as Crohn's disease and ulcerative colitis. These data were summarized in numbers and percentages for categories of ACEs and PCEs in a characterization table. Additionally, factor analysis and Monte Carlo parallel verification were employed to analyze the 11-item ACE questionnaires. Three ACEs subtypes with the highest correlation between ACEs items, Scree plot, Eigenvalues, and rotation matrix were categorized using the Generalized Least Squares extraction and Quartimax with Kaiser Normalization.

Research Question 2

> What are the associations between ACEs scores, individually and cumulatively, and adverse pregnancy (i.e., UWG and GD), and birth outcomes (i.e., preterm birth, SGA, and LGA) in the MTB-PACE participants?

For research question 2, multivariate logistic regression analyses examined the associations of the predictor variable (i.e., subtype and total ACEs score) on adverse pregnancy (i.e., the presence/absence of UWG or GD), and birth outcomes (i.e., the presence/absence of preterm birth, SGA, or LGA) among women who participated in MTB-PACE study. Regression models used total ACEs score (i.e., the cumulative scores of 8 ACEs types in the 11-item ACEs-Q), dichotomized ACEs score ≥ 3, and ACEs subtype score (i.e., the dichotomized ACEs score, 1 for presence and 0 for absence, in each subtype categorized in the factor analysis results). Finally, the response "preferred not to answer" was considered a missing value and was replaced using imputation program in IBM SPSS Statistics for Windows, Version 27.0.

The goodness of fit of the logistic regression models was examined through the Hosmer and Lemeshow test and the relationships between predictor and independent variables were identified and interpreted. Odd ratios and 95% confidence intervals were calculated, with a two-tail alpha at a significance level of .05 for participants with and without exposure to the particular ACE type(s), using the chi-square test (Field, 2018; Tabachnick & Fidell, 2019). The association models were adjusted for potential confounding effects such as maternal age, race/ethnicity, education, and SES of participants (Field, 2018; Tabachnick & Fidell, 2019).

Research Question 3

Do PCEs modify the associations between ACEs scores and adverse pregnancy (i.e., UWG and GD) or birth outcomes (i.e., preterm birth, SGA, and LGA)?

For research question 3, multivariate regression analyses described in the analysis of research question 2 were used to examine the potential effect modification of PCEs. The effect modification analysis of PCEs scores was evaluated by visual inspection of the estimated effects at 95% CI within two strata of participants with low versus high total PCEs scores. The PCEs strata included women with low PCEs scores of 4 and lower and those with high PCEs scores of 5 or higher, while the ACEs strata were participants with ACEs scores of 3 or higher in which ACEs scores of 2 or lower were categorized as a reference.

Results

Characteristics of the MTB-PACE Participants

From September 2020 to February 2021, a total of 595 women 18 years or older, who delivered a baby between 2015 and 2021 identified by the MTB Pregnancy Studies registry, were invited to participate in the MTB-PACE study. Among the 595 women, 39 (6.6%) were excluded from the analysis for the following reasons: 17 (2.9%) declined participation, 7 (1.2%)

had multiple births and 15 (2.5%) did not have complete delivery information. A total of 556 women met the inclusion criteria for the MTB-PACE study and their data were analyzed for the current study (Figure 1).

Demographic Characteristics of MTB-PACE Participants

Table 1 presents the demographics and characteristics of all participants and also by ACE score categories by the number of ACEs (0-1, 2, 3, and 4-8) reported from the PACE-Q. The MTB-PACE participants were predominantly well-educated (with college or above college education), White, non-Hispanic/Latina women between 30 to 35 years of age who lived in the Western U.S. The majority of participants (N = 477, 90.5%) had a high SES as measured by the Hollingshead four-factor index.

Health Conditions and Health Information of the MTB-PACE Participants

Table 2 shows frequency of the health conditions and information of all MTB-PACE participants and by the number of ACEs (0-1, 2, 3, and 4-8). Among 556 participants, 239 (43.0%) of the women had one preexisting health condition and 81 (14.6%) had two preexisting health conditions related to inflammatory/autoimmune diseases ranging from 0.9% for diabetes type I and SLE to 14% for asthma. Prenatal BMI categorized as obese and overweight were commonly reported by 22.5% and 13.3 % of MTB-PACE women. Additionally, 46 (8%) of the participants self-reported having a history of depression and anxiety. Health information related to tobacco use, either passively or actively, recreational drug use, or alcohol intake (4 or more drinks/occasion) were each endorsed by less than 6% of participants. Among the 67% of the MTB-PACE women with UWG, 78.2% had weight gain categorized as excessive, while the remaining women had less than ideal weight gain for their prenatal BMI, according to the recommendation by CDC (2019b). Finally, 5.9% of the women had GD, 8.1% had a preterm

birth, 6.3% delivered an SGA infant, and 6.9% had an LGA infant for gestational age (Table 9, Appendix C).

Research Question 1 Result

Objective 1a: Prevalence of ACEs/PCEs among MTB-PACE Participants

Prevalence of ACEs among MTB-PACE participants is summarized in Table 3. A total of 285 (51.3%) MTB-PACE participants reported more than one adverse childhood experience. The most common experience was emotional abuse which was reported in more than half of the participants, followed by household mental illness which was reported by 37.6% of them. Approximately 25% of women experienced physical or sexual abuse, and 20% of the women experienced parental divorce or separation, alcoholism, or domestic violence. The least commonly reported ACEs were recreational drug use or the incarceration of a household member. When evaluated cumulatively as a count of the 8-ACE sub-domains, about half of the participants reported 0-1 ACEs, 15.5% reported 2 ACEs, 14.7% reported 3 ACEs, and 21.0% reported 4-8 ACEs (Table 5).

Prevalence of PCEs among MTB-PACE participants is characterized in Table 3. More than 90% of the women reported having more than one positive childhood experience. Feeling safe, protected, or supported at home were among the most common experiences endorsed by more than three-fourths of MTB-PACE participants. Also, feeling supported by friends, feeling mentored, enjoying community events were reported by more than 70% of the participants, while only half of the women reported feeling like they belonged at their high school or feeling able to talk to their family. Further characterized cumulative PCEs of all 7 questions, 47.8% of the participants had the highest cumulative PCE scores of 6-7, 13.3% had PCE score of 5, 23.2% had PCE scores of 3-4, and 15.6% had PCE scores of 0-2 (Table 5). Table 5 also shows that women

who reported the highest number of ACEs also were more likely to report the lowest number of PCEs. On the contrary, women who reported the highest number of PCEs also were more likely to report the lowest number of ACEs.

Objective 1b: Factor Analysis of ACEs Questionnaires and Prevalence of ACEs Subtypes

Factor analysis and the Monte Carlo parallel verification suggested that a 3-factor model is suitable for the 11-item ACE questionnaire. Using the Generalized Least Squares extraction, Quartimax with Kaiser Normalization rotation, Eigenvalues were determined from 1.27 to 3.42. The rotated factor matrix and the correlation between ACE items are summarized in Table 4 and Figure 2 with the factor loading of > 0.30 as a threshold evaluation. Three factors were categorized for 11 ACE items. The first factor was Household dysfunction, a 5-item ACEs category that included family member substance abuse, parental divorce or separation, and parental incarceration. The second factor was physical/emotional abuse, which included three ACE items on witnessing or experiencing physical abuse or experiencing emotional abuse. Finally, sexual abuse was the third factor consisting of the remaining 3 ACE items on inappropriate childhood sexual experiences. The correlations between the three factors suggested they were weakly related to one another with coefficients from 0.21 (Sexual abuse and Physical/Emotional abuse) to 0.32 (Household dysfunction and Physical/Emotional abuse), and 0.30 (Household dysfunction and Sexual abuse).

Research Question 2 Result

Objective 2: Associations between ACEs and Pregnancy or Birth Outcomes

Overall, women with ACEs scores of 3 or more had increased odds of having unhealthy pregnancy (UWG and GD) or birth outcomes (LGA) in comparison to those with ACEs score of

0-2; however, only the association between ACEs scores and UWG was statistically significant (Table 6).

Unhealthy Gestational Weight Gain. Among 67% of women in the cohort who had UWG, 78.2% were categorized as excessive according to CDC guidelines for pregnant women. The prevalence of UWG, 61%-80%, monotonically increased with the number of ACEs (Appendix C, Table 9). In multivariable models (Table 7), each additional ACE was associated with a 16% increase in odds of UWG with 95% CI [1.05, 1.29]. Findings were similar when ACEs count was dichotomized into high vs. low ACEs (adjusted OR = 1.68, 95% CI [1.12, 2.51]). When analyzed by ACE subtype, the odds of UWG were elevated for women who endorsed physical/emotional abuse and household dysfunction, although confidence intervals in the latter estimate included the null. Finally, there was no association observed between sexual abuse and UWG.

Gestational Diabetes. Approximately 6% of the women in the cohort were diagnosed with GD. The prevalence of GD was fairly equal in various ACEs counts (4.3% -5.5%) but almost double (9.8%) for women with an ACEs score of 3 (Appendix C, Table 9). No increase in odds associated with household dysfunction or physical/emotional abuse in the study cohort was observed. Although there was some evidence that women with ACE scores of 3 or higher had increased odds of having GD (aOR of 1.36, 95% CI [0.64, 2.88]), compared to those with ACE scores of 0-2, and women who experienced sexual abuse had 40% higher odds for GD (95% CI [0.62, 3.14]); however, the confidence intervals were large and overlapped the null.

Preterm Birth. Among 8.1% of women in the cohort who delivered a preterm baby, the preterm birth prevalence was monotonically elevated with counts of ACEs. The prevalence of preterm birth ranged from 5.8%-9.3% for ACEs scores of 2 or higher, compared to 8.9% for the

reference (Appendix C, Table 9). The odds of preterm birth were elevated among women with household dysfunction (aOR= 1.48, 95% CI [0.78, 2.82]), although again this was not statistically significant. Other ACEs count and ACE subtypes such as physical/emotional abuse or sexual abuse did not show an increased risk for preterm birth.

Birth Weight for Gestational Age. Approximately 6.3% of women in the cohort delivered a small baby for GA, and 6.9% had LGA offspring. The highest prevalence of birth (SGA and LGA) was for women with ACEs score of 4 or higher; however, women with ACEs score of 3 appeared least likely to have SGA (2.4%) while a similar prevalence of LGA observed for ACE scores of 2 or 3 compared to other ACEs (Appendix C, Table 9). The odds of having SGA was slightly increased 18% with 95% CI [0.55, 2.66] for women who experienced sexual abuse, non-statistically significant. However, no association between ACEs count and other ACEs subtypes and SGA was observed. Finally, each additional ACE was associated with a 17% increase in odds of having LGA. The odds ratios for ACEs exposures and LGA ranged from 1.31 to 1.89 for other ACEs count and subtypes but all the confidence intervals were wide and included the null.

Research Question 3 Result

Objective 3: Examination of the Effect Modification of PCEs on ACEs-related Pregnancy and Birth Outcomes

Due to the small number of outcomes in stratified analyses of the specific cohort of women in ACE subtypes, examination of the effect modification for ACEs was analyzed as a cumulative variable as well as dichotomized ACEs of 3 or higher (ACEs 0-2 as reference). The effect modification of ACEs subtype by PCEs level could not be accurately assessed due to the small sample sizes in the stratification. As illustrated in Table 7, there was no evidence of PCEs

modifying the association between ACEs exposure and adverse pregnancy and birth outcomes. Point estimates between the two PCEs strata (PCEs scores ≥ 5 versus ≤ 4) were quite similar, and confidence intervals for the stratum-specific estimates widely overlapped for all of the pregnancy (UWG and GD) and birth outcomes (preterm birth, SGA, and LGA) in the study.

Discussions

The current study examined the characteristics of the MTB-PACE cohort and the prevalence of pregnancy and birth outcomes including UWG, GD, preterm birth, and birth weight for GA. The MTB-PACE participants were predominantly White (86.2%), non-Hispanic (92.3%), had high SES (88.8%), and reported having a college or above college education (87.0%). They had normal gestational age at delivery (M = 39.2 weeks, SD = 0.11) and delivered babies with normal birth weight for gestational age (M = 49.2 percentile, SD = 1.75). More than half of the participants had UWG, while only 8.1% of the women had a preterm birth, 5.8% had GD, 6.3% delivered a SGA infant, and 6.9% delivered a LGA infant.

Previous studies have examined the association between ACEs and adverse pregnancy outcomes (Appleton et al., 2019; Christiaens et al., 2015; Madigan et al., 2017; Margerison-Zilko et al., 2016; Ranchod et al., 2016; Schoenaker et al., 2019; and Selk et al., 2016), although there was heterogeneity in the designs, settings, and prevalence among ACE studies. Our findings of approximately half of participants experiencing no adverse childhood experience was similar to findings reported in previous studies by Ranchod et al. (2016), Schoenaker et al. (2019), and Smith et al. (2016). Over half of the women (51.3%) reported exposure to two or more ACEs. This frequency was primarily driven by emotional abuse, which was endorsed by over half (51.1%) of the respondents.

Factor analysis of 11 ACE items of ACEs-Q suggested that three subtypes household dysfunction, physical/emotional abuse, and sexual abuse best categorized the ACEs data. The orthogonal analysis was consistent with the factor loadings and correlation result found in a previous study of a large number of non-institutionalized adults in five U.S. states conducted by Ford et al. (2014) and later employed in the ACEs-related pregnancy studies of approximately 2,000 Canadian women by Racine et al. (2018). Due to small total counts of outcomes in each ACEs item, the current study examined three subtypes of ACEs and categorizations of exposure with ACEs scores of 3 or higher during subsequent analyses of pregnancy and birth outcomes.

Prevalence of PCEs in the MTB-PACE cohort aligns with a study by Bethell et al. (2019) in which approximately half of the participants had high scores of 6 or 7 on all items of the PCEs-Q. Due to the relatively small sample size within PCEs categorizations of exposure in the current study, the potential effect modifications of ACEs on pregnancy and birth outcomes was examined by two PCEs strata, one with relatively high PCEs scores (i.e., ≥ 5 cumulative scores) compared to those with lower PCEs scores (i.e., 4 or less).

Unhealthy Gestational Weight Gain

According to CDC guidelines of gestational weight gain for pregnant women, 67% of women in the cohort were categorized as having UWG. Among these, 78.2% of women had excessive gestational weight gain while 21.8% of UWG cases had inadequate weight gain during pregnancy. Examination of the association between cumulative total ACEs and ACEs ≥ 3 and pregnancy outcome revealed statistically significantly increased odds (aOR = 1.16, CI [1.05, 1.29], aOR = 1.68, CI [1.12, 2.51]) of having UWG, respectively. When further examined by ACE subtypes, household dysfunction and physical/emotional abuse increased odds (aOR = 1.29, CI [0.90, 1.56] and aOR= 1.79, CI [1.24, 2.59]) for UWG. Ranchod et al. (2016) found that

household alcoholism and physical abuse significantly increased the risk for excessive gestational weight gain; however, the authors examined alcoholism as a specific item in household dysfunction and physical abuse separately from emotional abuse without the inclusion of inadequate gestational weight gain.

The mechanism of UWG is unclear and may be influenced by the participants' characteristics, health conditions, and maternal lifestyle of MTB-PACE participants. Researchers reported the negative impact of ACEs exposures in which chronic stress in childhood may affect the normal function of the hypothalamic-pituitary-adrenal (HPA) axis interfering with individuals' appetite regulation. Eating comfort food or using food as a coping strategy to ease emotional and physical distress is common (Ranchod et al., 2016) while having increased childhood trauma and elevated prenatal anxiety put women at risk for excessive gestational weight gain (Diesel et al., 2014). This may plausibly explain the susceptibility for excessive gestational weight gain with little effect modification of PCEs in the current cohort. This includes the potential effect of health characteristics in which more than one-third of the women entered pregnancy overweight and obese, more than half reported having emotional abuse, and the high prevalence of depression/anxiety among women with low ACEs scores of 0-2 (or high PCEs scores). Although healthy eating may be disrupted by stressful experiences, the mechanism associated between ACEs/PCEs and inadequate gestational weight gain, if causal, remains to be elucidated. Additional work to determine causality and explore the underlying etiology of excess and inadequate gestational weight gain and ACEs/PCEs is needed. Furthermore, clinical implications involving screening for ACEs exposures, providing nutritional and/or physical education, and promoting healthy eating through individualized counseling or support groups may further help pregnant women maintain a healthy weight gain during and after pregnancy.

Gestational Diabetes

There were approximately 40% increased odds of having gestational diabetes among MTB-PACE women who experienced sexual abuse or ACEs scores of 3 or higher. The results; however, were not statistically significant at an alpha level of .05. Although with a different study design, sample, and setting, a recent data analysis of more than 3,000 Rhode Island women between 2016-2018 by Bala et al. (2020) found that there was a non-statistically significant increase in odds between ACEs scores of 1-2 or 3+ and GD.

According to the study by Racine et al. (2018), sexual abuse was not associated with maternal health outcomes including GD among the pregnancy cohort in the All Our Babies/Families study. Mason et al. (2016) found that forced sexual abuse and severe physical abuse were associated with increased GD risk; however, unlike the current study, the authors examined physical abuse separately from emotional abuse. In Schoenaker et al. (2019), the association between ACEs (physical abuse and household substance abuse) and GD risk was elevated only among women with prenatal depression symptoms, while Stanhope et al. (2020) found there were no increased odds for GD associated with ACEs ≥ 4 among a large cohort of Hispanic women. In our sample, there were no increased odds for GD associated with household dysfunction or physical/emotional abuse and no evidence of positive modification of PCEs. Versteegen and colleagues (2021) found a significant association between depression and GD and a non-significant association between ACEs/social support and GD among 300 pregnant women in the Albany Infant and Mother study at a New York prenatal care clinic. Possible explanations for these inconsistent findings may be due to the small sample size in ACEs subtypes and outcomes, the intensity of exposures which likely vary within and between studies, the instruments used, and the potential mediation effect of depression among many individuals.

Further research with a larger and more diverse sample, considering the severity of exposures, may provide a better understanding of the effect of ACEs, ACEs subtypes, and the potential effect modification of ACEs by PCEs level and the risk of GD.

Preterm birth

Household dysfunction and sexual abuse had some evidence of increased odds for giving birth before gestational week 37 among MTB-PACE women but all of the associations included the null. Associations between sexual abuse and elevated odds for preterm birth were found in past studies by Margericon-Zilko et al. (2016) and Selk et al. (2016). However, Margericon-Zilko and colleagues (2016) observed the effects of ACEs when sexual abuse was reported in both childhood and adulthood, and Selk et al. (2016) found the associations only for forced sexual activity in childhood or adolescence. Additionally, Mersky & Lee (2019) found that total ACEs were significantly associated with preterm birth, although when modeled as a categorical variable, the increased risk was only observed among women with a high level of childhood adversity. Salah et al. (2019) found that collective violence exposures in childhood were associated with a significant decrease in gestational age. In a large case-control study by Christiaens et al. (2015), lifetime physical/emotional abuse in both childhood and adulthood was associated with spontaneous preterm birth, and odds for delivering a preterm infant were elevated among women experiencing ≥ 2 ACEs. Finally, in a longitudinal study of pregnant women in 4 hospitals in Pakistan, Shaikh et al. (2021) found that ethnic and health disparity rather than ACEs were associated with preterm birth among Pakistani women. The discrepancy in the cohort studied, study design, instrument use, and findings between the current study and published papers indicated the complexity and diversity of ACEs exposures that may have a negative impact on preterm birth. In addition to non-statistical significance, there was no

indication of ACEs effects on preterm birth associated with physical/emotional abuse or ≥ 3 ACEs in the current study, and the MTB-PACE sample did not demonstrate the modification effect of PCEs ≥ 5 compared to PCEs ≤ 4 on preterm birth. The possible reasons may be due to insufficient power for stratified analysis and the potential effect of frequency, intensity, and timing of ACEs exposures on preterm birth.

Small Birth for Gestational Age

In the current study, there were increased odds of delivering a SGA baby in women who experienced sexual abuse, but the association was not statistically significant. We did not observe increased odds for SGA outcome among the study sample with ACEs scores of 3 or higher, and the association between ACEs and SGA in the current study was not modified by PCEs. To our knowledge, there is little research examining the association between ACEs and SGA. Appleton et al. (2019) found ACEs associated with a significant increase of infant cephalization index, which is defined as the percentage of head circumference divided by infant birth weight, among pregnant women who had high cumulative ACEs score. Furthermore, Appleton et al. (2019) indicated that a protective effect of social support (tangible and emotional) against the negative impact of ACEs ≤ 3 on infant cephalization. Additionally, Mersky and Lee (2019) found that total ACEs were significantly associated with low birth weight among women with severe childhood exposures, although low birth weight is commonly a result of prematurity, not growth restriction. Salah et al. (2019) found that witnessing community violence was significantly associated with a low birth weight of fewer than 2,500 grams, while Smith et al. (2016) suggested each additional ACEs score was associated with a decrease of 16.33 grams in infants' birth weight. The outcomes of these past studies and current study are slightly different from one and another in which diverse physiological mechanism(s) may likely contribute to the

findings. Further research considering health conditions including the types and timing of social support may strengthen the understanding of the association between PACEs and SGA.

Large Birth for Gestational Age

Little research has studied the impact of ACEs/PCEs on birth outcomes related to having a LGA baby (>90th percentile). Examination of the association between cumulative ACEs or dichotomized ACEs scores and LGA offspring indicated an increase of 17% to 89% odds of delivering an LGA baby but the confidence intervals slightly overlapped the null. ACE subtypes showed increased odds, aOR = 1.31 [0.66, 2.61] for household dysfunction, aOR = 1.69 [0.81, 3.55] for physical/emotional abuse, and aOR = 1.77 [0.85, 3.71] for sexual abuse; however, the associations were not statistically significant at an alpha level of .05 with wide-ranged CIs. Furthermore, women who experienced PCEs scores of ≥ 5 showed similar odds for LGA compared to those with PCEs scores of ≤ 4. The non-statistical significance in the current study may be due to the small sample size within ACEs subtypes, ACEs outcomes, and PCEs strata. Additional research may advance an understanding of the potential mediation of excessive weight gain and GD and the intergenerational effect of PACEs associated with LGA.

Summary

The current study estimated associations between total ACEs and ACE subtypes and adverse pregnancy and birth outcomes among a cohort of 556 MTB-PACE participants. Although most associations were not statistically significant and we did not find evidence of effect modification of ACEs by PCEs levels, most of our ACEs subtypes, outcomes, and PCEs strata were small and underpowered for the analyses. Post-hoc analyses on small strata comparing high PACEs to the reference may explore the extreme measures of PACEs effect on pregnancy and birth outcomes among MTB-PACE participants. Moreover, a longitudinal study

on a nationally representative population of women may further strengthen the understanding of the association between PACEs and pregnancy health and birth outcomes.

Study Limitations

This study has several limitations. The sample sizes were small for examining the effects of PACEs on rare pregnancy and birth outcomes using ACEs subtypes or PCEs strata in the association analyses. The non-random sampling in the current study underrepresented Black, non-Hispanic/non- Latina women or those from relatively disadvantaged backgrounds. As a result, the study findings may have limited generalization to these populations. Another limitation is the MTB-PACE data collection. The data collected in the MTB-PACE study is subject to recall bias because the information primarily relied on how accurately participants recall their experiences in childhood, in many cases, the time frame could be decades-long. Women may respond to the survey questions differently, depending on their emotional states, health conditions, and their already known pregnancy outcomes at the time of the survey (Cammack et al., 2018). Finally, the survey instruments used in the study may have a limitation in the lens of standardized assessment. Although PACE-Q demonstrates good internal consistency, scoring algorithm, and excellent test-retest reliability, information about content and convergent validity of PACE-Q is still limited in the research literature.

Conclusions

Despite the above caveats, this study contributes to the clinical knowledge and currently limited body of research concerning the prevalence and effects of adverse and positive childhood experiences on pregnancy (UWG and GD) and birth outcomes (preterm birth, SGA, and LGA). The current study analyzed three principal components of ACE-Q consisting of household dysfunction, physical/emotional abuse, and sexual abuse within a cohort of 556 women and

examined the associations of total ACEs, ACEs subtypes, ≥ 3 ACEs, and the effect modification of PCEs on pregnancy and birth outcomes. Further research using a longitudinal study design on a large and diverse sample of pregnant women, considering frequency, timing, and severity of childhood exposures would provide a better understanding of the associations between ACEs and PCEs and pregnancy and birth outcomes. The findings may facilitate PACE awareness, improve clinical implications, promote social support, reduce medical costs in the health care of pregnant women, and provide a better beginning for infant development.

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Table 1

*Demographics and Characteristics of All MTB-PACE Participants and by the Number of ACEs Reported (*N = *556)*

Demographics	*N (%)*	Number of ACE			
		0-1	2	3	4-8
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
Age (years)					
< 30	116 (20.9)	51 (18.8)	15 (17.4)	21 (25.6)	29 (24.8)
30-35	285 (51.3)	152 (56.1)	48 (55.8)	35 (42.7)	50 (42.7)
36-40	125 (22.5)	57 (21.0)	20 (23.3)	21 (25.6)	27 (23.1)
> 40	30 (5.4)	11 (4.1)	3 (3.5)	5 (6.1)	11 (9.4)
Race					
White	479 (86.2)	250 (92.3)	73 (84.9)	65 (79.3)	91 (77.8)
Black	24 (4.3)	3 (1.1)	6 (7.0)	4 (4.9)	11 (9.4)
Asian	34 (6.1)	11 (4.1)	6 (7.0)	9 (11.0)	8 (6.8)
Indian/Native American	5 (0.9)	2 (0.7)	1(1.2)	0 (0.0)	2 (1.7)
Other	13 (2.3)	5 (1.9)	0 (0.0)	3 (3.7)	5 (4.3)
Missing	1 (0.2)			1 (1.2)	
Ethnicity					
Hispanic/Latina	41 (7.4)	13 (4.8)	9 (10.5)	7 (8.5)	12 (10.3)
NonHispanic/NonLatina	513 (92.3)	258 (95.2)	77 (89.5)	73 (89.0)	103 (88.0)
Missing	2 (0.4)			2 (2.4)	

Demographics	*N (%)*	Number of ACE			
		0-1	2	3	4-8
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
Education					
High school or less	71 (12.8)	20 (7.4)	9 (10.5)	15 (18.3)	27 (23.1)
College	211 (37.9)	105 (38.7)	36 (41.9)	25 (30.5)	45 (38.5)
Above college	273 (49.1)	146 (53.9)	41 (47.7)	41 (50.0)	45 (38.5)
Missing	1 (0.2)			1 (1.2)	
SES					
Low (score > 3)	17 (3.1)	6 (2.2)	7 (8.1)	0 (0.0)	4 (3.4)
High (score ≤ 3)	494 (88.8)	245 (90.4)	73 (84.9)	77 (93.9)	99 (84.6)
Missing	45 (8.1)	20 (7.4)	6 (7.0)	5 (6.1)	14 (12.0)
Location					
Canada	48 (8.6)	27 (10.0)	6 (7.0)	7 (8.5)	8 (6.8)
Midwest U.S.	77 (13.9)	35 (12.9)	8 (9.3)	16 (19.5)	18 (15.4)
Northeast U.S.	79 (14.2)	37 (13.7)	12 (14.0)	17 (20.7)	13 (11.1)
Southeast U.S.	84 (15.1)	39 (14.4)	11(12.8)	15 (18.3)	19 (16.2)
Southwest U.S.	50 (9.0)	24 (8.9)	10 (11.6)	5 (6.1)	11 (9.4)
West U.S.	218 (39.2)	109 (40.2)	39 (45.3)	22 (26.8)	48 (41.1)

Note. MTB-PACE = MotherToBaby addendum study using Positive and Adverse Childhood Experience survey; ACE = adverse childhood experiences; SES = social economic status.

Table 2

*Health Conditions and Health Information of All MTB-PACE Participants and by the Number of ACEs Reported (*N = *556)*

Characteristics	*N (%)*	Number of ACE			
		0-1	2	3	4-8
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
Health Conditions					
Preexisting conditions					
Diabetes (Type I and II)	5 (0.9)	0 (0.0)	1(1.2)	1 (1.2)	3 (2.8)
Hypertension	9 (1.6)	4 (1.5)	0 (0)	1 (0.6)	4 (3.7)
Asthma	75 (13.5)	31 (11.8)	9 (10.5)	11 (13.4)	24 (22.4)
RA	44 (7.9)	24 (9.1)	7 (8.1)	4(4.9)	9 (8.4)
SLE	4 (0.7)	2 (0.8)	1 (1.2)	0 (0.0)	1 (0.9)
Crohn's disease	50 (9.0)	32 (12.2)	5 (6.1)	5 (6.1)	8 (7.5)
Ulcerative colitis	31 (5.6)	15 (5.7)	0 (0.0)	5 (3.1)	11 (10.3)
Prenatal BMI					
Underweight/Normal weight[a]	356 (64.0)	196 (72.3)	58 (67.4)	47 (57.3)	55 (47.0)
Overweight[b]	125 (22.5)	49 (18.1)	18 (20.9)	26 (31.7)	32 (27.4)
Obese[c]	74 (13.3)	26 (9.6)	10 (11.6)	8 (9.8)	30 (25.6)
Missing	1 (0.2)			1 (1.2)	

Characteristics	*N (%)*	Number of ACE			
		0-1	2	3	4-8
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
Health Information					
Smoking (passive/active)	33 (5.9)	8 (3.0)	6 (7.0)	6 (7.3)	13 (10.3)
Recreational Drugs	14 (2.5)	4 (1.5)	3 (3.5)	2 (2.4)	5 (4.3)
Alcohol (≥4 drinks/occasion)	11 (2.0)	7 (2.6)	0 (0.0)	3 (3.7)	1 (0.9)
Depression/Anxiety	46 (8.3)	10 (3.7)	15 (17.4)	5 (6.1)	15 (12.8)

Note. ACE = adverse childhood experiences; RA = rheumatoid arthritis; SLE = systemic lupus erythematosus; BMI = body mass index, [a] underweight/normal weight (BMI < 24.9), [b] overweight (25.0 < BMI < 29.9), [c] obese (BMI ≥ 30).

Table 3

Survey Responses of MTB-PACE Participants

	Ever[a]	Missing[b]	Imputed[c]
	n (%)	*n (%)*	*n (%)*
Positive childhood experiences.			
1. How often did you feel your family stood by you during difficult times?	430 (77.3)		
2. How often did you feel that you were able to talk to your family about your feelings?	289 (52.0)		
3. For how much of your childhood was there an adult in your household who made you feel safe and protected?	460 (83.0)		2 (0.4)
4. How often did your enjoy participating in your community's tradition?	401 (72.5)		3 (0.5)
5. How often did you feel supported by your friends?	397 (71.4)		
6. How often did you feel that you belonged at your high school?	289 (52.3)		3 (0.5)
7. How often were there at least two adults, other than your parents, who took a genuine interest in you?	398 (71.6)		

Note. . MTB-PACE = MotherToBaby addendum study using Positive and Adverse Childhood Experience survey; [a] Responses = yes, once, more than once, often, very often, most of the time, or all of the time; [b]Missing (blank) data only, [c]Missing (blank) data and no answer.

	Ever[a]	Missing[b]	Imputed[c]
	n (%)	*n (%)*	*n (%)*
Adverse childhood experience			
Household Dysfunction			
8. Did you live with anyone who was depressed, mentally ill, or suicidal?	207 (37.6)	1 (0.2)	5 (0.9)
9. Did you live with anyone who was a problem drinker or alcoholic?	107 (19.2)		
10. Did you live with anyone who used illegal street drugs or who abused prescription medications?	22 (4.0)		2 (0.4)
11. Did you live with anyone who served time or was sentenced to serve time in a prison, jail, or other correctional facility?	23 (4.1)		1 (0.2)
12. Were your parents separated or divorced?	107 (19.2)		2 (0.4)

Note. [a] Responses = yes, once, more than once, often, very often, most of the time, or all of the time; [b]Missing (blank) data only, [c]Missing (blank) data and no answer.

	Ever[a]	Missing[b]	Imputed[c]
	n (%)	n (%)	*n (%)*
Physical/Emotional Abuse			
13. How often did your parents or adults in your home ever slap, hit, kick, punch, or beat each other up?	107 (19.2)		1 (0.2)
14. Before age 18, how often did a parent or adult in your home ever hit, beat, kick, or physically hurt you in any way? Do not include spanking.	128 (23.1)	1 (0.2)	3 (0.5)
15. How often did a parent or adult in your home ever swear at you, insult you, or put you down?	282 (51.1)		4 (0.7)
Sexual Abuse			
16. How often did anyone at least 5 years older than you, or an adult, touch you sexually?	125 (22.5)		5 (0.9)
17. How often did anyone at least 5 years older than you, or an adult, try to make you touch them sexually?	85 (15.3)		8 (1.4)
18. How often did anyone at least 5 years older than you, or an adult, force you to have sex?	35 (6.3)		4 (0.7)

Note. [a] Responses = yes, once, more than once, often, very often, most of the time, or all of the time; [b]Missing (blank) data only, [c]Missing (blank) data and no answer.

Table 4

Factor Analysis of ACE-Q: Rotated Factors and Correlation

ACE-Q	Factor loading			Correlation		
	1	2	3	Factor 1	Factor 2	Factor 3
Factor 1: Household dysfunction				1.00	.32	.30
ACE 1[a] (PACE-Q8)[b]	.06	.25	**.38**			
ACE 2 (PACE-Q9)	.05	.13	**.53**			
ACE 3 (PACE-Q10)	.21	.05	**.63**			
ACE 4 (PACE-Q11)	.05	.05	**.56**			
ACE 5 (PACE-Q12)	.11	.10	**.43**			
Factor 2: Physical/Emotional abuse				.32	1.00	.21
ACE 6 (PACE-Q13)	.05	**.60**	.30			
ACE 7 (PACE-Q14)	.10	**.85**	.08			
ACE 8 (PACE-Q15)	.09	**.56**	.29			
Factor 3: Sexual abuse				.30	.21	1.00
ACE 9 (PACE-Q16)	**.82**	.14	.20			
ACE 10 (PACE-Q17)	**.89**	.07	.18			
ACE 11 (PACE-Q18)	**.62**	**.04**	.18			

Note. ACE-Q = Adverse Childhood Experience questionnaire. PACE = Positive and Adverse Childhood Experiences. [a]ACE item correspondent to [b] PACE question in the survey. Extraction Method: Generalized Least Squares; Rotation Method: Quartimax with Kaiser Normalization; Factor loadings greater than .30 appear in bold.

Table 5

*PACEs Prevalence of MTB-PACE Participants (*N = *556)*

Characteristics		Number of ACE[a]			
	N (%)	0-1	2	3	≥ 4
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
PCE scores[b]					
0-2	87 (15.6)	11 (4.1)	17 (19.8)	15 (18.3)	44 (37.6)
3-4	129 (23.2)	35 (12.9)	24 (27.9)	26 (31.7)	44 (37.6)
5	74 (13.3)	33 (12.2)	22 (25.6)	11 (13.4)	8 (6.8)
6-7	266 (47.8)	192 (70.8)	23 (26.7)	30 (36.6)	21(18.0)

Note. PACE = Positive and Adverse Childhood Experiences; MTB-PACE = MotherToBaby addendum study using Positive and Adverse Childhood Experiences survey; ACE = adverse childhood experiences; PCE = positive childhood experiences. [a]ACE score of 1 is answer "yes" on each of ACE items 1, 2-3, 4, or 5; ACE item 6, 7, or 8; and ACE item 9-11. [b] PCE score of 1 is answer "yes" on each of PCE items 1-7.

Table 6

*Associations between Total/Subtype ACEs and Pregnancy and Birth Outcomes (*N = *556)*

Outcomes	*N (%)*	Unadj OR [95% CI]	Adj OR [95% CI]
Pregnancy Outcomes			
Unhealthy weight gain ʃ			
Total ACE♯	372 (67.0)	1.20 [1.09, 1.33]**	1.16 [1.05, 1.29]*
ACE scores ≥3†	151 (75.9)ᵻ	1.89 [1.28, 2.79]**	1.68 [1.12, 2.51]*
ACE Subtype			
Household Dysfunction	208 (70.5)	1.42 [0.99, 2.02]	1.29 [0.90, 1.56]
Physical/Emotional Abuse	228 (73.5)	1.94 [1.36, 2.78]**	1.79 [1.24, 2.59]**
Sexual Abuse	93 (70.5)	1.27 [0.83, 1.94]	1.07 [0.68, 1.66]
Gestational Diabetes Ł			
Total ACE♯	32 (5.8)	1.00 [0.83, 1.20]	0.98 [0.81, 1.20]
ACE scores ≥3†	14 (5.8)ᵻ	1.40 [0.68, 2.89]	1.36 [0.64, 2.88]
ACE Subtype			
Household Dysfunction	16 (5.4)	0.87 [0.43, 1.78]	0.83 [0.40, 1.73]
Physical/Emotional Abuse	18 (5.8)	1.03 [0.50, 2.12]	1.00 [0.48, 2.08]
Sexual Abuse	10 (7.6)	1.48 [0.68, 3.21]	1.40 [0.62, 3.14]

Note. Unadj OR = unadjusted OR; adj OR = adjusted OR. ACE = adverse childhood experiences; ♯Total ACE (of 8 types); ACE subtype = score of ACE item in each subtype; † ACE scores 0-2 (reference) and 3 or more; ᵻ Frequency calculated in ACE ≥3 group (*N* = 199).

*p <.05, **p <.005.

Outcomes	*N (%)*	Unadj OR [95% CI]	Adj OR [95% CI]
Birth Outcomes			
Preterm birth ʃ			
Total ACE♯	45 (8.1)	1.01 [0.87, 1.19]	1.00 [0.85, 1.18]
ACE scores ≥3†	16 (8.0)ɬ	0.99 [0.52, 1.86]	0.94 [0.48, 1.84]
ACE Subtype			
Household Dysfunction	28 (9.5)	1.51 [0.81, 2.82]	1.48 [0.78, 2.82]
Physical/Emotional Abuse	24 (7.7)	0.90 [0.49, 1.65]	0.84 [0.45, 1.58]
Sexual Abuse	12 (9.1)	1.18 [0.59, 2.36]	1.07 [0.52, 2.21]
SGAŁ			
Total ACE♯	35 (6.3)	0.97 [0.81, 1.17]	0.97 [0.80, 1.17]
ACE scores ≥3†	10 (5.0)ɬ	0.70 [0.33, 1.49]	0.69 [0.32, 1.49]
ACE Subtype			
Household Dysfunction	18 (6.1)	0.93 [0.47, 1.85]	0.94 [0.47, 1.88]
Physical/Emotional Abuse	18 (5.8)	0.83 [0.42, 1.65]	0.81 [0.40, 1.64]
Sexual Abuse	9 (6.8)	1.12 [0.51, 2.45]	1.18 [0.52, 2.66]
LGA ʃ			
Total ACE♯	38 (6.8)	1.16 [0.98, 1.35]	1.17 [0.99, 1.39]
ACE scores ≥3†	18 (9.1)ɬ	1.67 [0.86, 3.24]	1.89 [0.94, 3.79]
ACE Subtype			
Household Dysfunction	22 (7.5)	1.24 [0.63, 2.41]	1.31 [0.66, 2.61]
Physical/Emotional Abuse	26 (8.4)	1.69 [0.83, 3.46]	1.69 [0.81, 3.55]
Sexual Abuse	13 (9.8)	1.74 [0.86, 3.51]	1.77 [0.85, 3.71]

Outcomes	*N (%)*	Unadj OR [95% CI]	Adj OR [95% CI]

Note. ACE = adverse childhood experiences. Unadj and Adj = Models were unadjusted or adjusted with confounders**.** ACE subtype = score of 0 (reference) and one on either ACE item in each subtype. ♯Total ACE scores (8 types) for outcome; † ACE scores 0-2 (reference) and 3 or more; ᵻ Frequency calculated in ACE ≥3 group (*N* = 199); ʃ Models adjusted for maternal age, race/ethnicity, and education, and SES; ᵸ.Models adjusted for maternal age, race/ethnicity, and education.

**p* <.05, ***p* <.005.

Table 7

*Examination of Effect Modification of PCEs on Pregnancy and Birth Outcomes (*N = *556)*

Outcomes	PCE scores ≤ 4 *n* = 216 (38.8%)	PCE scores ≥ 5 *n* = 340 (61.2%)
	Adjusted OR [95% CI]	Adjusted OR [95% CI]
Pregnancy Outcomes		
Unhealthy weight gain ʃ		
Total ACE♯	1.22 [1.03, 1.44]*	1.06 [0.99, 1.14]
ACE scores ≥3†	1.59 [0.85, 3.00]	1.42 [1.11, 1.83]*
Gestational Diabetes Ł		
Total ACE♯	1.04 [0.74, 1.46]	1.03 [0.91, 1.16]
ACE scores ≥3†	1.33 [0.31, 5.68]	1.88 [1.26, 2.80]**

Note. ACE = adverse childhood experiences; ♯Total ACE scores of 8 types; †ACE score 2 or less as reference. ŁRegression model was adjusted for maternal age, race/ethnicity, and education; ʃ Regression model was adjusted for maternal age, race/ethnicity, education, and socioeconomic status.

*p <.05, **p <.005.

Outcomes	PCE scores ≤ 4 *n* = 216 (38.8%)	PCE scores ≥ 5 *n* = 340 (61.2%)
	Adjusted OR [95% CI]	Adjusted OR [95% CI]
Birth Outcomes		
Preterm birth ʃ		
Total ACE♯	0.97 [0.75,1.24]	1.00 [0.89,1.13]
ACE scores ≥3†	0.84 [0.31,2.28]	0.93 [0.60,1.45]
SGA Ł		
Total ACE♯	0.89 [0.69,1.14]	0.75 [0.62,0.90]**
ACE scores ≥3†	0.54 [0.20,1.44]	0.24 [0.10,0.55]**
LGA ʃ		
Total ACE♯	1.15 [0.89,1.48]	1.07 [0.94,1.28]
ACE scores ≥3†	1.85 [0.62,5.56]	1.25 [0.79,1.99]

Note. ACE = adverse childhood experiences; GA = gestational age; SGA = small gestational age (<10th percentile); LGA = large gestational age (>90th percentile); GD = gestational diabetes; preterm birth = gestational age < 37 weeks. ♯Total ACE scores of 8 types. †ACE score 2 or less as reference. ŁRegression models were adjusted for maternal age, race/ethnicity, and education; ʃ Regression models were adjusted for maternal age, race/ethnicity, education, and socioeconomic status.

*p <.05, **p <.005.

Figure 1

MTB-PACE Study Sampling

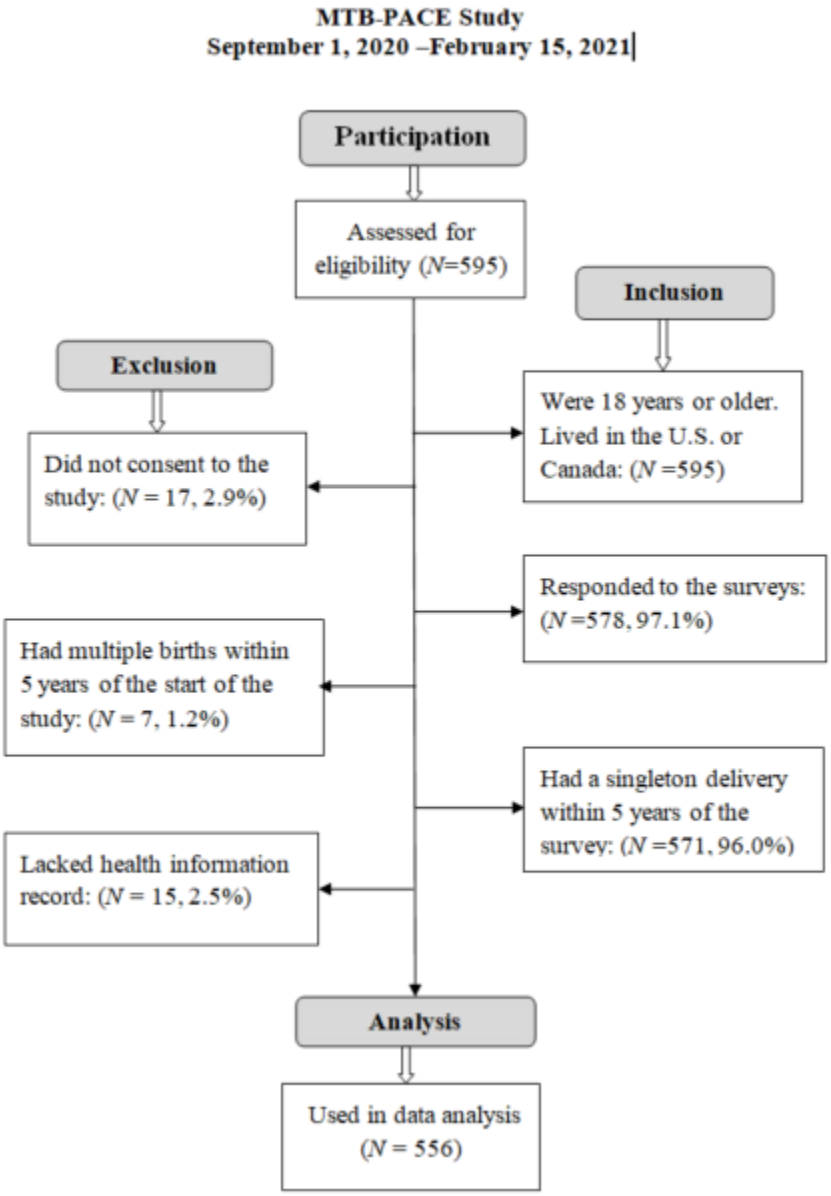
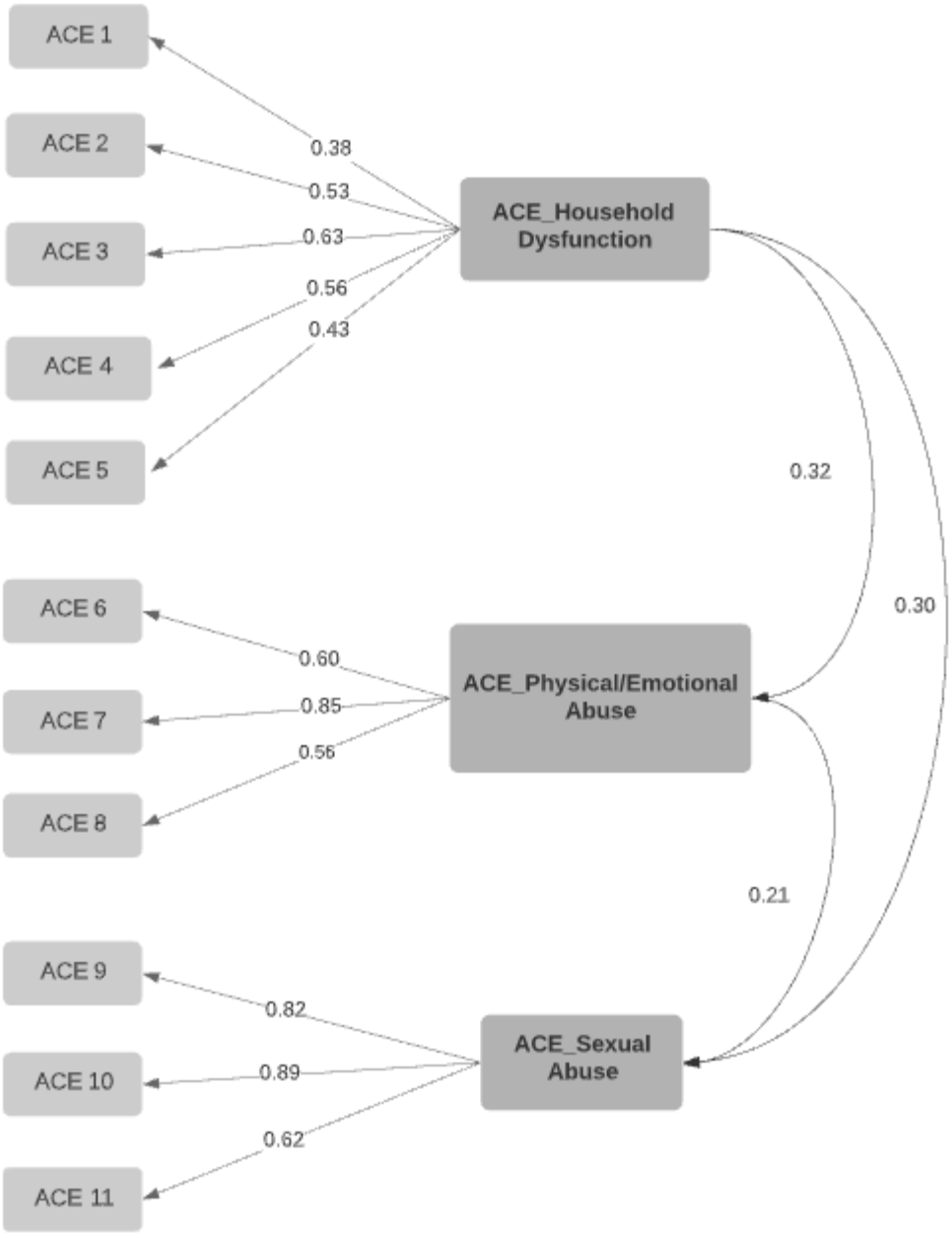


Figure 2

Diagram of Three Factor Analysis of ACE-Q



Note. ACE = adverse childhood experiences.

Appendix A

Positive and Adverse Childhood Experiences Questionnaire

Positive Childhood Experiences Questionnaire (PCEs-Q)

1. How often did you feel your family stood by you during difficult times? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?
2. How often did you feel that you were able to talk to your family about your feelings? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?
3. For how much of your childhood was there an adult in your household who made you feel safe and protected? Would you say never, a little of the time, some of the time, most of the time, all of the time, or prefer not to answer?
4. How often did your enjoy participating in your community's tradition? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?
5. How often did you feel supported by your friends? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?
6. How often did you feel that you belonged at your high school? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?
7. How often were there at least two adults, other than your parents, who took a genuine interest in you? Would you say never, rarely, sometimes, often, very often, or prefer not to answer?

Adverse Childhood Experiences Questionnaire (ACEs-Q)

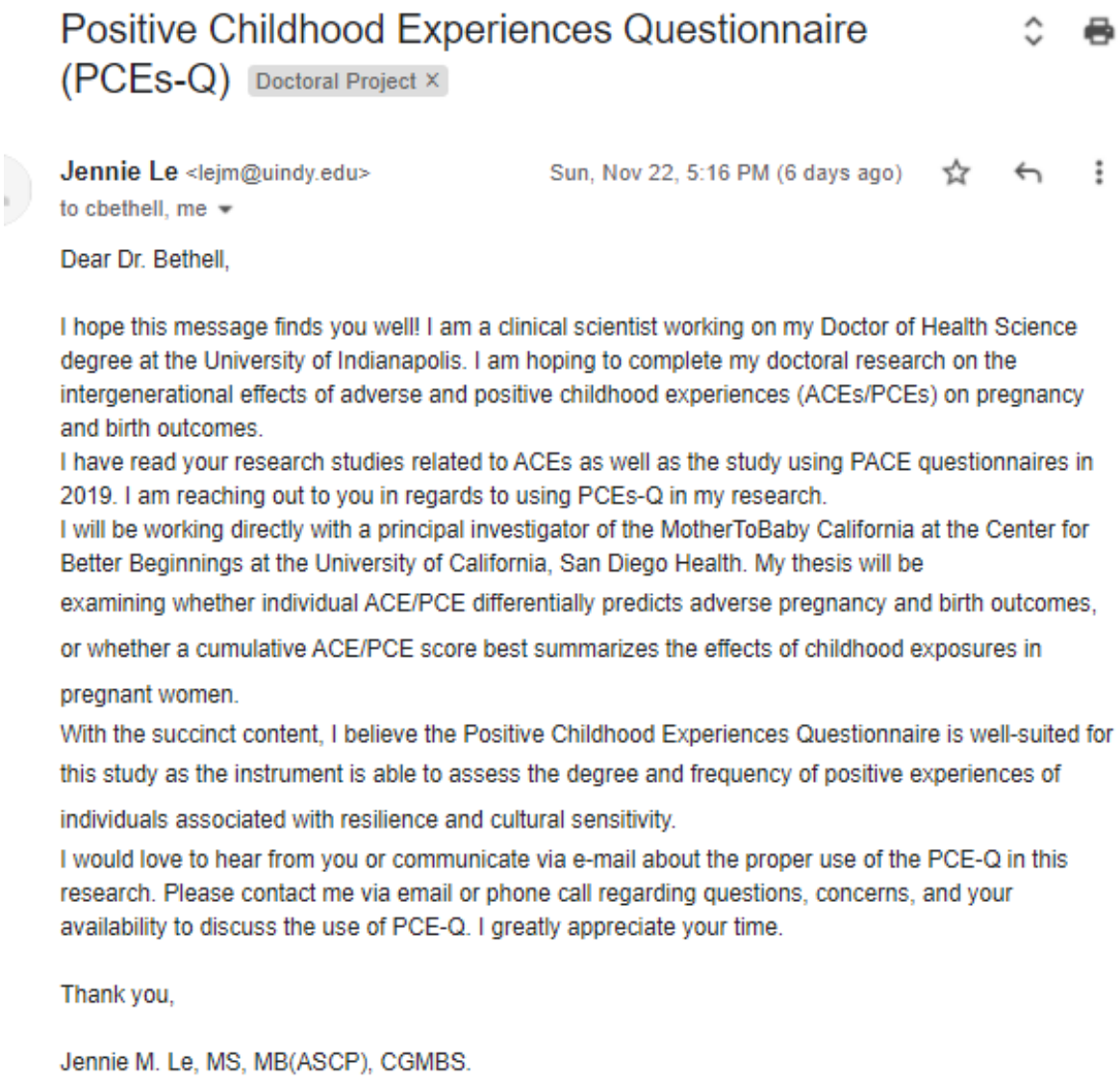
1. Did you live with anyone who was depressed, mentally ill, or suicidal? Yes, No, or Prefer not to Answer?
2. Did you live with anyone who was a problem drinker or alcoholic? Yes, No, or Prefer

not to Answer?

3. Did you live with anyone who used illegal street drugs or who abused prescription medications? Yes, No, or Prefer not to Answer?
4. Did you live with anyone who served time or was sentenced to serve time in a prison, jail, or other correctional facility? Yes, No, or Prefer not to Answer?
5. Were your parents separated or divorced? Yes, No, or Prefer not to Answer?
6. How often did your parents or adults in your home ever slap, hit, kick, punch, or beat each other up? Never, Once, More than once, or Prefer not to Answer?
7. Before age 18, how often did a parent or adult in your home ever hit, beat, kick, or physically hurt you in any way? Do not include spanking. Never, Once, More than once, or Prefer not to Answer?
8. How often did a parent or adult in your home ever swear at you, insult you, or put you down? Never, Once, More than once, or Prefer not to Answer?
9. How often did anyone at least 5 years older than you, or an adult, touch you sexually? Never, Once, More than once, or Prefer not to Answer?
10. How often did anyone at least 5 years older than you, or an adult, try to make you touch them sexually? Never, Once, More than once, or Prefer not to Answer?
11. How often did anyone at least 5 years older than you, or an adult, force you to have sex? Never, Once, More than once, or Prefer not to Answer?

Appendix B

Use of PACEs Questionnaire



Positive Childhood Experiences Questionnaire (PCEs-Q) Doctoral Project ×

Jennie Le <lejm@uindy.edu> Sun, Nov 22, 5:16 PM (6 days ago)

to cbethell, me

Dear Dr. Bethell,

I hope this message finds you well! I am a clinical scientist working on my Doctor of Health Science degree at the University of Indianapolis. I am hoping to complete my doctoral research on the intergenerational effects of adverse and positive childhood experiences (ACEs/PCEs) on pregnancy and birth outcomes.

I have read your research studies related to ACEs as well as the study using PACE questionnaires in 2019. I am reaching out to you in regards to using PCEs-Q in my research.

I will be working directly with a principal investigator of the MotherToBaby California at the Center for Better Beginnings at the University of California, San Diego Health. My thesis will be examining whether individual ACE/PCE differentially predicts adverse pregnancy and birth outcomes, or whether a cumulative ACE/PCE score best summarizes the effects of childhood exposures in pregnant women.

With the succinct content, I believe the Positive Childhood Experiences Questionnaire is well-suited for this study as the instrument is able to assess the degree and frequency of positive experiences of individuals associated with resilience and cultural sensitivity.

I would love to hear from you or communicate via e-mail about the proper use of the PCE-Q in this research. Please contact me via email or phone call regarding questions, concerns, and your availability to discuss the use of PCE-Q. I greatly appreciate your time.

Thank you,

Jennie M. Le, MS, MB(ASCP), CGMBS.

Christina Bethell Sun, Nov 22, 5:27 PM (6 days ago)

to Narangerel, me

Hello Jennie,

It is wonderful to hear of your work and commitment. I am copying Naraa Gombojav here who will send to you the items and scoring for the cumulative positive measure we developed and validated for the JAMA Peds study. Of course, there is much to consider in linking a history of ACEs/PCEs to current health. Do see the Hillis, et al. paper from the initial ACEs study showing how family strengths dramatically reduced prevalence of teen pregnancy and other papers I cite in our study.

Best and I'd love to get an update on how you are doing as you proceed,

Christina

Christina Bethell, PhD, MBA, MPH
Professor, Bloomberg School of Public Health
Johns Hopkins Univerity
615 N Wolfe Street, Rm E4152
Baltimore, Maryland 21205
cbethell@jhu.edu
443-287-5092

Narangerel Gombojav <ngomboj1@jhu.e... Nov 23, 2020, 5:53 AM (5 days ago)
to Christina, me

Hello Jennie,

Thank you for your interest in our work on Positive Childhood Experiences (PCEs) and your own work in this important area.
As requested, the questionnaire for the state added WI BRFS items we used to create a PCEs metric are attached. The PCEs items were adapted from the Child and Youth Resilience Measure-28 (CYRM-28). You can find a detailed explanation of which items were used (and adapted) in the body of the paper and more on the CRYM in this reference from the paper: Liebenberg L, Ungar M, LeBlanc JC. The CYRM-12: a 3 brief measure of resilience. *Can J Public Health*. 4 2013;104(2):e131-e135. Medline:23618205.

These items can be used in other studies as long as you include the appropriate citation in your work, which would be the WI BRFS survey itself. However, if you use the items as a cumulative score (and not as single items), we ask that your reference our paper (https://jamanetwork.com/journals/jamapediatrics/fullarticle/2749336) as it was in that work that the psychometric analysis and work was done to specify a PCEs cumulative score metric. Please refer to our paper and its appendices to learn more.

As you will see from the paper, the PCEs score was developed based on count of "very often/often" or "most/all of the time" responses to the 7 PCEs items. Again, you can find more information in the paper, Figures and Supplemental Appendices.

We have made the paper open access so that you and anyone can access it freely:
https://jamanetwork.com/journals/jamapediatrics/fullarticle/2749336

Best of luck in your research and other work and we would appreciate learning more about how you might use the items and/or our PCEs metric and research.

All the best,
Naraa

Naraa Gombojav, PhD
Assistant Scientist
Child and Adolescent Health Measurement Initiative
Department of Population, Family and Reproductive Health
Johns Hopkins Bloomberg School of Public Health
615 N. Wolfe Street, Room E4646
Baltimore, MD 21205

Appendix C

Table 8

*Estimated Sample Size Associated with Outcome and ACE Type using G*Power*

Article	Number of cases[a]	Outcome/ ACE Type	OR [95% CI]	G* Power Sample size[b]
Gestational diabetes, *N* = 3,181 (3.0%)[c]				
Mason et al. (2016)	258	Severe physical abuse	1.43 [1.22,1.67]	297
	1408	Physical abuse[d]	-	636
	318	Forced sexual abuse	1.31 [1.15,1.50]	154
	892	Sexual abuse[e]	-	245
Excessive Gestational weight gain, *N* = 2,356 (38.0%)[c]				
Ranchod et al. (2016)	990	Household Mental illness	1.10 [0.9, 1.20]	448
	1013	Household alcoholism	1.20 [1.10, 1.3]	454
	1084	Physical abuse	1.20 [1.10, 1.4]	212
Preterm birth, *N* = 4,110 (8.0%)[c]				
Selk et al. (2016)	518	Forced sexual abuse	1.24 [1.13, 1.37]	90
	908	Touch-only sexual abuse	1.03 [0.95, 1.11]	67
	317	Severe physical abuse	1.11 [0.99, 1.25]	117

Note. ACE = adverse childhood experiences; preterm birth = gestational age between 20 to 37 weeks. [a] Cases associated with outcome and ACE type. [b] Sample size estimated at $\alpha = .05$ and $\beta = 0.8$, [c] Number and percentage of outcome , [d] Sever, moderate, and mild physical abuse, [e] Forced and touch-only sexual abuse.

Table 9

*PACEs Prevalence and Health Outcomes of MTB-PACE Participants (*N = *556)*

Outcomes	*N (%)*	Number of ACE			
		0-1	2	3	4-8
		n = 271	*n* = 86	*n* = 82	*n* = 117
		(48.7%)	(15.5%)	(14.7%)	(21.0%)
Pregnancy					
Unhealthy weight gain	372 (67.0)	165 (60.9)	57 (66.3)	57 (69.5)	94 (80.3)
Missing	1 (0.2)				
Gestational diabetes	32 (5.9)	15 (5.5)	4 (4.9)	8 (9.8)	5 (4.3)
Missing	3 (0.5)				
Birth					
Preterm birth	45 (8.1)	24 (8.9)	5 (5.8)	5 (6.1)	11 (9.3)
Missing	2 (0.4)				
Birth weight for GA					
SGA	35 (6.3)	20 (7.4)	5 (5.8)	2 (2.4)	8 (7.5)
LGA	38 (6.9)	16 (5.9)	4 (4.7)	4 (4.9)	14 (12.1)
Missing	3 (0.6)				

Outcomes	*N (%)*	Number of PCE			
		0-2	3-4	5	6-7
		n = 87	*n* = 129	*n* = 74	*n* = 266
		(15.6%)	(23.2%)	(13.3%)	(47.8%)
Pregnancy					
Unhealthy weight gain	372 (67.0)	67 (77.0)	90 (69.8)	48 (64.9)	167 (62.8)
Missing	1 (0.2)				
Gestational diabetes	32 (5.9)	8 (9.2)	2 (1.6)	5 (6.8)	17 (6.4)
Missing	3 (0.5)				
Birth					
Preterm birth	45 (8.1)	6 (6.9)	13 (10.1)	6 (8.1)	20 (7.5)
Missing	2 (0.4)				
Birth weight for GA					
SGA	35 (6.3)	10 (11.5)	9 (7.0)	4 (5.4)	12 (4.5)
LGA	38 (6.9)	7 (8.1)	12 (9.3)	3 (4.1)	16 (6.0)
Missing	3 (0.6)				

Note. ACE = adverse childhood experiences; PCE score of 1 is answer "yes" on each of PCE items 1-7. preterm birth = GA < 37 weeks; SGA = small birth weight (<10th percentile) for GA; LGA = large birth weight (>90th percentile) for GA.

Table 10

Post-hoc Power Analysis of MTB-PACE Study

Outcomes	*N (%)*	Adj OR [95% CI]	G* Power Estimation
Pregnancy Outcomes			
Unhealthy weight gain ʃ			
Total ACE♯	372 (67.0)	1.16 [1.05, 1.29]*	1.00
ACE scores ≥ 3†	151 (75.9)ɬ	1.68 [1.12, 2.51]*	1.00
ACE Subtype			
Household Dysfunction	208 (70.5)	1.29 [0.90, 1.56]	1.00
Physical/Emotional Abuse	228 (73.5)	1.79 [1.24, 2.59]**	1.00
Sexual Abuse	93 (70.5)	1.07 [0.68, 1.66]	0.96
PCE scores ≥ 5	215 (63.2)	1.42 [1.11, 1.83]*	0.95
PCE scores ≤ 4	157 (72.7)	1.59 [0.85, 3.00]	1.00
Gestational Diabetes Ł			
Total ACE♯	32 (5.8)	0.98 [0.81, 1.20]	0.41
ACE scores ≥ 3†	14 (5.8)ɬ	1.36 [0.64, 2.88]	0.17
ACE Subtype			
Household Dysfunction	16 (5.4)	0.83 [0.40, 1.73]	0.19
Physical/Emotional Abuse	18 (5.8)	1.00 [0.48, 2.08]	0.22
Sexual Abuse	10 (7.6)	1.40 [0.62, 3.14]	0.12
PCE scores ≥ 5	22 (6.5)	1.88 [1.26, 2.80]**	0.26
PCE scores ≤ 4	19 (8.8)	1.33 [0.31, 5.68]	0.24

Outcomes	*N (%)*	Adj OR [95% CI]	G* Power Estimation
Birth Outcomes			
Preterm birth ʃ			
Total ACE♯	45 (8.1)	1.00 [0.85, 1.18]	0.72
ACE scores ≥3†	16 (8.0)ɬ	0.94 [0.48, 1.84]	0.26
ACE Subtype			
Household Dysfunction	28 (9.5)	1.48 [0.78, 2.82]	0.48
Physical/Emotional Abuse	24 (7.7)	0.84 [0.45, 1.58]	0.41
Sexual Abuse	12 (9.1)	1.07 [0.52, 2.21]	0.21
PCE scores ≥ 5	26 (7.6)	0.93 [0.60,1.45]	0.44
PCE scores ≤ 4	19 (8.8)	0.84 [0.31,2.28]	0.32
SGAŁ			
Total ACE♯	35 (6.3)	0.97 [0.80, 1.17]	0.46
ACE scores ≥3†	10 (5.0)ɬ	0.69 [0.32, 1.49]	0.10
ACE Subtype			
Household Dysfunction	18 (6.1)	0.94 [0.47, 1.88]	0.22
Physical/Emotional Abuse	18 (5.8)	0.81 [0.40, 1.64]	0.22
Sexual Abuse	9 (6.8)	1.18 [0.52, 2.66]	0.11
PCE scores ≥ 5	16 (4.7)	0.24 [0.10,0.55]**	0.17
PCE scores ≤ 4	19 (8.8)	0.54 [0.20,1.44]	0.26
LGA ʃ			
Total ACE♯	38 (6.8)	1.17 [0.99, 1.39]	0.54

Outcomes	*N (%)*	Adj OR [95% CI]	G* Power Estimation
ACE scores ≥3†	18 (9.1)[ɬ]	1.89 [0.94, 3.79]	0.26
ACE Subtype			
Household Dysfunction	22 (7.5)	1.31 [0.66, 2.61]	0.31
Physical/Emotional Abuse	26 (8.4)	1.69 [0.81, 3.55]	0.38
Sexual Abuse	13 (9.8)	1.77 [0.85, 3.71]	0.19
PCE scores ≥ 5	19 (5.6)	1.25 [0.79,1.99]	0.24
PCE scores ≤ 4	19 (8.8)	1.85 [0.62,5.56]	0.27

Note. ACE = adverse childhood experiences. [♯]Total ACE scores (8 types) for outcome; † ACE scores 0-2 (reference) and 3 or more; [ɬ] Frequency calculated in ACE ≥3 group (*N* = 199); ACE subtype = score of 0 (reference) and one on either ACE item in each subtype. [ʃ] Models adjusted for maternal age, race/ethnicity, and education, and SES; [Ł].Models adjusted for maternal age, race/ethnicity, and education.

*p <.05, **p <.005.

Appendix D

Determination Letters

UNIVERSITY OF CALIFORNIA, SAN DIEGO

UCSD

BERKELEY DAVIS IRVINE LOS ANGELES RIVERSIDE SAN DIEGO SAN FRANCISCO

SANTA BARBARA SANTA CRUZ

DEPARTMENT OF PEDIATRICS
DIVISION OF DYSMORPHOLOGY AND TERATOLOGY

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E-MAIL: gbandoli@ucsd.edu

November 10, 2020

To: Whom It May Concern

From: Gretchen Bandoli, Ph.D., M.P.H.

Re: Jennie Le's Dissertation Topic: Effects of Positive and Adverse Childhood Experiences on Pregnancy and Birth Outcomes

In support of the dissertation project named above, we are providing Jennie Le a dataset mainly procured from an online survey. The dataset is prepared with abstracted variable relevant to the topic from a sub-study we conduct at the Center for Better Beginnings. The dataset is devoid of personal identifiable information (PII), and therefore considered a limited dataset.

The UCSD HRPP/IRB continually reviews the studies that we conduct including the source of the limited dataset. We also have obtained consent from participants in research studies that include the data use in research analysis that will not identify them. While I am a co-investigator in the studies where the data is sourced for the above project, we consulted with the UCSD IRB Reliance Office regarding Jennie Le's participation in order to analyze the limited dataset. It was determined that reliance agreement between the two institutions is not required since Jennie will not be engaged in human subjects research. It "means that IRB submission/approval for her activity is not required because it is not under IRB purview."

Feel free to contact me with any questions.

Sincerely,

Gretchen Bandoli, Ph.D., M.P.H., M.B.A.
Assistant Professor
Center for Better Beginnings, UCSD Departments of Pediatrics and
Associate Director, UCSD Center for Life Research Course

Appendix E

SES SCORES

MOB: Occupation _____ x 5 = 0

☐ Education _____ x 3 = 0

Enter 1, if entering Occ/Ed information; Else=0

Total = 0

FOB: Occupation _____ x 5 = 0

☐ Education _____ x 3 = 0

Enter 1, if entering Occ/Ed information; Else=0

Total = 0

*(Total MOB + FOB)/Total Count = 0.0

**Use the average of BOTH parents total scores ONLY if FOB will provide support AND: BOTH work full time OR BOTH work part time OR BOTH are not working and no one else will be providing support. (Round down to assign the final SES score.)*

SES:

Preg ID:_____

Calculated by:_____

Date calculated:_____

*Validated by:*_____

*Date validated:*_____

SCORING GUIDE

EDUCATION	SCORE
<7th gr	1
9th gr	2
partial HS	3
HS grad	4
partial college/voc. school	5
college grad	6
MA/MD/PhD/JD	7

SES TOTAL	SES SCORE
66-55	1
54-40	2
39-30	3
29-20	4
19-8	5

NOTES: *If not using Total MOB + FOB for scoring SES, explain here:*

Revised 9/19/17