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Associations of Psychosocial Stress and Pregnancy Complications Among Low Income Pregnant Women

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ASSOCIATIONS OF PSYCHOSOCIAL STRESS AND PREGNANCY COMPLICATIONS AMONG LOW INCOME PREGNANT WOMEN

by

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Abstract

Objective: Associations of psychosocial stress and pregnancy complications among low-income pregnant women were examined.

Methods: We administered a self-report survey to 107 obstetrics patients. Exposures included global stress, discrimination, and stressful life events (financial, relationship, and traumatic). Outcomes included number and type of complications reported. Associations were assessed in multivariable Poisson or logistic models adjusting for gravidity, gestational age, and pre-pregnancy substance use.

Results: Total events (beta=0.32, SE=0.10, p=0.002), financial events (beta=0.28, SE=0.10, p=0.002), and relationship events (beta=0.24, SE=.10, p=0.016) were positively associated with number of complications. Life events also were associated with vaginal bleeding (adjusted odds ratio [aOR] = 1.85, 95% confidence interval [CI]= 1.08-3.15, p=0.02), and hypertension (aOR = 2.06, 95% CI = 1.17-3.61, p=0.01). Global stress and discrimination were positively associated with kidney/bladder infections (aOR = 1.66, 95% CI= 1.02-2.72, p=0.04, and aOR= 1.66, 95% CI= 1.00-2.74, p=0.05, respectively).

Conclusion: Psychosocial stress is associated with pregnancy complications.

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Introduction

Substantial pregnancy-related racial disparities exist in the United States (U.S.). Of particular relevance to the Mid-South region is that Black babies and mothers have worse outcomes than White babies and mothers. Likewise, Black pregnant women are more likely than White women to experience medical complications during pregnancy that increase the risk of adverse outcomes to themselves and their babies. This introduction will review the literature on the prevalence, racial disparities, and social determinants of birth outcomes and pregnancy complications.

Birth Outcomes and Maternal Mortality in the United States

Nearly four million babies are born each year in the U.S. In 2018 there were 3,745,540 live births, including 1,956,413 non-Hispanic White, 552,029 non-Hispanic Black, and 886,210 Hispanic births of any race (CDC, 2018). While most of these pregnancies and births are healthy, a substantial number of women, especially ethnic minority women, experience serious health complications during pregnancy (Bornstein et al., 2020). Further, these complications result in increased morbidity and mortality for both mothers and their children (Bornstein et al., 2020).

Of the 380,000 pre-term births (defined as a live birth before 37 weeks of pregnancy) in the U.S. each year, 9.1% were to white mothers, 11.6% to Native Americans, and 13.8% to Black mothers (CDC, 2019). The overall rate of cesarean deliveries in 2017 was 31.9%, but the percent varied by race and ethnicity. For example, 30.8% of the cesarean deliveries conducted in 2017 were for Hispanic women, 31.6% for white women, and 36.1% for African American women (CDC, 2018). Disparities also exist for low birth rates, with rates for Black women double that (14.1%) of Whites (7.0%) and Hispanics (7.5%) (CDC, 2018). Lastly, infant

mortality rates (defined as the number of infant deaths per 1,000 live births) differ substantially by race and ethnic group (5.7 to Hispanic births, 10.8 to Black births, and 4.6 to White births) (Collins et al., 2004; CDC, 2020).

It is estimated that 700 women die in the U.S. every year due to pregnancy complications (Petersen et al., 2020), and minority women have an increased risk of dying from pregnancy complications compared to White women (Creanga et al., 2014). The overall pregnancy-related mortality ratio (i.e., pregnancy-related deaths per 100,000 live births [PRMR]) was 16.7 per 100,000 births, with non-Hispanic Black women (40.8 per 100,000 births), non-Hispanic Native American/Alaska Native (NA/AN) women (29.7 per 100,000 births), and Asian and Pacific Islander women (13.5 per 100,000 births) experiencing higher pregnancy related mortality rates than non-Hispanic white women (12.7 per 100,000 births) (Petersen et al., 2020). Black woman and American Indian/Alaskan Native women face increased odds of PRMR that persist across age groups (ages < 20 - ≥40) and educational attainment. For example, the PRMR in 2019 for non-Hispanic Black and NA/AN women 30 years of age or older was about five times that of their white counterparts (Petersen et al., 2020). Further, the PRMR for non-Hispanic Black (41.0 per 100,000 births) and NA/AN women (32.0 per 100,000 births) with "some college" were higher than all racial/ethnic groups with less than a high school diploma (all remaining racial/ ethnic groups PRMR less than 25.0 per 100,000 births) (Petersen et al., 2019). These adverse birth outcomes are preceded and predicted by several medical complications that may occur during pregnancy.

In Shelby County Tennessee, a predominately Black county, profound racial differences exist in birth outcomes. In 2019, 13 percent of babies were born preterm, with Black babies disproportionally affected compared to Whites (14.5% vs. 9.4%, respectively) (Tennessee

Department of Health, 2019). Similarly, 11.8% of babies had low birthweight including 14.9% of Black babies compared to 6.8% of Whites (Tennessee Department of Health, 2019).

Medical Complications During Pregnancy and Racial/Ethnic Disparities

There are several common medical complications that women may experience during pregnancy that contribute to adverse birth outcomes. Pregnancy complications are defined by the Centers for Disease Control and Prevention (CDC) as "health problems that occur during pregnancy that can affect the mother's health, the baby's health, or both, and greatly contribute to adverse birth outcomes" (CDC, 2020, np). These complications include vaginal bleeding; kidney and bladder infections; severe nausea, vomiting, and dehydration; incompetent cervix; high blood pressure (including pregnancy-induced hypertension, preeclampsia, eclampsia, and toxemia); placental problems (e.g., abruptio placentae or placenta previa); preterm labor; premature rupture of membranes; and gestational diabetes (Intapad, 2013). These conditions can compromise fetal development which can have negative effects that follow children into adulthood and increase the mother's risk of developing complications in future pregnancies (Neiger, 2017; Alderdice et al., 2012).

There are substantial racial and ethnicity disparities in many medical complications experienced during pregnancy. Black women in particular experience a greater burden of pregnancy complications compared to other racial groups (Oribhabor et al., 2020). Black women, compared to White women, are at higher risk for hypertensive disorders, premature rupture of membranes, placental abruption, peripartum infection, placenta previa, preterm labor, and antepartum and postpartum hemorrhage (Bornstein et al., 2020; Creanga et al., 2014). In a retrospective, cross-sectional cohort study in California that examined 443,532 mothers in labor who were at risk for cesarean delivery, Black women, when compared to white women, had

increased risk of 12 out of 31 conditions that are correlated with increased cesarean delivery risk (Gregory & Korst, 2003), including prenatal medical complications such as hypertensive disorders and ruptured membranes. In a cross-sectional study examining 608 women (304 Black, 304 White), recruited from randomly selected hospitals in North Carolina and who had one of three pregnancy-related morbidities (pregnancy-related hypertension, puerperal infection, or hemorrhage), Black women had more severe hypertension, lower hemoglobin concentrations preceding hemorrhage, and a higher rate of obesity, all of which increase Black women's risk of death (Harper et al., 2007).

Vaginal bleeding is a common pregnancy complication that may occur at any stage of pregnancy and is associated with preterm delivery and low-birth weight (Amirkhani et al., 2013; Hackney & Glantz, 2011). In the second and third trimesters, vaginal bleeding is a risk factor for placenta previa, placenta abruption, fetal demise, and spontaneous miscarriage (Amirkhani et al., 2013) which increases the risk for maternal mortality (Koifman et al., 2008).

Urinary tract infections (UTIs) are among the most common pregnancy complications mothers experience and are estimated to occur in 8% of pregnancies (Baer et al., 2021). Studies have shown that UTIs disproportionately affect minority women including NA/AN women (24.2%) and Black women (20.3%) compared to White women (16.6%) (Whitehead et al., 2009). Studies have also reported that 25%-40% of pregnant women with untreated UTI's are at an increased risk for other pregnancy complications including premature birth, cesarean delivery, and low-birthweight children (Kalinderi et al., 2018**)** Further, UTIs increase the risk of hypertensive disorders, including preeclampsia, by causing adverse systematic inflammatory responses during pregnancy (Yan et al., 2018).

Hypertensive disorders during pregnancy are classified into four categories which include: chronic hypertension, preeclampsia-eclampsia, preeclampsia superimposed on chronic hypertension, and gestational hypertension (Mammaro et al., 2009). Hypertensive disorders are estimated to occur in about 7% of all pregnancies and are responsible for 10% to 15% of all maternal deaths in the United States (Lai et al., 2017). Further, hypertensive disorders increase the risk of maternal complications including placental abruption, stroke, and gestational diabetes, as well as fetal complications including low-birthweight babies and death (Shahul et al., 2015). Hypertensive disorders disproportionately affect Black pregnant women, compared to Whites (Miller et al., 2020, Ghosh et al., 2014). For example, Ghosh et al. (2014) reported in a study of 56,617 nulliparous women that Black women had higher rates of entering pregnancy with chronic hypertension (adjusted odds ratio (AOR)=1.43, 95% CI 1.11–1.84) and had higher odds of developing mild (AOR=1.26, 95% CI 1.10–1.45), severe (AOR=1.31, 95% CI 1.10–1.57) or superimposed preeclampsia (AOR=1.98, 95% CI 1.40–2.80), compared to White women. These racial disparities in hypertensive disorders during pregnancy persist when controlling for socioeconomic differences (Shahul et al., 2015). Although these racial disparities are partly due to black women being more prone to elevated blood pressure than White women prior to pregnancy, which persists into pregnancy (Miller et al., 2020), Black women also disproportionately experience psychosocial stress and other social determinants of poor - pregnancy outcomes. These non-biological factors including discrimination, racism, poverty, and poorer health care can lead to blood pressure disorders and other health conditions during pregnancy, as reviewed below.

Social Determinants of Pregnancy Complications and Negative Birth Outcomes

Racial and ethnic disparities in pregnancy complications and birth outcomes reflect social inequities (Hobel et al., 2008) which are important but often overlooked determinants (Grobman et al., 2018). The magnitude of social determinants' contributions to pregnancy outcomes is suggested by a study by Goldenberg and colleagues which reported that screening methods which consider multiple medical risk factors such as fetal fibronectin, cervical length, history of preterm birth, and bacterial vaginosis only predict 60% of preterm births, leaving the other 40% of preterm births unexplained. This suggests that social factors are important, yet often overlooked, determinants of prenatal health.

Social determinants of health (SDHs) are defined as the conditions surrounding where an individual is born, grows, lives, works, and ages and have been linked to birth outcomes (Maness, 2016; Nkansah-Amankra et al., 2010). The most fundamental SDH is socioeconomic status (SES), measured by income, education or occupation, which, is negatively related to overall mortality and associated with a host of preventable chronic illnesses (Kim et al., 2018; Ospina et al., 2020) Likewise, SES is inversely associated with pregnancy and birth outcomes (Kim et al., 2018). Low SES increases the risk of experiencing adverse pregnancy complications such as preeclampsia, eclampsia, and gestational diabetes and increases the risk of adverse birth outcomes such as preterm birth and maternal death (Kim et al., 2018). For example, pregnant women with low educational attainment are more likely to suffer from adverse birth outcomes compared to those with higher educational attainment (Zhang et al., 2019). In a cross-sectional, California-based population study, black women had higher rates of preterm birth even when controlling for education (adjusted odds ratio (AOR)=1.69, 95% CI 1.38–2.08) (Bravemen et al., 2015).

SES differences across groups and individuals reflect numerous disparities in social and environmental conditions that impact pregnancy and birth outcomes (Ospina et al., 2020). Communities that are characterized by high rates of poverty and crime, high rates of crowded living, majority Black, and low in educational attainment are risk factors for low birth weight, preterm birth, and other adverse birth outcomes (Nkansah-Amankra et al., 2010). For example, women who develop either diabetes or hypertension have increased risk of preterm or cesarean birth (Lai et al., 2017); the development of diabetes and hypertension is related to social determinants such as inadequate access to physical activity opportunities and poor nutrition (Hill et al., 2013). Additionally, women who experience abuse or violence by a partner are at increased odds of having little to no prenatal care, requiring hospitalization during pregnancy, and delivering low birth weight children (Maness et al., 2016).

SES and other social determinants play a major role in explaining racial differences between Blacks and Whites in pregnancy complications and birth outcomes (Kozhimannil et al., 2016) since Blacks, compared to Whites in the U.S., are more likely to live in disadvantaged communities (Kozhimannil et al., 2016). However, racial/ethnic disparities in pregnancy complications and birth outcomes persist even when SES is held constant. For example, a study that examined Black and White soldiers and their spouses living on a military base in the US with equal pay, access to healthcare, and living arrangements, found that Black mothers still experienced more adverse birth outcomes compare to White mothers (Alexander et al, 1993; Rawlings & Weir, 1992) Another study that examined more than 600 Black mothers and 400 White mothers, found that Black college graduates still had 1.67 times the risk of delivering preterm, and 2.48 times the risk of delivering low birthweight children, compared to White college graduates (McGrady et al., 1992). Adjustment for several measures of social and

economic status including income did not reduce the race association. These findings suggest that disparities in social conditions in and of themselves do not adequately explain the elevated rates of pregnancy complications and birth outcomes experienced by Black women in the U.S. Another possible contributor to these disparities that deserves greater attention is psychosocial stress during pregnancy, which is associated with social and racial disparities, and may be a more proximal determinant of increased risk of perinatal outcomes such as pregnancy complications (Nutor et al., 2018; Kim et al., 2018).

Linkages of Psychosocial Stress with Pregnancy Complications and Birth Outcomes

Investigators believe that differences in individual responses to stressors, availability and access to social resources, and socioeconomic status differences between racial groups are the main routes by which social determinants of health adversely affect birth outcomes (Nkansah-Amankra et al., 2010). Psychosocial stress is a consequence of external demands that draw upon the adaptive capability of an organism and result in psychological and biological changes that increases risk of several diseases (Dominguez et al., 2008). Psychosocial stress is an umbrella term for a host of stressors including perceived global stress (Cohen et al., 1983), experiencing life events that are usually perceived to be stressful (Witt et al., 2014), and discrimination (Kim et al., 2014). Global perceived stress is typically measured with questions that assess a person's perception of the overall magnitude of stress experienced during a recent period, and how he or she has coped with the stress (Cohen et al., 1983). In contrast, some stress scales such as the Pregnancy Risk Assessment Monitoring System (PRAMS) Stressful Life Events Scale **(**Goodman et al., 1998**)** inquire about whether any of several life events have occurred during a specific time which are typically considered to be stressful, such as moving to a new address or

losing a job. Lastly, discrimination is typically perceived as stressful (Williams et al., 2007) and is assessed by items such as "You are treated with less respect than other people are" (yes vs no).

Socially disadvantaged pregnant women experience numerous psychosocial stressors, such as financial difficulties, unemployment, relationship difficulties and inadequate social support (Hobel et al., 2008), all which can contribute to pregnancy complications and adverse birth outcomes (Alderdice et al., 2012). Adults living below poverty are also two to three times more likely to report serious psychological stress than those living above poverty (APA, 2016). Moreover, the poverty rate for African Americans (20.8%) compared to Whites (8.1%) contributes to myriad of stressors and a greater burden of stress for low SES Black women. (APA, 2016; Dominguez et al., 2008).

There is evidence that all three types of psychosocial stressors – perceived global stress, stressful life events, and discrimination are related to adverse birth outcomes, although linkages of stress to pregnancy complications have not been adequately studied (Dominguez et al., 2008; Wadhwa et al., 2011). Perceived global stress encompasses feelings or thoughts that one may have about a stressful situation, how much stress it generates at a given point or over time, and how well one perceives oneself to cope with it (Tanpradit & Kaewkiattikun 2020; Cohen et al., 1983). Increased levels of perceived stress are associated with adverse birth outcomes including preterm birth, low birthweight, risk of gestational hypertension, and infant mortality. Further, it can have a strong negative effect on quality of life for pregnant women (Thongsomboon et al., 2020; Bane et al., 2020). For example, Tanpradit & Kaewkiattikun (2020) reported in an unmatched case-control study of 200 postpartum Thai women, that mean perceived global stress score on the PSS-10 scale (Cohen et al., 1983) at postpartum was significantly greater in mothers who gave birth preterm, compared to term births (19.43±4.48 vs 14.08±4.06, $p<0.001$). Further,

in a prospective cohort study examining perceived global stress among Puerto Rican women, woman in the highest quartile of stress experienced more than three times the risk for preterm birth (OR=3.30, 95% CI 1.38-8.87) and low birthweight (OR= 3.53, 95% CI 1.27-9.86) (Szegda et al., 2018).

Few studies have evaluated whether perceived global stress is associated with pregnancy complications. In a prospective study, Oni and colleagues (2015) assessed perceived global stress, using the 10-item Perceived Stress Scale (PSS-10; Cohen et al.,1983) among 146 pregnant women in New Orleans and Baton Rouge six to twenty-three months after Hurricane Katrina. Then, after their delivery they determined from the mothers' medical records whether they had experienced any of several pregnancy complications (pregnancy-induced hypertension, gestational diabetes, induction of labor, or cesarean section). Dichotomizing participants at the sample median of the PSS-10 score, they found that women who reported the most stress (i.e., scoring in the top half) were more likely than those scoring in the bottom half to have developed pregnancy induced hypertension (aOR 1.16, CI 1.05-1.30; p=<0.01) and gestational diabetes (aOR=1.13, CI 1.02-1.25; p=0.02), while cesarean birth was just outside statistical significance (aOR=1.07, CI 1.00-1.14; p=0.06). Perceived stress was not associated with induction of labor (aOR=1.03, 95% CI= 0.97-1.08; p=0.39).

Roy-Matton and colleagues (2011) conducted a prospective observational study of 303 pregnant women in Quebec, Canada, recruited during ten to twenty weeks of gestational age, and followed through delivery. Participants were administered three instruments that assessed several aspects of perceived stress. The "perceived stress" measured included the 8-item MSP-9 scale (Lemyre & Tessier, 2003) that assessed global perceptions of feeling stressed (e.g., "I feel calm, "I feel rushed"). "Psychological distress" was measured with the 14-item IDPESQ (Préville et

al., 1992), which assessed symptoms of anxiety, depression, cognitive difficulty, and irritability. Lastly, "Daily hassles" was assessed using the 12-item Prenatal Profile Hassles Scale (Misra et al., 2001) which assessed perceived stress about several specific aspects of daily life including finances, relationship problems, working, and moving/relocating. Pregnancy complications were categorized dichotomously as experiencing at least one of seven complications during the pregnancy (i.e., pre-term birth medication indications, preterm premature rupture of the membranes (PPROM), spontaneous preterm delivery, intrauterine growth restriction (IUGR), gestational hypertension, and gestation diabetes). Women with complications had a higher mean perceived stress scores at ten to twenty weeks of pregnancy (32.6 ± 11.7 vs. 29.3 ± 10.3; $P < 0.05$; possible score range = 9 to 72). Psychological distress and daily hassles were not associated with pregnancy complications.

In sum, there is evidence from several studies that perceived stress is related to adverse birth outcomes, but only two studies to date (Roy-Matton et al., 2013; Oni et al., 2015) have evaluated whether perceived global stress is related to pregnancy complications. These studies are limited, however, in that both exposures and outcomes were assessed crudely (e.g., dichotomizing perceived stress scores or pregnancy complications). This thesis expands on this work by including specific measures of stressors and several specifical pregnancy complications.

Many studies have assessed whether the number of stressful life events recently experienced was associated with birth outcomes. Stanhope & Hogue (2020) used PRAMS data from a representative sample of pregnant women in Georgia from 2012 to 2015 to assess the cross-sectional associations between experiencing stressful life events (trauma, financial, and relational) and pre-term birth. Women who experienced any financial stress vs. those who did not report financial stress had increased prevalence of preterm birth (adjusted prevalence ratio

(aPR)= 1.32 (95% CI= 0.97-1.79). Additionally, those who experienced high numbers of stressful life events, collapsed across trauma, financial, and relational events, had higher prevalence of preterm birth. Specifically, compared to women who reported no stressful life events, those reporting 4 or more events had 25% greater prevalence of pre-term birth (aPR = 1.25, 95% CI= 0.82-1.91), and those reporting 5 or more events had 57% greater prevalence of pre-term births (aPR= 1.57, 95% CI= 0.97-2.54).

Zhu and colleagues (2010) reported in a cross-sectional study of 1800 Chinese women that increased stressful life event scores were associated with preterm birth during the first trimester (adjusted risk ratio [aOR]= 2.40; 95% CI= 1.13–5.09) and the second trimester (aOR= 2.86; 95% CI= 1.26–6.47), and that each additional life event was associated with a 99-gram decrease in infant birth weight (95% CI -137.98-60.20). Weber and colleagues (2020) reported in a cohort study of 4395 U.S. women that women experiencing relationship difficulties were at risk of preterm birth (RR: 1.9, 95% CI= 0.9-3.9) and low birth weight (RR= 2.0, 95% CI= 0.9-4.4); further women who reported someone close to them was a victim of violence or abuse had increased risk of low birthweight (RR= 1.8, 95% CI= 1.1-2.7). In sum, there is consistent evidence that experiencing a greater number of stressful life events during pregnancy increases the risk of adverse birth outcomes.

Few studies, however, have evaluated whether stressful life events are related to complications during pregnancy. Chen and colleagues (2020) reported in a cross-sectional analysis of women who had a live birth in 2007 in Los Angeles County that financial stressors were significantly associated with higher risk of gestational diabetes, and one additional financial stressor was associated with 20% greater odds of having gestational diabetes (OR=1.20; 95% CI= 1.01-1.40, p=0.03). The sum of all stressors was positively associated with hypertensive

disorders during pregnancy, albeit not significantly associated (OR=1.05; 95% CI=0.99, 1.13, p=0.12).

Another study by Zheng and colleagues (2020) included a cross-sectional analysis of 956 pregnant women in Beijing, China. “Severe stressful events” were assessed with the question “During the period after your last menstruation, have you experienced any severe stressful events, including the death or life-threatening diseases in first-degree relatives or partners, intensive conflict with others or other very severe life events that caused strong psychic trauma to you?” Participants reported whether or not any severe stressful event had occurred (yes or no) and also the frequency with which the event(s) had happened: no stressful life events, once or less than one time per week, or more than one time per week. Adjusted for age, BMI, ethnicity, SES, smoking status and drinking status, women who reported at least one severe stressful event had 2.22 greater odds (95% CI= 1.56-3.16) of experiencing abnormal vaginal bleeding during their pregnancy; However, no substantial dose-response association was observed. Compared to women who reported no stressful life events, those who reported them once or less than one time per week had 2.21 greater adjusted odds of experiencing abnormal vaginal bleeding (95% CI= 1.49-3.29) whereas those who reported severe stressful events more than once per week had 2.22 greater odds of vaginal bleeding (95% CI=1.47-3.34). In sum, Zheng et al. (2020) found a positive association between stressful life events and pregnancy complications. However, only vaginal bleeding was assessed, and it is unknown whether stressful life events are associated with other pregnancy complications.

Finally, Zachariah (2009) conducted a prospective observational study of 111 women registered in urban clinics in northeastern United States. Participants were administered several psychological instruments at fourteen to twenty-two weeks of pregnancy, including the Life

Events Scale (Norbeck, 1984), for which 79 events were self-assessed as to whether they had occurred and were considered by the respondent to be "bad." Complications during pregnancy, including hypertensive disorders, placenta previa, abruptio placenta, and pre-term labor, were assessed from medical records after delivery. Participants were dichotomized to have experienced any complications vs. no complications throughout the entire pregnancy. The number of bad events reported at fourteen to twenty-two weeks of pregnancy did not differ between participants with versus without complications, but did predict neonatal complications, including low birth weight and prematurity.

One understudied type of stressor that may affect pregnancy complications and birth outcomes is discrimination. Discrimination refers to the act of making unjustified distinctions between human beings based on a group, class, or other category to which they are perceived to belong (Earnshaw et al., 2013). Discrimination in relation to one's socioeconomic status or race is especially common (Rosenthal et al., 2015). For example, studies have reported the Black and Hispanic women were at increased odds of discrimination compared to white women due to racial, language, or cultural barriers (Attanasio & Kozhimannil, 2015).

One study found indirect evidence that discrimination increases the risk of low birth weight. Lauderdale (2006) compared prevalence of low birth weight, according to ethnicity of the mother, among all newborns in the state of Michigan during the six months following September 2001 (when the 9/11 tragedy occurred) and the same six calendar months one year earlier. Lauderdale hypothesized that after 9/11, pregnant women who appeared to be of Middle Eastern origin would experience greater discrimination than other pregnant women, which would be reflected in a greater risk of delivering a baby with low birthweight, defined as < 2500 grams. This hypothesis was supported. Relative risk of delivering a baby with low birth weight after

9/11 (October 2001-March 2002) compared to before 9/11 (October 2000-March 2001) was not statistically significant for all women (relative risk [RR]= 1.00, 95% CI= 0.97-1.02, p=0.850). Likewise, risk of developing a low-birth-weight baby after 9/11 did not increase for all foreign-born women (RR= 1.00, 95% CI= 0.97-1.04, p=0.912), non-Hispanic blacks (RR= 1.00, 95% CI= 0.93-1.07, p= 0.899), or Hispanic women (RR= 0.99, 95% CI= 0.95-1.03, p=0.592). In contrast, risk of delivering a low birthweight baby was higher after 9/11 than before 9/11 for women with Arabic surnames (RR= 1.34, 95% CI= 1.04-1.73, p= 0.022). Risk was especially high for women who gave birth to a baby whose given name was "ethnically distinctive," suggesting a stronger ethnic identity and greater likelihood of experiencing ethnic discrimination in the aftermath of 9/11. For this sub-group, risk of delivering a low-birth-weight baby was more than two times greater after 9/11 than before (RR= 2.25, 95% CI= 1.29-3.90, p=0.003).

One other study directly assessed discrimination and its relation to birth outcomes. Earnshaw et al (2013) conducted a secondary analysis of stress and birth outcome data, using structural equation modeling, from a randomized controlled trial testing two models of care delivery, among 420 Black or Latina pregnant women in New York City. Participants completed the Everyday Discrimination Scale (Williams et al., 1997) during the second trimester of pregnancy along with the Center for Epidemiological Studies Depression Scale (Radloff, 1977) to measure depressive symptoms. Birth weight was assessed from labor and delivery logs at hospitals and health centers. In the logistic regression model, everyday discrimination was associated with greater odds of low birth weight controlling for maternal age, native or foreign born, grade level, relationship status, nutrition, exercise, pregnancy history and gestational age (OR=2.87, p=0.05). In the structural equation model, everyday discrimination had a statistically significant indirect effect on birth weight through depressive symptoms of (-0.04, p=0.01). A

one-point increase in the score on the Everyday Discrimination Scale was associated with a 49-gram reduction in birth weight.

Although beyond the scope of this thesis, it is important to note that multiple biomarkers, including hormonal responses, may mediate the associations of psychosocial stress with birth outcomes and pregnancy complications. Stress levels are hypothesized to stimulate neuroendocrine responses which can result in cervical changes, uterine complications, and preterm labor and birth (Anachebe, 2006). Multiple stress response hormones (i.e., cortisol, corticotropin-releasing hormone [CRH], adrenocorticotropic hormone [ACTH]) are viewed as likely contributors towards pregnancy complications and adverse birth outcomes (Latendresse, 2009; Anechebe, 2006).

Studies that examined maternal placenta CRH levels during early gestations periods (16-20 weeks) documented that increased CRH levels are associated with increased risk of preterm birth and can increase the odds of preterm birth substantially (Latendresse, 2009). In a study of 524 socioeconomically and ethnically diverse women, psychosocial stress levels at eighteen to twenty weeks of gestation were associated with changes in maternal CRH (corticotrophin-releasing hormone) levels which is a biomarker for low birthweight (Wadhwa et al., 2011). Multiple stress response hormones have been found to contribute to increased production of CRH including ACTH, oxytocin, cortisol and catecholamines (Hillhouse & Grammatopoulos 2002) indicating there are likely multiple cascading physiological pathways linking psychosocial stressors to pregnancy complications and birth outcomes.

Psychosocial stress can also inhibit proper immune system functionality and lead to increased risk for intraamniotic infection or inflammation (Anechebe, 2006). For example, studies have also found positive associations between CRH levels and inflammatory responses

during gestation which emphasizes that such responses are driven by increased levels of stress response hormones (Coussons-Read, 2013). In sum, endocrine changes and fetal development problems can stem from maternal exposure to psychosocial stress, which leads to fetal exposure to stress hormones, resulting in pregnancy complications and adverse birth outcomes (Hobel et al., 2008).

Conclusions

This review indicates that there is a sizeable literature on how psychosocial stress influences birth outcomes, especially pre-term birth, but little is known about how psychosocial stress influences medical complications during pregnancy. Since multiple physiological pathways exist by which stress may influence these complications, as reviewed above, and because complications during pregnancy are important determinants of birth outcomes (Dominguez et al., 2005), understanding how stress and pregnancy complications are linked is important. It is especially important to reduce bias as much as possible in assessing these associations, by considering important confounders including gravida status (number of pregnancies**)**, gestational age (trimester of pregnancy), and substance use. Substance use, for example, is associated with psychosocial stress (Sinha, 2008) and adverse birth outcomes (Louw, 2018) and therefore may confound stress/pregnancy complication associations. Many studies have controlled for common covariates such as gestational age, but fewer studies have adjusted for substance use before pregnancy, and gravida status of mother. Both variables are related to psychosocial stress (Alderdice et al., 2012**)**

Purpose of The Thesis

This thesis fills the gap in understanding how psychosocial stress is linked to pregnancy complications by examining the associations of perceived stress, stressful life events, and discrimination on several pregnancy complications among a sample of 107 low-income pregnant women, a majority of whom are African American. My hypotheses are that greater perceived stress, more stressful life events, and greater perceived discrimination will be associated with (1) greater likelihood of experiencing several pregnancy complications and (2) a greater cumulative number of pregnancy complications.

Methods

Design and Data Description

We utilized a cross-sectional observational design to examine the associations of psychosocial stress and pregnancy complications among low income, pregnant women receiving prenatal health care at Regional One Health (ROH), a public hospital in Memphis, TN. Eligibility requirements included that the patient must be pregnant, English speaking, reside in Shelby County, and be at least 18 years of age.

Enrollment Procedures

When a patient arrived for her scheduled prenatal appointment at ROH, she was approached by one of the two study physicians who verified her eligibility. If the patient met the inclusion criteria, the study was explained to her. After acquiring consent, the participant was given a confidential brief questionnaire containing the study instruments which she self-completed while waiting in a private exam room for her appointment.

Measures

Descriptive and pregnancy-related variables: Several sociodemographic characteristics were assessed including self-reported age, race, and education. Pregnancy-related characteristics included gravida status (self-reported number of pregnancies) and pregnancy stage (1^{st}, 2^{nd}, or 3^{rd} trimester). Self-reported substance use history (before pregnancy) was assessed, including tobacco, alcohol, marijuana. A composite substance use flag variable was created indicating whether participants reported use of any substance prior to pregnancy versus none.

Exposures: Perceived global stress, stressful life events, and perceived discrimination were assessed as exposures. Perceived global stress was measured by the Perceived Stress Scale (PSS-4; Cohen et al., 1983; Karam et al., 2012), which is a four item self-report measure developed to assess the degree to which respondents find life situations to be uncontrollable, overwhelming, or unpredictable. These items included: (1) In the last month, how often have you felt that you were unable to control the important things in your life? (2) In the last month, how often have you felt that things were going your way? (3) In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? (4) In the last month, how often have you felt confident about your ability to handle your personal problems? Internal consistency was adequate in our study (Cronbach alpha = 0.68), and previous studies using the PSS-4 have documented good test-retest reliability over two weeks and adequate predictive ability (Karam et al., 2012).

Stressful Life Events Screening Questionnaire (SLESQ), from the Pregnancy Risk Assessment Monitoring (PRAMS; http://www.cdc.gov/prams/questionnaire.htm) questionnaire asked participants if they experienced any of 13 specific stressful events six months before or during the current pregnancy (yes versus no). These events were: (1) A close family member or

friend was very sick and had to go into the hospital, (2) I got separated or divorced from my husband or partner, (3) I moved to a new address, (4) I was homeless or had to sleep outside, in a car, or in a shelter, (5) My husband or partner lost their job, (6) I lost my job, (7) My husband, partner, or I had a cut in work hours or pay, (8) I argued with my husband or partner more than usual, (9) My husband or partner said he didn't want me to be pregnant, (10) I had problems paying the rent, mortgage, or other bills, (11) My husband, partner, or I went to jail, (12) Someone very close to me had a problem with drinking or drugs, and (13) Someone very close to me died. Total number of stressful events was calculated by summing all of the events that were reported from the list of 13 events. The 13 items were also classified into three distinct sub-groups, based on previous studies (Burns et al., 2015; Stone et al., 2015) to reflect relational partner-related events (items 2, 8, 9) trauma-related events (items 1, 4, 11, 12, 13), and financial events (items 3, 5, 6, 7, 10). The reported events within each of the three sub-groups were summed. The total score, as well as each of the three sub-scale scores, were analyzed in separate models to test associations with pregnancy complications (discussed below in the Statistical Analysis section). Previous studies using the SLESQ have documented good test-retest reliability over two weeks and adequate predictive ability (Allen et al., 2019; Allen et al., 2020).

Perceived Discrimination was assessed using the Everyday Discrimination Scale (EDS) (Williams et al., 1997) which measures routine and unfair treatment in everyday life. These items included: (1) You are treated with less courtesy than other people are, (2) You are treated with less respect than other people are, (3) You receive poorer service than other people at restaurants or stores, (4) People act as if they think you are not smart, (5) People act as if they are afraid of you, (6) People act as if they think you are dishonest, (7) People act as if they're better than you are, (8) You are called names or insulted, and (9) You are threatened or harassed. A 5-level

response variable for each item captured the frequency with which the event typically occurs in their day-to-day life, ranging from "never" to "almost every day". Internal consistency was good in our study (Cronbach alpha = 0.84), and previous studies using the EDS have documented good test-retest reliability over two weeks and adequate predictive ability (Krieger et al., 2005).

Outcomes: We assessed whether each of nine specific pregnancy complications were experienced during the current pregnancy, derived from the PRAMS survey. The nine complications included: vaginal bleeding; kidney or bladder urinary tract infection (UTI); gastrointestinal issues, including severe nausea, vomiting or dehydration; Hypertensive disorders, defined as high blood pressure or hypertension, including pregnancy-induced hypertension, preeclampsia, or toxemia; and labor pains more than three weeks before the baby was due (preterm or early labor). A sum score was calculated reflected the total number of complications reported, and each individual complication also was examined separately as a dichotomous outcome. Details about all exposure and outcome measures are contained in the Supplemental Table.

Statistical Analysis

Initially, data were checked and cleaned by conducting univariate analyses to verify accuracy of data distribution (e.g., range of values) and to assess missing values. Several sociodemographic and pregnancy-related variables, as well as substance use before pregnancy were assessed as potential confounders, using the "10% rule" (Budtz-Jørgensen et al., 2007), such that a variable was considered to be a confounder if its presence in a model changed the exposure/outcome association by at least 10% compared to when the variable was excluded. Several sociodemographic, pregnancy-related, and behavioral variables were assessed as potential confounders including age, race, and education, trimester of the pregnancy, gravidity

status, and substance use before pregnancy. Variables that met this 10% criterion were included as covariates in multivariable models. Models for which the outcomes were assessed by the total number of pregnancy complications used Poisson regression which accommodates count data. Goodness of fit for Poisson models was assessed using the goodness of fit chi-square test using a p-value of >0.05 to judge fit being adequate (Williams, 2007). Models that assessed whether each specific pregnancy complications were reported (dichotomous variables) were assessed with logistic regression models. Exposure variables (psychosocial stressors) were standardized by subtracting the sample mean score from each participant's score and dividing by the sample standard deviation; this was done to facilitate comparison of the magnitude of associations across analyses.

Results

All eligible patients who were invited to participate did so, resulting in 107 mothers included in the sample. There was very little missing data; of the seventeen variables analyzed, there was, at most, one missing case.

Based on the 10% rule criterion described above to select confounders, a standard set of covariates was included in all multivariable models, including gravida status, pregnancy stage, and substance use before pregnancy (modeled as a dichotomous flag variable indicating whether any substance use was reported before pregnancy).

As shown in Table 1, the average age of participants was 27.1 ± 5.5 years with a range of 18 to 41 years. Most respondents were Black (88.8%) and 11.2% were white. Most respondents graduated high school (85.8%) and 44.3% completed at least some college. In general, participants reported low levels of psychosocial stressors. Mean perceived global stress scores on

the PSS-4 was 4.5 (possible score range was 0-16), 5.2 for the Everyday Discrimination Scale (possible score range from 0 to 27), 2.4 for the Stressful Life Events Screening Questionnaire (possible score range from 0 to 10), 0.7 for the trauma sub-scale (possible score range 0-4), 1.1 for the financial stressors sub-scale (possible score range 0 to 3), and 0.5 for the relationship sub-scale (possible score range 0 to 3).

In terms of outcomes, participants reported an average of 0.80 complications (SD 0.95) out of 13 assessed complications. Almost half of the mothers reported no complications (48%), 31% reported one complication, and 21% reported two or more complications. Of the 13 specific complications, five were reported by at least five respondents, and were analyzed as separate outcomes, including (1) Kidney or bladder (urinary tract) infection (UTI) reported by 22% (n=23), (2) Severe nausea, vomiting, or dehydration reported by 17% (n=18) (3), Vaginal bleeding, reported by 14% (n=15) of respondents, (4) High blood pressure hypertension (including pregnancy-induced hypertension, preeclampsia, or toxemia), reported by 14% (n=15), and (5) Labor pains more than 3 weeks before baby was due (preterm or early labor), reported by 5% (n=5).

As shown in Table 2, the association of each psychosocial stressor (discrimination, perceived global stress, the total number of reported stressful life events, and the number of trauma events, financial events, and relationship events, with the total number of pregnancy complications) were assessed in Poisson regression models. Goodness of fit was adequate for all six tested models (all p-values > 0.092). Both crude (unadjusted) and multivariable (adjusted) models are reported. Multivariable models controlled for gravidity, trimester, and substance use before pregnancy. Total number of stressful life events, as well as the number of financial events and relationship events, were positively associated with the number of pregnancy complications

reported, in both crude and adjusted models. In the adjusted models, a one standard deviation difference in the total number of stressful life events reported (2.3 extra events) was associated with 0.32 extra pregnancy complications (beta=0.32 SE=0.10, p=0.002). Likewise, the financial events and relationship events sub-scales were both positively and significantly associated with the sum of the number of pregnancy complications reported in adjusted models ($\beta_{\text{finanacial}}$=0.28, SE=0.10, p=0.002 and $\beta_{\text{relationship}}$=0.24, SE=.10 p=0.016).

Table 3 reports multivariable associations of the six psychosocial stress variables with the five most prevalent specific pregnancy complications. The odds of reporting kidney or bladder infections was increased in participants who reported greater perceived discrimination and global perceived stress. A one standard deviation increases in the perceived discrimination score (6.1 points) and perceived global stress (3.0 points) were both associated with 66% greater odds of reporting kidney or bladder infections ($aOR_{\text{perceiveddiscrim.}}$= 1.66, 95% CI= 1.02-2.72, p=0.04, and $aOR_{\text{perceivedstress}}$= 1.66, 95% CI= 1.00-2.74, p=0.05).

The odds of vaginal bleeding were increased in participants who reported a greater number of stressful life events as well as a greater number of financial events and relationship events. A one standard deviation increase in the total of stressful life events (2.3 extra events) was associated with 85% greater odds of reporting vaginal bleeding during pregnancy (aOR= 1.85, 95% CI= 1.08-3.15, p=0.02), and 106% greater odds of hypertensive disorders (aOR= 2.06, 95% CI= 1.17-3.61, p=0.01). A one standard deviation increase in the sum of financial events (1.3 extra events) and relationship events (0.7 extra events) was associated with 73% and 71% greater odds or reporting vaginal bleeding (aOR= 1.73, 95% CI= 1.03-2.91, p=0.04, and aOR= 1.71, 95% CI= 1.02-2.88, p=0.04), respectively.

Finally, similar to vaginal bleeding, the odds of hypertensive disorders were increased in participants who reported more stressful life events. A one standard deviation increase in the total number of stressful life events reported (2.3 events) was associated with a doubling of the odds of reporting a hypertensive disorder (aOR= 2.06, 95% CI= 1.17-3.61, p=0.01). Likewise, a one standard deviation increase in the number of financial events (1.3 events) and relationship events (0.07 events) reported, were associated with an approximately doubling of the odds of a hypertensive disorder ($aOR_{financial}$= 2.27, 95% CI= 1.32-3.88, p=0.003, and $aOR_{hypertensive}$= 1.95, 95% CI= 1.15-3.29, p=0.01).

Discussion

This thesis examined cross-sectional associations between psychosocial stress and pregnancy complications among low-income women, a majority of whom were African American. It was hypothesized that three major indices of psychosocial stress (perceived global stress, perceived discrimination, and the number of stressful life events reported) as well as the number of specific types of stressful life events—trauma events, financial events, and relationship events—would be positively associated with pregnancy complications, including the number of complications experienced during the pregnancy, and whether each of several specific types of pregnancy complications was experienced. Results partially supported these hypotheses. The total number of stressful life events reported was positively associated with the number of pregnancy complications reported in both a crude model and a multivariable model that adjusted for several confounders. Total number of stressful life events was also positively associated with two specific pregnancy complications including vaginal bleeding and hypertensive disorders. The associations between stressful life events and pregnancy complications were strongest for two specific types of stressful life events—the number of financial events and the number of

relationship events reported. The number of trauma events reported was positively but not significantly associated with pregnancy complications.

Despite the differential associations of type of psychosocial stress with pregnancy complications, it is noteworthy that perceived discrimination, perceived global stress and the number of stressful life events reported for the most part all were positively associated with all five of the specific complications assessed. Perceived global stress and discrimination were positively, albeit non-significantly, associated with the total number of complications reported, and in fact, the association of perceived global stress with complications was fairly large (adjusted beta= 0.21, SE= 0.11) and just outside the range of statistical significance (p=0.054). Lack of statistical significance for some of these associations may reflect statistical power limitation or random or systematic error in the self-report instruments used, as discussed below.

Both perceived global stress and discrimination were positively associated with kidney or bladder infections. To our knowledge, no studies have assessed links between psychosocial stress and kidney or bladder infections. However, psychosocial stress has well-known effects on immune functioning (Tsyglakova et al., 2019), and has been causally linked to other kinds of infections including enteric (Gui, 1998) and upper respiratory (Pedersen et al., 2010). The cross-sectional nature of the present study is not able to elucidate directionality of the association and further research is needed to disentangle these potentially important links.

Although the sample size of this study was fairly small (n=107) the fact that several statistically significant associations were found indicates that the magnitude of associations was fairly strong. For example, a one standard deviation increases in the number of stressful life events reported (2.3 extra events out of the nine that were reportable) was associated with an approximate doubling of the odds of vaginal bleeding and hypertensive disorders. Both financial

and relationship stress were also associated with doubling of the odds of these two pregnancy complications.

Vaginal bleeding and hypertensive disorders are both pervasive complications during pregnancy, affecting 12% and 7% of pregnant women in the U.S., respectively, and are linked to subsequent pregnancy complications and adverse birth outcomes (Devilbiss et al., 2020; Shahul et al., 2015). Most of our sample (60%) of women were in their second trimester, and vaginal bleeding during the second trimester is a risk factor for other complications including placenta previa and fetal demise (Amirkhani et al., 2013). Furthermore, hypertensive disorders disproportionately affect Black mothers, compared to White mothers, and increase the risk of other maternal complications including placental abruption, gestational diabetes, and fetal complications (Shahul et al., 2015). There is an extensive literature from numerous populations demonstrating that psychosocial stress, including stressful life events, is associated with, and predicts, high blood pressure (Spurill, 2010). Proposed mechanisms of action for this effect are increased endocrine responses that elevate heart rate and cardiac output through repeated activation and failure to decline to resting levels (Spurill, 2010). It is unclear whether psychosocial stress, particularly stressful life events, may influence vaginal bleeding through the same physiological mechanisms. Vaginal bleeding during pregnancy is caused by a variety of infection/immune processes and women with first-trimester bleeding during pregnancy have an increased risk of complications during pregnancy, and reoccurrence of bleeding in subsequent pregnancies (Lykke et al., 2010).

An interesting an unexpected finding in this thesis study was that the number of stressful events reported, rather than the perceived stressfulness of events, showed stronger and more consistent associations with pregnancy complications. To our knowledge, only three other

studies have assessed associations between psychosocial stress and pregnancy complications, and two studies assessed the occurrence of stressful events, and the other assessed perceptions of stressfulness. Unfortunately, no study assessed both perceived stress and number of stressful events, and neither study comprehensively examined pregnancy complications. Zheng et al. (2018) in a cross-sectional study of 956 pregnant, urban Chinese women, reported that experiencing stressful life events was associated with increased odds of vaginal bleeding, adjusted for demographic and behavioral factors. Limitations of this study is that only "severe" stressors, rather than common "everyday" stressors were assessed, and vaginal bleeding was the only pregnancy complication to be assessed. More research is needed to determine the types of stressors that are associated with vaginal bleeding and directionality of the association. These results are consistent with our study, which also found that experiencing stressful life events, rather than the perception of the stressfulness of them, was associated with greater odds of vaginal bleeding.

Another study, by Roy-Matton and colleagues (2011) assessed several features of pregnant women's perceptions about stressors they were experiencing, including global ratings of stress in general for which higher ratings were associated with greater likelihood of reporting having any complications. Individual complications were not assessed. However, Roy used a prospective design and thus was able to determine temporality, namely that perceived stress preceded the development of pregnancy complications. In contrast, this thesis study was cross-sectional, with psychosocial stress and pregnancy complications assessed at the same time. Further, women in our study were assessed at varying gestational ages (1st trimester through 3rd trimesters) and so not all of them had equal opportunity to develop complications. However, our multivariable models controlled for differing gestational age. A limitation of the Roy-Matton et

al. (2011), study is that associations between psychosocial stress and pregnancy complications were assessed only in bivariable analyses that did not control for confounders. This thesis adjusted for several important confounders including gravidity, trimester of pregnancy, and substance use before pregnancy.

The limited assessment of both exposures and outcomes in these two studies make it difficult to compare results to this thesis. Assessing stress/pregnancy complications associations are important given that complications are pervasive (Whitehead et al., 2009), costly (Law et al., 2015), influence pregnant women's quality of life (Neiger, 2017) and are important determinants of birth outcomes (Dominguez et al., 2005). More research is needed that prospectively assesses a variety of psychosocial stressors to determine whether they predict the occurrence and severity of important pregnancy complications.

Thus, it is not clear why the number of stressful life events reported is more strongly related to pregnancy complications than either global perceptions of stress or perceptions of discrimination in this study. Beyond the methodological issues noted above, a possible explanation for the finding that the number of stressful events experienced, rather than the perception of the stressfulness of these events, was more strongly associated with pregnancy complications may involve the relative sensitivity of the instruments in combination with the so-called "undoing hypothesis". The "undoing hypothesis" asserts that experiencing positive emotions can "undo" the adverse health effects precipitated by negative emotions (Cavanagh & Larkin, 2018; Fredrickson & Levenson, 1998) which is manifested in a reciprocal association between reporting of positive and negative affect or emotions, such as depression or stress. However, weaker reciprocal relationships between positive and negative emotions have been observed in U.S. Blacks compared to U.S. Whites (Lankarani & Assari, 2017). This weak

association in Blacks is speculated to explain why they, compared to Whites, show weaker associations between depression and subsequent chronic disease, why depressive symptoms predict development of major depressive disorder more weakly for Blacks than Whites, and why Blacks, particularly Black women, report better well-being in the face of adversity (Ryff et al., 2003; Lankarani & Assari, 2017). Because the Stressful Life Events Scale used in this thesis was a simple checklist that asked participants to report whether events were experienced, not how stressful they were, it is possible that this measure is more sensitive at capturing experiences that produce physiological stress responses that increase risk of pregnancy complications but that are not necessarily perceived as stressful. In contrast, the Perceived Stress Scale-4 and the Everyday Discrimination Scale, used in this study, capture global perceptions of the perceived level of distress caused by difficult life circumstances in general. Further research is needed to compare objective vs. subjective stress ratings in pregnant women.

This thesis makes a useful contribution to the literature in documenting novel associations between psychosocial stress and pregnancy complications. However, several additional limitations should be noted. First, the study was cross-sectional and therefore we do not know whether stress causes pregnancy complications, or that pregnancy complications cause stress. It is likely that causality is bi-directional, since experiencing any of the complications explored in this study is likely to be perceived as stressful in that they may impact the status of the pregnancy. Second, all the data collected were based on self-report and pregnancy complications could not be verified through medical records. Inaccuracy or biased reporting due to under-reporting are possible but seem unlikely to be serious problems. Because the time period during which complications were reported was fairly short, and pregnancy complications are a salient feature of pregnancy (i.e., typically theses health issues are discussed regularly at

prenatal health visits) it seems likely that our participants were able to accurately report on whether they experienced these health issues. Third, the relatively small sample size may have prevented us from detecting some associations. Fourth, the sample was drawn from a single prenatal care center in one city and generalizability to other populations is unknown. Fifth, although we used a standard checklist of pregnancy complications from PRAMS, gestational diabetes was not assessed. Gestational diabetes is a highly prevalent and important pregnancy complication (Wendland et al., 2012) and future studies should determine its association with psychosocial stress. Sixth, it was not possible to weight pregnancy complications for the seriousness of the health issue, such as its likelihood of leading to an adverse birth outcome or its duration. However, we supplemented this outcome by examining whether each specific complication was related to stressors. Lastly, we did not assess psychosocial functioning other than stress. Affective states such as depression and anxiety are correlated with stress (Dunkel Schetter et al., 2012; Earnshaw et al., 2013) and may confound stress/complication associations.

In conclusion, this study documents that psychosocial stress in low-income pregnant, predominantly Black women is associated with medical complications during pregnancy. This adds to a large literature documenting that psychosocial stress causes physiological changes that can cause pregnancy complications and subsequent adverse birth outcomes. As such, the long-term consequences of high levels of stress during pregnancy can be immense. Adverse birth outcomes are linked to lifelong effects such as cerebral palsy, behavioral and social-emotional problems, life-long learning difficulties, and chronic health problems in adulthood including diabetes and heart disease (Luu et al., 2017). Further, pregnancy complications can have a negative impact on the quality of life for mothers after birth (Shishehgar et al., 2013). Helping low-income pregnant women to manage psychosocial stress potentially may help reduce

complications and improve birth outcomes. In fact, several small trials have found that stress reduction techniques significantly reduce perceived stress and anxiety during pregnancy which can greatly improve birth outcomes and reduce the risk of pregnancy complications (Guardino et al., 2014; Thomas et al., 2014; Tragea et al., 2014; Vieten & Astin, 2008; Zhang et al., 2019). Further research is needed to better quantify the associations of perceived global stress, stressful life events, and perceived discrimination on pregnancy and birth complications, and to determine whether helping pregnant women cope with these stressors improves the health and well-being of themselves and their children.

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Table 1. Sociodemographic characteristics, psychosocial stressors, and pregnancy complications (n=107)

	Mean, Standard Deviation, or %
Sociodemographics	
Age, years	27.1, 5.5
Education (%)	
No high school diploma	14.1%
Graduated High school	41.5%
Attended college	44.3%
Race (%)	
White	11.2%
Black	88.8%
Psychosocial Stressors	
Perceived Global Stress[1]	4.4, 3.0
Discrimination[2]	5.2, 6.1
Stressful Life Events[3]	2.4, 2.3
Trauma sub-scale	0.7, 0.9
Financial sub-scale	1.1, 1.3
Relational sub-scale	0.5, 0.7
Other predictor variables	
Substance Use Before Pregnancy [4]	0.9, 1.0
Gravidity[5]	2.5, 2.7
Pregnancy Stage	
First trimester	
Second trimester	25.2%
Third trimester	59.8%
	1.87%
Pregnancy Complications	
Number of complications reported[6]	0.8, 0.1
Vaginal Bleeding	14.0%
Kidney or Bladder (UTI)	21.5%
Severe Nausea, Vomiting/ Dehydration	17.0%

Hypertension (PIH) preeclampsia/ toxemia	14.0%
Labor Pains 3 or more weeks before due date	4.7%

[1] Perceived Stress Scale 4 (PSS-4; Cohen et al., 1983); score range is 0-16

[2] Everyday Discrimination Scale (EDS; Williams et al., 1997); score range is 0-27

[3] Stressful Life Events Screening Questionnaire (Goodman et al., 1998); score range is 0-10.

[4] The sum of substances the participant reported using prior to pregnancy (cigarettes, alcohol, marijuana).

[5] The number of prior pregnancies.

[6] The sum of 5 complications reported including vaginal bleeding; Kidney or bladder (UTI); Severe nausea, vomiting, or dehydration; high blood pressure disorders, preeclampsia or toxemia; labor pains more than 3 weeks before the baby was due (preterm or early labor).

Table 2. Results of multivariable Poisson regression models regressing sum of the number of pregnancy complications on psychosocial stressors.[1]

	Crude Models			*Adjusted Models*[1]		
	Beta	*SE*	*p*	*Beta*[1]	*SE*	*p*
Discrimination	0.03	0.11	0.788	0.04	0.11	0.744
Perceived global stress	0.21	0.11	0.050	0.21	0.11	0.054
Stressful life events	**0.25**	**0.10**	**0.008**	**0.32**	**0.10**	**0.002**
Trauma sub-scale	0.14	0.10	0.174	0.19	0.11	0.074
Financial sub-scale	**0.24**	**0.10**	**0.013**	**0.28**	**0.10**	**0.005**
Relationship sub-scale	**0.22**	**0.10**	**0.021**	**0.24**	**0.10**	**0.016**

[1] Models are adjusted for gravidity, trimester, and substance use before pregnancy.

Table 3. Results of multivariable logistic regression models regressing individual pregnancy complications on psychosocial stressors.[1]

	Pregnancy complication (odds ratio, 95% confidence interval, p-value)				
	Vaginal bleeding	Kidney or bladder (urinary tract) infection (UTI)	Severe nausea, vomiting, or dehydration	High blood pressure hypertension (including pregnancy-induced hypertension [PIH]), preeclampsia, or toxemia)	Labor pains more than 3 weeks before baby was due (preterm or early labor)
Discrimination	0.89, 0.49-1.62, 0.70	**1.66, 1.02-2.72, 0.04**	0.94, 0.55-1.61, 0.82	1.03, 0.55-1.92, 0.92	0.50, 0.10-2.50, 0.40
Perceived stress	1.44, 0.83-2.51, 0.19	**1.66, 1.00-2.74, 0.05**	1.05, 0.63-1.75, 0.86	1.14, 0.65-2.00, 0.64	0.68, 0.25-1.85, 0.45
Stressful life events	**1.85, 1.08-3.15, 0.02**	1.47, 0.90-2.42, 0.13	1.19, 0.70-2.02, 0.52	**2.06, 1.17-3.61, 0.01**	1.10, 0.36-3.39, 0.87
Trauma sub-scale	1.40, 0.83-2.34, 0.21	1.25, 0.75-2.06, 0.39	1.03, 0.60-1.76, 0.93	0.96, 0.52-1.77, 0.91	0.78, 0.20-3.3, 0.72
Financial sub-scale	**1.73, 1.03-2.91, 0.04**	1.30, 0.81-2.10, 0.28	1.12, 0.76-1.65, 0.58	**2.27, 1.32-3.88, 0.003**	1.42, 0.58-3.51, 0.45
Relationship sub-scale	**1.71, 1.02-2.88, 0.04**	1.53, 0.96-2.44, 0.07	1.27, 0.77-2.12, 0.36	**1.95, 1.15-3.29, 0.01**	0.67, 0.17-2.67, 0.57

[1] Models are adjusted gravidity, trimester, and substance use before pregnancy.

Supplemental Table. Scales and Variables

Scale	Source	Aim of Use	Items and Scoring
Dependent Variables			
Pregnancy Risk Assessment Monitoring System (PRAMS N9)	Shulman, Holly et al., (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of Design and Methodology. American Journal of Public Health. 108. e1-e9. 10.2105/AJPH.2018.304563.	Defined by the Centers for Disease Control as health problems that occur during pregnancy that can affect mother's health, the baby's health, or both, and greatly contribute to adverse birth outcomes. Centers for Disease Control and Prevention. (2020). Reproductive Health U.S. Department of Health and Human Services. https://www.cdc.gov/reproductivehealth/maternalinfanthealth/pregnancy-complications.html	1. Vaginal bleeding 2. Kidney or Bladder (urinary tract) infection (UTI) 3. Severe nausea, vomiting, or dehydration that sent me to the doctor or hospital 4. Cervix had to be sewn shut (cerclage for incompetent cervix) 5. High blood pressure, hypertension (including pregnancy-induced hypertension [PIH]), preeclampsia or toxemia. 6. Problems with the placenta (such as abpruptio placentae or placenta previa) 7. Labor pains more than 3 weeks before my baby was due (preterm or early labor) 8. Water broke more than 3 weeks before my baby was due (premature rupture of membranes [PROM]) 9. I had to have a blood transfusion 10. I was hurt in a car accident Response Choices 0- No 1- Yes

Independent Variables			
Perceived Stress Scale, 4 item version (PSS-4)	Karam, F. et al., (2012). Reliability and validity of the 4-item perceived stress scale among pregnant women: results from the OTIS antidepressants study. *Research in nursing & health*, *35*(4), 363–375. https://doi.org/10.1002/nur.21482	To assess and measure mothers' perceived stress	1. In the last month, how often have you felt that you were unable to control the important things in your life? 2. In the last month, how often have you felt things were going your way? 3. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? 4. In the last month, how often have you felt confident about your ability to handle your personal problems? Response choices 0- Never 1- Almost 2- Sometimes 3- Fairly Often 4- Very Often
Everyday Discrimination Scale (EDS) (9 items)	Williams, D.R., et al., (1997). "Racial Differences in Physical and Mental Health: Socioeconomic Status, Stress, and Discrimination." Journal of Health Psychology 2(3):335-351. Harnois, C. E., et al., (2019). Measuring perceived mistreatment across diverse social groups: An evaluation of the Everyday	To assess mothers' perceived discrimination.	1.You are treated with less courtesy than other people are 2. You are treated with less respect than other people are. 3. You receive poorer service than other people at restaurants or stores. 4. People act as if they think you are not smart 5. People act as if they are afraid of you. 6. People act as if they think you are dishonest 7. People act as if they're better than you are.

	Discrimination Scale. *Social science & medicine (1982)*, *232*, 298–306. https://doi.org/10.1016/j.socscimed.2019.05.011		8. You are called names or insulted 9. You are threatened or harassed. 0-Never 1-Less than once a year 2-A few times a year 3-A few times a month 4-At least once a week 5-Almost every day
Stressful life events Screening Questionnaire (13 items)	Allen, A. M, et al., (2019). Stressful life events are associated with perinatal cigarette smoking. *Preventive medicine*, *118*, 264–271. https://doi.org/10.1016/j.ypmed.2018.11.012	To assess mother's life events that increase perceived stress	1. A close family member or friend was very sick and had to go to the hospital. 2. I go separated or divorced from my husband or partner. 3. I moved to a new address. 4. I was homeless or had to sleep outside, in a car, or in a shelter. 5. My husband or partner lost their job. 6. I lost my job. 7. My husband, partner, or I had a cut in work hours or pay. 8. I argued with my husband or partner more than usual. 9. My husband or partner said he didn't want me to be pregnant. 10. I had problems paying the rent, mortgage, or other bills.

			11. My husband, partner, or I went to jail. 12. Someone very close to me had a problem with drinking or drugs. 13. Someone very close to me died. Response Choices: 0- No 1- Yes
Relationship Events (sub scale 3 items)	Shulman, Holly et al., (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of Design and Methodology. American Journal of Public Health. 108. e1-e9. 10.2105/AJPH.2018.304563.	To assess relationship events	1. I go separated or divorced from my husband or partner. 2. I argued with my husband or partner more than usual. 3. My husband or partner said he didn't want me to be pregnant. Response Choices: 0- No 1- Yes

Financial Events (sub scale 5 items)	Shulman, Holly et al., (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of Design and Methodology. American Journal of Public Health. 108. e1-e9. 10.2105/AJPH.2018.304563.	To assess financial life events	1. I moved to a new address. 2. My husband or partner lost their job. 3. I lost my job. 4. My husband, partner, or I had a cut in work hours or pay. 5. I had problems paying the rent, mortgage, or other bills. Response Choices: 0- No 1- Yes

Trauma Events (sub scale 5 items)	Shulman, Holly et al., (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of Design and Methodology. American Journal of Public Health. 108. e1-e9. 10.2105/AJPH.2018.304563.	To assess traumatic events	1. A close family member or friend was very sick and had to go to the hospital. 2. I was homeless or had to sleep outside, in a car, or in a shelter. 3. My husband, partner, or I went to jail. 4. Someone very close to me had a problem with drinking or drugs. 5. Someone very close to me died. Response Choices: 0- No 1- Yes
Substance Use Before Pregnancy (3 items)	Shulman, Holly et al., (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of Design and Methodology. American Journal of Public Health. 108. e1-e9. 10.2105/AJPH.2018.304563.	Sum score of marijuana, cigarette, and alcohol use before pregnancy.	In the 3 months before you got pregnant, how many cigarettes did you smoke on an average day? Response Choices: 0- I didn't smoke then 1- I smoked on some days, but not everyday 2- 1 to 5 cigarettes a day 3- 6 to 10 cigarettes a day 4- 11 to 20 cigarettes a day 5- 21 to 40 cigarettes a day 6- 41 cigarettes or more a day

			In the 3 months before you got pregnant, how many alcoholic drinks did you have in an average week? Response Choices: 0- I didn't drink then 1- Less than 1 drink a week 3- 1 to 3 drinks a week 4- 4 to 6 drinks a week 5- 7 to 13 drinks a week 6- 14 drinks or more a week In the 3 months before you got pregnant, how often did you smoke marijuana? Response Choices: 0- I didn't' smoke then 1- Less than once a month 2- At least once a month, but not once a week 3- At least once a week, but not every day 4- At least once a day