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The Impact of Mother–Father Relationship, Social Support and Neighborhood Context on Preterm Birth

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A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University

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Abstract

THE IMPACT OF MOTHER–FATHER RELATIONSHIP, SOCIAL SUPPORT AND NEIGHBORHOOD CONTEXT ON PRETERM BIRTH

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Background: Preterm birth is a major public health concern in the US and has been linked with significant infant morbidity and mortality. The rate of preterm birth in the US has seen successive increases from 2014 to 2017. Previous studies have suggested that quality of the mother-father relationship, social support, and neighborhood violence may be associated with preterm birth; however, findings are equivocal.

Objectives: The main objectives of this dissertation were: 1) to determine the modifying effect of perceived residential environment on the association between quality of mother–father relationship and preterm birth in a sample of African-American women, 2) to examine whether the receipt of social support modifies the association between neighborhood violence exposure and preterm birth in a nationally representative sample of US women, and 3) to determine the extent to which neighborhood violence mediates the association between neighborhood deprivation and preterm birth in a geographic cohort of women in Richmond city, Virginia.

Methods: Data were obtained from three sources – 1) Life-course Influences on Fetal Environments (LIFE) study, 2) National Longitudinal Study of Adolescent to Adult Health, and

3) live birth records, police crime reports and census data for Richmond city, Virginia. Multivariable log-binomial regression models were used to examine the modifying effect of perceived residential environment on the association between quality of mother–father relationship and preterm birth, as well as the modifying effect of social support on the association between neighborhood violence exposure and preterm birth. Multilevel structural equation modeling was used to examine the mediational influence of neighborhood violence on the association between neighborhood deprivation and preterm birth.

Results: For the association between neighborhood violence exposure and preterm birth, maternal receipt of social support modified the association [(Tertile 1: adjusted prevalence ratio (APR)=1.12; 95% CI=1.11-1.13, p<.0001); (Tertile 2: APR=1.07; 95% CI=1.06-1.08, p<.0001); and (Tertile 3: APR=0.88; 95% CI=0.86-0.89, p<.0001)] in a nationally representative sample of US women. No significant interaction was observed between any domain of the mother–father relationship and perceived maternal residential environment (all $p > 0.05$) in a sample of African American women. Additionally, no significant association was found between the quality of mother–father relationship and preterm birth (Trust domain: APR=1.03, 95% CI=0.99-1.07; dependability domain: APR=1.01, 95% CI=0.98-1.06; criticism domain: APR=1.03, 95% CI=0.99-1.07). The association between neighborhood deprivation and preterm birth in a geographic cohort of women in Richmond city, Virginia, was not mediated by neighborhood violence (β=0.063, 95% CI= –0.025, 0.151).

Conclusions: Rates of preterm birth in women exposed to neighborhood violence may be improved by providing adequate social support during the pregnancy period. Insufficient evidence was found to support the modifying effect of perceived residential environment on the association between the mother-father relationship and preterm birth, as well as the mediational

effect of neighborhood violence on the association between neighborhood deprivation and preterm birth. Future studies are needed to confirm these findings.

Chapter 1: Background, Specific Aims and Description of Datasets

BACKGROUND

Epidemiology of preterm birth

Preterm birth, defined as the birth of a baby before 37 completed weeks of gestation, is an important cause of perinatal mortality in the United States (US) and contributes significantly to perinatal and infant morbidity.[1] About 1 in every 10 infants born in the US is born preterm.[2] Over the past decade, the rate of preterm birth in the US has steadily declined with rates getting to an all-time low of 9.57% in 2014.[3] However, in 2017, there was a 4% increase in the rate of preterm birth from that observed in 2014.[2] Complications of preterm birth are the leading cause of death among children under 5 years of age and are responsible for nearly 1 million annual deaths globally.[4] Additionally, infants born preterm have higher rates of both short and long-term health complications and lifelong disabilities which include mental retardation, learning and behavioral problems, cerebral palsy, lung problems, vision and hearing loss, diabetes, high blood pressure, and heart disease.[5,6] Furthermore, children who are born preterm have a higher risk of increasing difficulties with complex language functions compared to term-born children.[7] The effect of preterm birth is not limited to babies born prematurely, but also extends to parents of preterm babies. The delivery of a preterm baby has been reported to be associated with adverse maternal health outcomes such as postpartum depression, anxiety and posttraumatic stress disorders.[8,9] Similarly, the birth of a preterm baby has been associated with increased risk of anxiety and depression in fathers of preterm babies.[10]

Racial/ethnic differences in preterm birth

Racial/ethnic disparities in the rate and risk of preterm birth in the US have consistently been reported over the past decades.[3,11] Infants born to non-Hispanic Black women have been

reportedly shown to have higher likelihood of being born preterm than infants born to non-Hispanic White and Hispanic women.[2,3,12] Data from the National Vital Statistics Reports show that in 2017, compared to preterm birth rates of 9.06% for non-Hispanic White infants and 9.61% for Hispanic infants, non-Hispanic Black infants had a preterm birth rate of 13.92%.[2] The cause(s) of this racial/ethnic disparity in preterm birth observed in non-Hispanic Black women is not fully understood.[12-14] While traditional maternal risk factors such as prior preterm delivery, multiple gestation, underweight and obesity, short and long interpregnancy intervals, tobacco use, bacterial vaginosis, low socioeconomic status, amongst others have been examined to try and explain the disparity in preterm birth observed in non-Hispanic Black women, these risk factors have only been able to explain a small amount of variance.[15] This highlights the need for new and expanded research that can improve the current understanding of observed racial/ethnic disparities in preterm birth.

Influence of paternal factors on preterm birth

Recently, there has been increased interest in the study of paternal factors as well as neighborhood or contextual factors to try and improve the current understanding of preterm delivery. Such paternal factors include paternal depression,[16] paternal race,[17] father's attitude towards the pregnancy,[18] father's health behaviors during the prenatal period,[18] quality of relationship between father and mother,[19] and paternal involvement during pregnancy.[20] Research have suggested that paternal factors can directly or indirectly influence the risk of preterm birth in the mother.[21,22] For example, paternal factors such as race can directly contribute to fetal genotype and influence the risk of preterm birth through genetic factors such as gene polymorphism.[17] Conversely, paternal factors may have an indirect influence on the risk of preterm birth in mothers. Fathers may influence maternal health behaviors such as utilization of

prenatal care services, smoking, alcohol and drug use during pregnancy.[23,24] For example, findings from a national study that examined the effect of maternal smoking on birthweight, revealed that smoking mothers had greater consumption of cigarettes when their partner also smoked.[23] Fathers may also indirectly influence the risk of preterm birth in a mother through stress. This pathway is particularly important for the effect of maternal-paternal relationship on the risk of preterm birth. A poor quality of maternal-paternal relationship can lead to the build-up of maternal stress.[19] Maternal stress can lead to an increase in stress hormones such as cortisol and corticotrophin-releasing hormone (CRH), which can eventually get into the fetal system. Increased levels of CRH may initiate premature labor, reduce placental perfusion, and/or increase the release of cortisol.[19] Furthermore, chronic stress also can stimulate a pro-inflammatory immune response and impair growth hormone secretion which can be inimical to the growth and development of the baby.[19] Additionally, maternal stress may lead to poor health behaviors, such as smoking,[25] lack of physical exercise,[26] and poor diet.[27] Exploring the influence of paternal factors on the risk of preterm birth may help to improve the understanding of risk factors of preterm birth.

Influence of neighborhood factors on preterm birth

Similarly, recent research findings have suggested that the risk of adverse birth outcomes such as preterm birth may involve a complex interaction between individual and neighborhood-level factors.[28] This is supported by the ecological model which suggests that birth outcomes such as preterm birth are impacted by individual-level characteristics, which in turn are strongly influenced by the larger community and society.[28] This has warranted the examination of the influence neighborhood-level factors have on the risk of preterm birth. Evidence from neighborhood-level research have shown mixed findings on the influence of neighborhood-level

factors on preterm birth.[29,30] Masho et al., in a multilevel study to examine the effect of community-level factors on preterm birth, reported neighborhood poverty as an important risk factor influencing preterm birth.[29] Similarly, Vinikoor-Imler et al. reported that neighborhood features such as neighborhood degradation and walkability were associated with preterm birth.[30] Another important characteristic of the neighborhood environment that influences preterm birth is neighborhood violence.[31] Residence in a neighborhood with high rates of violence has been reported to be associated with an increased risk of preterm birth.[31,32] Messer et al. in a multilevel analysis reported that living in very high violent-crime-rate census block-group quartiles was suggestive of increased odds of preterm birth.[31] In another multilevel study which examined violent crime and preterm birth in a racially diverse urban area, Messina and Kramer reported an association between living in a high crime area and an increased risk of preterm birth for women over 30 years of age.[32] However, some studies have reported null findings between residential environment and preterm birth.[33,34] For example, Sealy-Jefferson, et al. in a study to examine the association between perceived physical and social residential environment and preterm delivery in African-American women, reported no significant association between perceived residential environment and preterm birth.[33]

The role of stress and social support

A common denominator in the mechanisms through which paternal and neighborhood factors influence preterm birth is maternal stress. Maternal stress has been shown to greatly increase a woman's risk of preterm birth.[35,36] Various studies over the years have examined the influence that receipt of maternal social support has on maternal stress. The receipt of maternal social support during the prenatal period has been reported to have a buffering effect on the risk of preterm birth.[37] The buffering effect of social support is thought to act by reducing maternal

stress and anxiety and/or by providing maternal coping mechanisms for stress.[38] However, existing literature on the buffering effect of social support on the risk of preterm birth are mixed. Many studies have reported no evidence for the effectiveness of social support interventions in the prevention of preterm birth,[38-40] while a few others have reported a buffering effect on the risk of preterm birth.[37] Bryce, et al. in an early randomized controlled trial to test the effect of a program of additional antenatal social support on the occurrence of preterm birth in women at risk of preterm birth, reported that the receipt of social support had little or no effect on the prevention of preterm birth.[39] Similarly, Villar, et al. in another randomized trial of psychosocial support during high-risk pregnancies, reported that psychosocial support in high-risk pregnancies are unlikely to reduce the risk of preterm birth.[40] However, findings from these studies were limited by two factors. First, these studies did not account for neighborhood contextual variables that affect stress. The negative health impact of environmental stressors has been shown to not only depend on individual perception, but also on actual environmental risks.[41] Therefore, measurement of environmental risks must include neighborhood contextual variables.[41] Second, these studies were clinic-based rather than population-based and may have been diluted by including women in the intervention group who did not need social support (i.e. with a low level of stress). This was demonstrated in a retrospective, case control study by Ghosh et al. which reported that women with low partner support and chronic stress had an increased risk of preterm birth.[37] However, for women with moderate to high support from fathers, chronic stress did not increase risk of preterm birth.[37] This suggests that the buffering effect of social support may only be observed in women with high level of stress and may not be seen in women with low levels of stress; thus, warranting further examination in women with high level of stress.

Using data from three sources, 1) a retrospective cohort study of non-Hispanic Black/African American women in disadvantaged neighborhoods in three metropolitan county areas in Detroit, Michigan, 2) National Longitudinal Study of Adolescent to Adult Health (restricted use data), and 3) Vital statistics birth data for Richmond city, Virginia, which was geocoded and combined with census data and police crime report, this study aims to examine the impact of the quality of the mother–father relationship, receipt of maternal social support and neighborhood contextual factors on preterm birth in US women.

SPECIFIC AIMS

Specific Aim 1a: To examine the association between quality of mother–father relationship and preterm birth in a sample of African-American women.

This study hypothesizes that quality of mother–father relationship is *inversely* associated with the rate of preterm birth.

Specific Aim 1b: To determine the modifying effect of perceived residential environment on the association between quality of mother–father relationship and preterm birth in a sample of African-American women.

This study hypothesizes that perceived residential environment will modify the association between quality of mother–father relationship and preterm birth such that residential environment with positive attributes will be associated with *reduced* rates of preterm birth and vice-versa.

Specific Aim 2: To examine whether the receipt of social support modifies the association between neighborhood violence exposure and preterm birth in a sample of US women.

This study hypothesizes that the receipt of social support will modify the association between neighborhood violence exposure and preterm birth such that the receipt of a higher level of social support will be associated with *reduced* rates of preterm birth and vice-versa.

Specific Aim 3: To determine the extent to which neighborhood violence mediates the association between neighborhood deprivation and preterm birth.

This study hypothesizes that neighborhood violence will partially mediate the association between neighborhood deprivation and preterm birth.

DESCRIPTION OF DATASETS

Data sources

This research work utilized data from three different sources. Data for study aims one and two were obtained from the Life-course Influences on Fetal Environments (LIFE) study and the National Longitudinal Study of Adolescent to Adult Health, respectively. Study aim three utilized data obtained from live birth records, police crime reports and census data for Richmond city, Virginia.

The LIFE study is a retrospective cohort study that was conducted among Black/African American women who were within the ages of 18 and 45 years, recently delivered of a singleton live baby, and resided in three metropolitan counties (Wayne, Oakland and Macomb) in Detroit, Michigan. The main purpose of the LIFE study was to examine the association between racism and preterm birth among Black/African-American women. All participants were recruited from hospitals during the immediate postpartum hospitalization period, utilizing the labor and delivery and postpartum unit logs. Enrollment occurred from June 2009 through May 31, 2011 and written informed consent was obtained from each woman upon enrollment into the study.

Trained interviewers conducted interviews in women's hospital rooms immediately after delivery and medical history were abstracted from medical records. Women were excluded from the study if they did not speak English, had intellectual disabilities, serious cognitive deficits, or significant mental illness, on the basis of medical history or any prior records, or were currently incarcerated. Participation rate for the study was 71%, yielding a sample of 1,411 women. The LIFE study was approved by the Providence Hospital and Medical Centers Institutional Review Board (IRB), the Wayne State University IRB Behavioral Committee, and the Northeastern University IRB.

The National Longitudinal Study of Adolescent to Adult Health (Add Health) is an ongoing longitudinal study of a nationally representative sample of adolescents in grades 7-12 in the United States in 1994–95.[42] The participants have been followed through adolescence and the transition to adulthood with five in-home interviews (waves I to V).[42] Restricted-use data from waves I, II, III, and IV were utilized in this study. Add Health examines social, economic, psychological, and physical well-being of youths, as well as contextual factors on the family, neighborhood, community, school, friendships, peer groups, and romantic relationships. Wave I commenced in 1994–1995 when respondents were in grades 7–12, and waves II (grades 8–12) commenced in 1996. Wave III of the Add Health study commenced in 2001 when the original wave I respondents were 18–26 years old, and wave IV commenced in 2008 when respondents were 26–32 years old. Data from wave V was not utilized in this study as data collection is still ongoing. Add Health utilized a stratified, random sampling methodology to select a representative sample of adolescents in the United States and a mixed mode design was employed to collect data. Response rate for waves I, II, III, and IV were 79.0, 88.6, 77.4, and 80.3 percent, respectively. Written informed consent were obtained from parents or guardians

and assent from adolescents in waves I and II. For waves III and IV, written informed consent was obtained from each respondent. The Add Health study was approved by the Public Health Institutional Review Board at the University of North Carolina, Chapel Hill.

The third data set combined live birth records, police crime reports and US census data in Richmond city, Virginia. Live birth records in Richmond city were obtained from the Virginia Department of Health Vital Statistics for a 10-year consecutive period (2006-2015). Live birth records contain information on maternal sociodemographic history (e.g. age, race, and education), reproductive history (e.g. gestational age at delivery, birth weight, and prenatal care attendance) and risky behaviors (e.g. smoking and alcohol use). Live birth records were geocoded using maternal addresses utilizing the ArcGIS software package (ESRI 2011. ArcGIS Desktop: Release 10.1. Redlands, CA: Environmental Systems Research Institute) to identify residential census tracts. Geocoded live birth records were then linked to the 5-year estimates (2008–2012) of the American Community Survey using the unique residential census tract identifiers. Crime reports were obtained from the Richmond Police Department, Virginia. The police crime report provided data on reported crime incidents involving youths aged 10 to 24 years in all census tracts in Richmond city, Virginia, which occurred during the 10-year period from 2006 to 2015. Crime incidents were restricted to Class A reportable offenses (aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism). Crime data was then merged via census tract with the geocoded live birth record and census data.

This dissertation project was reviewed and approved by the Virginia Commonwealth University institutional review board and the Virginia Department of Health for study aim three.

Chapter 2:

The Modifying Effect of Perceived Residential Environment on the Association between Quality of Mother–Father Relationship and Preterm Birth in a Sample of African-American Women

ABSTRACT

Background: Preterm birth is a major public health concern in the United States, especially among African-American/Black women. The association between the mother-father relationship and preterm birth as well as the modifying effect of the residential environment on the association has not been fully examined. This study aims to examine the association between quality of the mother-father relationship and preterm birth and the modifying effect of perceived residential environment on the association in a sample of African-American women.

Methods: Data from the Life Influences on Fetal Environments (LIFE) study (N=1,140) was analyzed. The mother-father relationship was measured using items derived from the social networks in adult relations questionnaire and assessed through three domains (trust, dependability, and criticism) and the perceived maternal residential environment was assessed via five domains (social cohesion and trust, healthy food availability, walking environment, social disorder, and danger/safety). The association between each domain of the mother-father relationship and preterm birth, and the modifying effect of perceived maternal residential environment on the association was examined using multivariable log-binomial regression.

Results: For measures of mother–father relationship, the median scores for the trust, dependability and criticism domains were 14.0 (IQR: 12.0-15.0), 14.0 (IQR: 12.0-15.0), and 10.0 (IQR: 8.0-12.0), respectively. Approximately, 1 in 6 women in the study sample (17.5%) had a preterm birth. No significant interaction was observed between any domain of the mother–father relationship and the perceived maternal residential environment (all $p > 0.05$). Additionally, no significant association was found between the quality of mother–father relationship and preterm birth (Trust domain: adjusted prevalence ratio (APR)=1.03, 95% CI=0.99-1.07; dependability domain: APR=1.01, 95% CI=0.98-1.06; criticism domain: APR=1.03, 95% CI=0.99-1.07)

Conclusions: Findings from this study suggest that there is no significant association between the quality of mother-father relationship and preterm birth. Additionally, insufficient evidence was found to support the modifying effect of perceived maternal residential environment on the association in a sample of African American women. Future studies are recommended to confirm the results of the current study.

INTRODUCTION

Preterm birth is a major public health concern in the US. According to the National Center for Health Statistics, about 1 in every 10 (9.93%) infants born in the US in 2017 was delivered preterm.[2] Racial/ethnic disparities have consistently been reported in the rate of preterm birth, with Non-Hispanic (NH) Black women having the highest rates of preterm birth relative to NH White and Hispanic women.[2,43-45] In 2017, the rate of preterm birth among NH Black women (13.9%) was over 40 percent higher than the rate of preterm birth among NH White (9.1%) and Hispanic women (9.6%).[2] Preterm birth has been associated with a host of morbidities which include breathing problems,[46] feeding difficulties,[47] cerebral palsy,[48] developmental delay,[49] and vision[50] and hearing problems.[51] Furthermore, preterm birth contributes to over one third of infant deaths in the US[52] and exerts a huge economic burden on families as well as the healthcare system.[53]

Various factors have been associated with increased risk of preterm birth. These include sociodemographic factors (e.g. age,[54] education,[55] race/ethnicity[56]), reproductive factors (e.g. parity,[57] interpregnancy interval,[58] previous preterm birth[59]), and risky behaviors (e.g. smoking[60], alcohol use[61]), amongst others. The association between the quality of the mother-father relationship and preterm birth however, has not been fully examined, with only few studies examining the association[37,62-64] and none examining the association among NH Black women. A limitation to the examination of the association between the quality of the mother-father relationship and preterm birth has been the lack of valid and reliable instruments to measure the relationship between the mother and father of the baby. Many studies that have examined the association have utilized proxies such as marital status[62,63] and paternal support[37] to measure the relationship between the mother and father of the baby. However, these proxies do not

effectively measure the mother-father relationship. For example, Lim and Park, in a study to examine risk factors for preterm birth and low birth weight in extramarital births, utilized marital status as a proxy for mother-father relationship.[65] They reported that the odds of preterm birth was significantly higher for extramarital births compared to marital births. The use of marital status as a proxy for the quality of the mother-father relationship has been regarded as somewhat controversial and problematic.[19] Bloch, et al. argued that, just as there are 'good' marriages and 'bad' marriages, outside of marriage, there are intimate partner relationships that can either be 'good' or 'bad'.[19] Therefore, good relationships outside of marriage may provide the same indirect and direct health-related advantages often associated with and attributed to 'being married'.[19]

Various mechanisms have been suggested to explain the influence of the quality of the mother-father relationship on the risk of preterm birth, prominent of which is the effect of maternal stress.[19] A 'poor' mother-father relationship may be indicative of an emotionally or financially non-supportive partner and this may diminish both physical and emotional maternal well-being by increasing stress.[19] Maternal stress is believed to play a major role in increasing the risk of preterm birth by activating the neuroendocrine system which triggers the release of mediators such as adrenalin, corticotrophin-releasing hormone, cortisol, and other chemical messengers that increase the risk of preterm birth.[19,66]

The Role of Perceived Residential Environment

The residential environment, defined as people's housing environment is comprised of the housing unit, neighborhood, and the community in which the residents are located.[67] Compared to objective measures of the residential environment (that is, area-level indicators that can be characterized independent of a resident's own perception; e.g. median income,

unemployment rate), subjective measures of the residential environment (that is, individual-level assessments of a resident's neighborhood in a range of domains; e.g., perceived safety and cohesion, perceived social disorder) have been postulated to be more proximal determinants of health.[68] Furthermore, objective measures of the residential environment (e.g. based on census data) may not well characterize the range of neighborhood domains that are relevant to health.[69,70]

Perception of the residential environment has been reported to be associated with preterm birth.[71,72] Bhatia, et al. in a study that utilized the 2010–2012 Los Angeles Mommy and Baby surveys examined the associations of mothers' perception of neighborhood quality and maternal resilience with the risk of preterm birth.[71] They reported that the risk of preterm birth among mothers who perceived their neighborhood to be of poor quality was about 30% greater compared to mothers who perceived their neighborhood to be of good quality.[71] In the same vein, Giurgescu et al. in a study among African-American women receiving prenatal care at a medical center in Chicago, reported that perceived adverse neighborhood conditions were related to psychological distress,[72] which is an established risk factor for preterm birth.[73,74] While these studies suggest that perceived residential environment is associated with an increased risk of preterm birth, not all studies found a significant relationship between perceived residential environment and preterm birth.[75] Sealy-Jefferson, et al. in a study among African-American women in metropolitan Detroit, Michigan, reported no significant association between perceived residential environment (healthy food availability, walkability, safety, social cohesion, and social disorder) and preterm birth.[75] However, in women with 12 or less years of education, they found significant inverse associations between preterm birth rates and perceived residential environment (healthy food availability, walkability, safety, and social disorder).[75] The effect of

the residential environment on preterm birth may be explained by the influence of stress.[74,76] Residence in a neighborhood with negative neighborhood attributes may serve to increase maternal stress,[76] which predispose such women to an increased risk of preterm birth.[74] Furthermore, maternal stress arising from exposure to neighborhoods with negative attributes may influence the development of risky maternal behaviors such as cigarette smoking and alcohol drinking during the pregnancy period to help alleviate stress.[77,78] These risky behaviors which are developed by mothers to help to alleviate stress may be harmful to the fetus and ultimately increase the risk of preterm birth. Given that perceived residential environment has been postulated to increase the risk of preterm birth through maternal stress,[71,72] it is plausible that negative maternal perception of the residential environment in women with poor quality of mother-father relationship may further increase the risk of preterm birth, such that as maternal perception of the residential environment worsens, the risk of preterm birth may increase.

All of these factors raise questions as to the joint effect of exposure to poor quality of mother-father relationship and negative maternal perception of the residential environment on the risk of preterm birth in African-American women. Using a sample of African-American women from metropolitan Detroit, Michigan, this study aims to examine the modifying effect of maternal perception of the residential environment on the association between quality of mother-father relationship and preterm birth.

Innovation

The impact of the quality of the mother-father relationship on the risk of preterm birth has not been well examined. The few studies available have been limited methodologically by inadequate measurement of the quality of mother-father relationship. Furthermore, no study has examined how maternal perception of the residential environment modifies the association

between quality of the mother-father relationship and the risk of preterm birth. Examination of the association between the quality of the mother-father relationship and the risk of preterm birth utilizing an extensive measurement tool which covers multiple domains of the mother-father relationship will address previous methodological limitations in measuring the quality of mother-father relationship. Furthermore, this study will help to improve the understanding of how maternal perception of the residential environment modifies the association between the quality of the mother-father relationship and risk of preterm birth in African-American women.

Conceptual framework

This study draws upon an adaptation of the dual hazards hypothesis.[79] The dual hazards hypothesis suggests that the interplay between two independent risk factors of an outcome serves to amplify the risk of that outcome. As depicted in figure 2.1, in the context of the present study, African-American women with poor quality of mother-father relationship and negative perception of the residential environment may be at an especially greater risk of preterm birth due to the accumulation of risk factors.

METHODS

Data source and study sample

Data from the LIFE study was utilized in this study. The LIFE study is a retrospective cohort study that was conducted among Black/African American women within the ages of 18 and 45 years in three Detroit metropolitan counties to examine the association between racism and preterm birth among Black/African-American women. Details of the LIFE study have previously been documented in chapter one. All women in the study sample with singleton live births who had complete information on the father-of-baby relationship and perception of the

residential environment were included in the current study. Women with missing or incomplete information on the father-of-baby relationship (N=118; 8.4%), perception of the residential environment (N=115; 8.2%) or both (N=37; 2.6%) were excluded from the current study. This yielded a total sample size of 1,140 women representing approximately 81% of the LIFE study cohort. To determine that the sample size was adequate to detect a significant main effect, sample size was calculated using the G-power software using an effect size of 0.5 and a power of 80% at a two-sided significance level of 5%. A sample size of 1048 women was estimated.

Measures

Outcome variable

The outcome variable, preterm birth, was defined as the birth of a baby before 37 completed weeks of gestation. Preterm birth was categorized using the gestational age at delivery into 2 levels - preterm birth (<37 completed weeks) and term birth (≥37 completed weeks) based on the World Health Organization (WHO) classification.[4] Gestational age was obtained from maternal medical records, primarily using an early obstetric ultrasound scan (between 6 and 20 weeks' gestation). For cases where an early obstetric ultrasound scan was unavailable or implausible, gestational age was estimated using the last menstrual period reported by the mother. In the event that the early ultrasound and last menstrual period estimates were missing or improbable, the gestational age was estimated using later ultrasound (>20 weeks gestation), clinician's estimate at birth, or medical record at birth. Due to the small number of women with extremely preterm (N=12; 1.1%) and very preterm (N=29; 2.5%) births in the study sample, preterm birth could not be classified as such.

Exposure variable

The exposure variable, quality of mother–father relationship, was measured using 14 items derived from the social networks in adult relations questionnaire (Appendix 1).[80,81] Examples of items include, “father of baby is always there when I need him” and “I feel that I can tell father of baby just about everything”. Women were asked to indicate the extent to which they agreed or disagreed with items on the scale. Response options were on a Likert scale and ranged from 1=strongly agree to 5=strongly disagree. To ease interpretation of the study results, exploratory factor analysis (EFA) was used to identify the factor structure of the items (Table 2.3) and reverse coding was done to ensure that a higher score indicated a better quality of mother-father relationship. Scores for each factor identified by the EFA were determined by summing up the scores of the items that made up the factor.

Effect Modifier

Perceived residential environment was measured using valid and reliable scales that measured five domains of the residential environment. These domains include social cohesion and trust, healthy food availability, walking environment, social disorder, and danger/safety. For each domain, interviewers asked women to report their agreement with items on the scale. For social cohesion and trust, healthy food availability, walking environment, and danger/safety domain scales, item response ranged from 1= “Strongly agree” to 5= “Strongly disagree”, and for the social disorder scale, item response ranged from 1=”A big problem” to 3=”Not a problem”. Use of these five domains to measure residential environment has previously been utilized[33] and shown to be reliable in a sample of African-American women. For each domain, scores for each item were summed to create a total score for that residential environment domain. Reverse coding was performed as necessary. Lower scores indicate better perceived residential environment for all scales, except the social disorder scale in which a higher score indicates

lower perceived social disorder. These scales used to measure the five domains of the perceived residential environment are shown in appendix two.

Covariates

Sociodemographic factors such as maternal age (continuous), maternal education (≤12 years or >12 years), marital status (married, cohabitating, widowed, divorced, or separated, or never married), household income (<$20,000, $20,000-49,999 or ≥$50,000), and maternal insurance (private, Medicaid, multiple, or no coverage) were assessed. Reproductive factors such as previous live birth (0 or ≥1), pre-pregnancy body mass index (BMI) [underweight (<18.50), normal weight (18.50-24.99), overweight (25.00-29.99) and obese (≥30.00)], and physical activity (yes or no) were also assessed. Risky maternal behaviors such as drinking alcohol, cigarette smoking, and marijuana use during pregnancy were assessed and categorized as dichotomous variables (yes or no). Maternal medical conditions before pregnancy (yes or no), maternal social support (continuous), and perceived stress in the last month of pregnancy (continuous) were assessed. Maternal social support was measured using the general social support scale and perceived maternal stress was measured using the Cohen's perceived stress scale. Mother's place of birth (US-born or foreign-born) and maternal self-reported length of stay in current residential environment were also assessed.

Analytic strategy

Exploratory factor analysis was conducted to identify the factor structure of items used to measure the mother-father relationship (that is, to identify domains of the mother-father relationship). Factor loadings were extracted using the Geomin oblique rotation and the pattern matrix. The EFA was conducted to allow for 5 factors based on the eigenvalues on the scree plot

(Figure 2.2). To determine the best model fit for the EFA, the following goodness of fit indices were used: chi-square goodness of fit index,[82] root mean square error of approximation (RMSEA),[83] comparative fit index (CFI),[84] Tucker-Lewis index (TLI),[85] root mean square residual (RMSR), Akaike information criterion (AIC), and Bayesian information criterion (BIC). Recommended cutoff points for these indices were utilized as follows: chi-square test, p-value > 0.05, RMSEA $\leq$ 0.07, CFI $\geq$ 0.95, TLI $\geq$ 0.95, and RMSR < 0.05. For AIC and BIC, a lower value is preferred. Cross-loadings and residual variance were also assessed. Exploratory factor analysis was conducted using Mplus 8.1 (Muthén & Muthén, Los Angeles, CA) utilizing maximum likelihood estimation.

Descriptive and inferential analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC) to determine the characteristics of the study population. Percentages (for categorical variables) and median and interquartile range (IQR; for continuous variables) were calculated. Because the study outcome (preterm birth) was not rare in the study population (17.5%), log-binomial regression using the GENMOD procedure and utilizing a binary distribution and log link function was used to examine the association between quality of mother–father relationship and preterm birth. An unadjusted model which did not control for any confounder was initially created. To determine the parsimonious (adjusted) model, potential confounders whose inclusion in the regression model resulted in a change of 10% or more in the unadjusted estimate[86] were included in the final adjusted model. Because no potential confounder resulted in a change of 10% or more in the unadjusted estimate, confounders obtained from extant literature[37,64] were included in the final adjusted model. To explore the effect modifying role of perceived maternal residential environment on the association between quality of mother–father relationship and preterm birth, each domain of the perceived residential environment was included separately as a

two-way interaction term in the adjusted model and statistically tested using the likelihood ratio test utilizing the -2Log likelihood. A significant p-value (<.05) on the likelihood ratio test signify the presence of effect modification. Where the interaction term is significant, the adjusted model will be explored to describe the modifying effect of perceived residential environment on the association between quality of mother-father relationship and preterm birth. Effect modification analysis will involve a continuous-continuous interaction, and an approach that will compute simple slopes will be utilized, i.e., the slopes of the dependent variable on the independent variable when the effect modifier is held constant at different combinations of high and low values, e.g. one standard deviation below and above the mean. Furthermore, in order to test the assumption of the conceptual model which specifies that the mother-father relationship is not associated with perceived residential environment, Pearson correlation tests were run and showed very weak correlations (Table 2.5). Statistical significance was set a priori at 5% and results are presented as prevalence ratios (PRs) and 95% confidence intervals (CIs).

RESULTS

Characteristics of the study sample are shown in Table 2.1. The median age of women in the study sample was 26.0 years (interquartile range (IQR): 22.0-31.0). Over half of the study sample had greater than 12 years of education (69.0%), had household income of $20,000 and above (72.0%), and were on Medicaid (54.7%). More than half of the women were overweight or obese (64.6%) and had one or more previous live births (55.5%). About 16%, 17%, and 46% of women smoked cigarettes, drank alcohol, and used marijuana, respectively. For quality of mother–father relationship, median scores for the trust, dependability and criticism domains were 14.0 (IQR: 12.0-15.0), 14.0 (IQR: 12.0-15.0), and 10.0 (IQR: 8.0-12.0), respectively. Approximately, 1 in 6 women in the study sample (17.5%) had a preterm birth.

Fit measures and residual variance for the EFA of the mother–father relationship measure are shown in Table 2.2. Of the five models in the EFA, the five-factor model had the best fit measures (χ^2=71.31, df=31, p=0.000; RMSEA=0.034; CFI=0.997; TLI=0.990, RMSR=0.007, AIC=42135.560, BIC=42578.973); however, negative residual variance (Heywood case) was observed for item 12, and the model could not be used. The next best model was the four-factor model (χ^2=189.78, df=41, p=0.000; RMSEA=0.056; CFI=0.987; TLI=0.972, RMSR=0.019, AIC=42234.033, BIC=42627.058). This model, however, did not have any significant item loading on the fourth factor. Furthermore, cross-loadings were observed for items 5, 6, and 7. Factor 4 was deleted, leaving a three-factor model (χ^2=380.74, df=52, p=0.000; RMSEA=0.074; CFI=0.972; TLI=0.951, RMSR=0.023, AIC=42402.991, BIC=42740.589). Factor one consisted of items 2, 3, and 4 which captured the "trust" domain, factor 2 consisted of items 1, 8, and 9 which captured the "dependability" domain, and factor 3 consisted of items 11, 12, and 13, which captured the "criticism" domain. Inter-factor correlation between factors 1 and 2, factors 1 and 3, and factors 2 and 3 were 0.83, -0.46, and -0.42, respectively. The percentage of the total variance for the entire set of variables explained by the three factors could not be documented as this is not reported in Mplus. Factors, factor loadings, and eigenvalues are shown in Table 2.3**.**

Table 2.4 shows characteristics of the five scales that measured the five domains of the perceived residential environment. Internal reliability of the scales as measured by the Cronbach's alpha for the study sample showed good reliability for each scale (social cohesion and trust, Cronbach's $\alpha = 0.84$; healthy food availability, Cronbach's $\alpha = 0.90$; walking environment, Cronbach's $\alpha = 0.80$; social disorder, Cronbach's $\alpha = 0.93$; and danger/safety, Cronbach's $\alpha = 0.91$). Median scores show that about 50% of women perceived their residential environment to have healthy foods available, be walkable, safe, and without a problem of social

disorder. Less than 50% of women perceived their residential environment to be socially cohesive and trusted.

Table 2.6 shows the estimates of the interaction term, 95% confidence intervals, and p-values of the interaction between quality of mother–father relationship and domains of the maternal perceived residential environment. No significant interaction was observed between any domain of the mother–father relationship and the perceived residential environment (all $p > 0.05$).

Results of the association between quality of mother-father relationship and preterm birth are shown in Table 2.7. Unadjusted analyses show that for all domains of the mother-father relationship (trust, dependability, and criticism), a unit change in the mother-father relationship score, was not significantly associated with increased rates of preterm birth. Upon adjusting for confounders in the parsimonious models, the association remained unchanged. With every unit change in the mother-father relationship score for all domains (trust, dependability, and criticism), no significant increase in the rates of preterm birth was observed, with prevalence ratios close to unity.

DISCUSSION

Findings from this study showed that there was no significant association between quality of mother-father relationship and preterm birth, and perceived maternal residential environment does not modify the association between quality of mother-father relationship and preterm birth in this sample of African-American women. The lack of significant association between quality of mother-father relationship and preterm birth for all domains of the mother-father relationship observed in the current study is in contrast to findings from previous studies that examined the

association using proxies such as marital status and paternal support.[64,65] Lim and Park, utilizing marital status as a proxy for mother-father relationship, reported significantly higher odds of preterm birth for women with extramarital births compared to women with marital births.[65] Similarly, Masho, et al., in a study to examine the impact of paternal support and marital status on low birth weight and preterm births among women in Virginia, reported that women who were unmarried and with no paternity status had significantly higher odds of having preterm low birth weight babies.[64] The absence of significant findings in the association between quality of mother-father relationship and preterm birth observed in the current study may be due to the buffering effect of social support on maternal stress, such that the effect of a poor quality of mother-father relationship is of minimal impact. Poor quality relationship of the mother with the father of baby has been suggested to lead to maternal emotional, psychological, and/or financial stress,[19] and maternal stress in turn increases the risk of preterm birth.[74,87] Moreso, maternal receipt of social support has been shown to positively buffer the negative effect of stress.[88-90] In the current study sample (both term and preterm), African-American women reported fairly high levels of perceived stress; however, they also reported very high levels of social support. The receipt of such high levels of social support may have buffered the negative effect of maternal stress that may have arisen from poor maternal relationship quality with the father of the baby. Further investigation (see table 2.8 and Fig. 2.3) revealed that the association between the quality of mother-father relationship for the trust domain and preterm birth was modified by maternal receipt of social support. For women who had a social support score that was one standard deviation above the mean social support score, with every unit increase in trust between the mother and father of baby, no association with preterm birth was observed. However, women who had a social support score that was one standard deviation below the mean social support

score, had lower rates of preterm birth with every unit increase in trust between the mother and father of baby. Future studies are recommended to examine the modifying effect of social support on the association between mother-father relationship and preterm birth in African-American women.

Furthermore, findings from this study showed no significant modifying effect of perceived maternal residential environment on the association between quality of mother-father relationship and preterm birth. This lack of modifying effect may have been due to a lack of variability in the subjective scales used to measure maternal perception of the residential environment. However, a previous study among African-American women in metropolitan Detroit, Michigan, that examined area-level (block group) variability in subjective reports of the residential environment using four of the five scales that were used to measure maternal perception of the residential environment in the current study, reported a good amount of variability across census block groups.[91] Findings from that study showed that intra-neighborhood (block group) correlation as estimated by the intraclass correlation coefficients for four subjective residential environment scales ranged from approximately 11% to 30% (healthy food availability – 10.7%, walking environment – 18.8%, social disorder – 30.2%, and danger/safety – 30.4%).[91] This indicates that a substantial proportion of variance in maternal perception of the residential environment across neighborhoods was captured by the five scales used to measure maternal perceived residential environment. The lack of significant interaction between perceived residential environment and quality of mother-father relationship in the current study may have been due to a lack of sufficient sample size to detect significant interaction. In the current study, although, the sample size for the main effect was sufficient based on a priori sample size calculation, sample size for interaction was not calculated and may

not have been sufficient. Fleiss, J.L. reported that the sample size required to detect an interaction is four times that for a main effect of the same magnitude;[92] and as such, the sample size for the current study may not have been sufficient to detect significant interaction. Nonetheless, the width of the 95% confidence intervals of the interaction terms were narrow and may suggest that increasing the sample size may not necessarily detect significant interactions as the width of confidence intervals is proportional to 1/square root (N).

Strengths and Limitations

This study has various strengths. First, the use of mother-father relationship questions to measure the quality of mother-father relationship helped to overcome limitations of previous studies that used marital status and paternal support as a proxies for the mother-father relationship, as it allowed for examination of different domains of the mother-father relationship. Also, the use of valid and reliable scales that have been shown to capture a good amount of neighborhood variability to measure maternal perception of the residential environment allowed for accurate and reliable measurement of the domains of the perceived maternal residential environment. This study has some limitations, though. First, the study sample size may not have been sufficient to detect significant interaction between the mother-father relationship and perceived residential neighborhood. Studies with larger sample size are needed to examine the modifying effect of perceived residential environment on the association. Second, information on mother-father relationship and perceived residential environment were obtained from study participants in the immediate delivery period. There is the possibility of recall bias, especially in women with preterm birth. Third, the study sample was limited to African American women from a suburban population in Detroit, Michigan. As such, findings from the study may only be generalized to African American women from such suburban populations.

CONCLUSIONS

Results from this study show that there is no significant association between quality of mother-father relationship and preterm birth in a sample of African-American women. However, supplemental findings revealed that the quality of mother-father relationship was associated with a reduced risk of preterm birth in African American women who had low social support. Furthermore, insufficient evidence was found to support the effect modifying role of maternal perception of the residential environment on the association between the mother-father relationship and preterm birth in a sample of African-American women. Future studies in African American women with larger sample size are recommended to confirm the results of the current study.

Chapter 3:

Does the Receipt of Social Support Modify the Association between Neighborhood Violence Exposure and Preterm Birth?

ABSTRACT

Background: Preterm birth remains a major public health concern in the United States. Maternal exposure to neighborhood violence has been linked with increased risk of preterm birth across different racial/ethnic groups. However, it is unclear whether maternal receipt of social support modifies the risk of preterm birth in women exposed to neighborhood violence. This study aims to examine the modifying effect of social support on the association between neighborhood violence exposure and preterm birth among a nationally representative sample of US women.

Methods: Data from the National Longitudinal Study of Adolescent to Adult Health (Waves I-IV) were analyzed (N=4,419). The study outcome was preterm birth measured as a binary variable (yes or no), and the main exposure and effect modifier were continuous measures of neighborhood violence and social support, respectively. Multivariable log-binomial regression was used to examine the association between neighborhood violence exposure and preterm birth controlling for confounders. The interaction between neighborhood violence exposure and social support was tested in the model ($p < .0001$) to explore the modifying effect of maternal social support.

Results: The rate of preterm birth in the study sample was 10.7% and the prevalence of neighborhood violence exposure was 28.1%. Approximately 39%, 47%, and 14% of women received low (tertile 1), medium (tertile 2) and high (tertile 3) levels of social support, respectively. Adjusted prevalence ratios and associated 95% confidence intervals for the association between neighborhood violence exposure and preterm birth at tertiles 1, 2, and 3 of social support were 1.12 (95% CI=1.11-1.13, $p<.0001$), 1.07 (95% CI=1.06-1.08, $p<.0001$), and 0.88 (95% CI=0.86-0.89, $p<.0001$), respectively.

Conclusions: This study showed that maternal exposure to neighborhood violence is significantly associated with preterm birth in a national representative sample of US women. However, the direction of the observed association varied depending on the level of social support received during pregnancy, such that women with higher levels of social support who were exposed to neighborhood violence had decreased rates of preterm birth. Intervention programs aimed at identifying and providing adequate social support to pregnant women who are exposed to neighborhood violence are recommended to mitigate the risk of preterm birth.

INTRODUCTION

In the US, the rate of violent crime perpetration and victimization remains high despite a significant decline over the past two decades.[93-96] In 2016, among all age categories, an estimated 10.7 million arrests were made for violent crimes and other offences in the US.[96] Similarly, in 2016, about 5.7 million US residents aged 12 or older were victims of at least one form of violent crime.[95] Thus, making violent crime perpetration and victimization of significant public health importance in the US.

Exposure to neighborhood violence has been associated with a host of negative health outcomes which include medical conditions such as asthma;[97] psychiatric conditions such as depression,[98] anxiety,[98] and posttraumatic stress disorder;[99] adverse birth outcomes such as low birthweight[100] and preterm birth;[100] physical injury,[101] and death.[102] In addition to negatively affecting individual health outcomes, neighborhood violence has been reported to adversely impact the community by increasing the cost of health care, reducing productivity, decreasing property values, and disrupting social services.[103]

An important maternal health outcome associated with exposure to neighborhood violence is preterm birth; which is the birth of a baby before 37 completed weeks of gestation.[104-107] Koppensteiner and Manacorda using microdata from the Brazilian vital statistics on births examined the impact of in-utero exposure to neighborhood violence on preterm birth.[104] They reported that exposure to neighborhood violence during the first trimester of pregnancy led to an increase in the risk of preterm birth. Similarly, Mayne, et al. in a study to examine the impact of exposure to neighborhood violence on pregnancy outcomes among women living in the Chicago community area, reported that exposure to neighborhood violence was associated with a significant increase in the odds of preterm birth.[106] However, not all studies have reported

significant associations between exposure to neighborhood violence and preterm birth.[108,109] Clemens and Dibben using data from the Scottish Longitudinal Study, examined the association between exposure to neighborhood violence during pregnancy and birth weight and prematurity.[108] They reported no significant increase in the risk of preterm birth among women exposed to neighborhood violence. The differences in study findings may be due to the use of different methods in the measurement of neighborhood violence exposure and may signify the need for a uniform method of neighborhood violence exposure measurement.

Various pathways have been elucidated to explain the mechanisms through which exposure to neighborhood violence increase the risk of preterm birth. These pathways have been postulated to occur through direct and/or indirect mechanisms. Direct effect of neighborhood violence on preterm birth may manifest in the form of direct victimization such as assaults and robberies which may trigger the onset of preterm labor.[110] On the other hand, indirect effect of neighborhood violence exposure on preterm birth may occur through the influence of stress.[111,112] Exposure to neighborhood violence has been shown to increase maternal stress[111,112] which may negatively impact optimum growth and development of the baby and increase the risk of preterm birth.[35,113] Additionally, stress may lead women to engage in smoking,[114] drinking[115] and other unhealthy behaviors as strategies to reduce stress, and this may increase their risk of preterm birth. Furthermore, fear of neighborhood violence victimization may lead to reduced access and utilization of prenatal care services[116] which has been associated with an increased risk of preterm birth.[117]

The Role of Maternal Social Support

The receipt of maternal social support has been widely believed to be associated with reduced risk of preterm birth. However, empirical evidence supporting this belief is scarce.

Findings from studies, especially early clinical trials consistently reported no association between the receipt of maternal social support and reduced risk of preterm birth.[39,40] For example, Bryce, et al. in a randomized control trial to test the effect of a program of additional antenatal social support on the occurrence of preterm birth in women at risk of preterm birth, reported no evidence for the effectiveness of social support interventions in the prevention of preterm birth.[39] A systematic review and meta-analysis also reported no evidence for a direct association between social support and preterm birth.[38] Findings however, suggest that social support may provide a buffering mechanism between maternal stress and preterm birth. This buffering effect on the risk of preterm birth is thought to act by reducing stress and anxiety, or by providing coping mechanisms for women with high stress during pregnancy.[38] For example, a retrospective cohort study that examined the risk of preterm birth in women who participated in group prenatal care (centering pregnancy) and received sessions on stress reduction, reported that compared to women who received traditional care, women who participated in group prenatal care had lower odds of preterm birth.[118] Similarly, Ghosh, et al. in another study, reported that women with low partner support and chronic stress had an increased risk of preterm birth while in women with moderate to high support from fathers, chronic stress did not increase risk of preterm birth.[37] This suggests that the buffering effect of social support may more likely be observed in women with high level of stress and may not be seen in women with low levels of stress; thus, warranting further examination in women with high levels of stress such as women exposed to neighborhood violence. Given the observed buffering effect of maternal social support on maternal stress in the reduction of the risk of preterm birth, this study hypothesized that the receipt of maternal social support in women exposed to neighborhood violence will

buffer the stressful effect of exposure to neighborhood violence and reduce the risk of preterm birth.

Using a nationally representative and diverse sample of women in the US, this study seeks to examine the modifying effect of maternal social support on the association between neighborhood violence exposure and preterm birth.

Innovation

Research focusing on the influence of neighborhood violence exposure on the risk of preterm birth has increased over the past decade. However, how exposure to neighborhood violence may influence the risk of preterm birth is still not well understood. It has been postulated that the increased risk of preterm birth in women who are exposed to neighborhood violence may be mediated through stress. Thus far, no study, to the author's knowledge, has examined how the receipt of social support in women exposed to neighborhood violence modifies the risk of preterm birth by buffering the effect of maternal stress. Examination of how the receipt of social support modifies the association between exposure to neighborhood violence and preterm birth can help to improve the understanding of the buffering effect of social support on the risk of preterm birth in women that are exposed to neighborhood violence.

Conceptual framework

This study utilized the "stress-buffering" model of social support as elucidated by Cobb.[119] The stress-buffering model helps to explain the interaction between social support and environmental stress. It posits that supportive interactions among people are protective against the health consequences of life stress. Social support is defined as information leading the subject to believe that he/she is cared for and loved, esteemed, and a member of a network of

mutual obligations.[119] As depicted in Figure 3.1, the receipt of maternal social support is proposed to modify the effect of neighborhood violence exposure on the risk of preterm birth.

METHODS

Data source and study sample

This study utilized restricted-use data from waves I, II, III, and IV of the National Longitudinal Study of Adolescent to Adult Health (Add Health).[42] Add Health is an ongoing school-based longitudinal study of a nationally representative sample of youths in the US. It examines physical, social, economic, and psychological well-being of respondents, as well as contextual factors such as income and poverty, unemployment, availability and utilization of health services, crime, church membership, and social programs and policies. Add Health commenced in 1994–1995 (wave I) when respondents were in grades 7–12 (N=20,745), and respondents were followed through adolescence into adulthood with in-home interviews in five different waves (waves I-V). Wave II (N=16,706) of the Add Health study was conducted in 1996, a year after wave I, and wave III (N=15,197) commenced in 2001 when the original wave I respondents were 18–26 years old. Wave IV (N=15,701) commenced in 2008 when respondents were 24–32 years old. Data from wave V was not utilized in the current study as participant interviews are still ongoing. Add Health utilized a stratified, random sampling methodology to select a representative sample of adolescents in the US and a mixed mode design was employed to collect data. Response rate for waves I, II, III, and IV were 79.0, 88.6, 77.4, and 80.3 percent, respectively. Written informed consent were obtained from parents or guardians and assent from adolescents in waves I and II. For waves III and IV, written informed consent was obtained from each respondent. Add Health was approved by the Public Health Institutional Review Board at

the University of North Carolina, Chapel Hill, and the present study was reviewed by the Virginia Commonwealth University Institutional Review Board.

For the current study, all women with singleton live births (cesarean or vaginal) who participated in waves I to IV and had valid sampling weights (to make generalizations to the wider US population) were included. Live births were restricted to only the first live birth (first-order live birth) to prevent clustering (i.e., two or more births from the same participant). Furthermore, only women who had complete information on neighborhood violence, gestational age, and social support were included. Second or higher order births (N=2324), multifetal birth (N=112), and women with incomplete information on neighborhood violence (N=44), gestational age (N=12), or social support (N=23) were excluded from the study. This yielded a total sample size of 4,419 women. Selection of the study sample is shown in Figure 3.2.

Measures

The dependent variable, preterm birth, was defined as the birth of a baby before 37 completed weeks of gestation. Using methods described in previous studies,[120,121] preterm birth was measured as a binary variable (yes or no) using the gestational age at delivery. Gestational age of participants was measured at wave IV. At wave IV, participants were asked about previous pregnancies and their outcomes. If they indicated that they had given birth [live births (vaginal or caesarian)], they were asked, “Was [baby's name] born before or after [his/her] due date?” and then “How many weeks or days early/late was [baby's name] born?” This information was used to calculate gestational age by subtracting the response from 40 weeks.

The independent variable, exposure to neighborhood violence, was measured as a binary variable using information from waves I, II, and III. It was measured using 4-items that assessed

the extent to which participants have witnessed or been a victim of violence within the neighborhood during the past 12 months. The items include (1) witnessing someone being shot or stabbed, (2) being threatened with a knife or gun, (3) being shot at or stabbed, and (4) being physically assaulted. These items have previously been employed to measure neighborhood violence exposure in various studies[122-124] and have been shown to tap commonly represented types of personal victimization on benchmark scales of neighborhood violence exposure.[125,126] For each study wave, items were scored as 0 or 1, with a score of 1 representing exposure to neighborhood violence and a score of 0 representing no exposure to neighborhood violence. Scores for all four items were summed to form the neighborhood violence score for each wave, with a minimum score of 0 and a maximum score of 4. A higher score indicates greater exposure to neighborhood violence and a lower score indicates lower exposure to neighborhood violence. To accurately capture maternal exposure to neighborhood violence and maintain the prospective nature of the study, maternal exposure to neighborhood violence was assessed only in study waves prior to delivery of the baby. For example, if a woman reported delivery of her baby during wave III, exposure to neighborhood violence was assessed only at waves I and II. Total neighborhood violence scores were obtained by summing neighborhood violence scores across applicable study waves for each woman. Women who had a total score of zero were categorized as having never been exposed to neighborhood violence and women with total scores greater than zero (i.e. one to twelve) were categorized as having been exposed to neighborhood violence.

The effect modifier, maternal social support, was measured at wave IV using the level of support as perceived by respondents from three relationship domains – friends, religion, and partner support. Friend support was measured by number of close friends and was derived from one item, “How many close friends do you have?” with the instruction that close friends meant

people whom the participant felt at ease with, could talk to about private matters, and could call on for help. Friend support was scored in a numerical value from 0 to 2 as follows: 0 = no close friends, 1 = one to two close friends, 2 = three or more close friends. Religious support was measured using a single item on a 5-point Likert-type scale. Women were asked, "How often do you turn to your religious or spiritual beliefs for help when you have personal problems, or problems at school or work? Response choices include 0 = never, 1 = seldom, 2 = sometimes, 3 = often, and 4 = very often. Religious support was rescaled as follows, 0 = never, 1 = seldom or sometimes, and 2 = often or very often. Partner support was measured using marital status during pregnancy and birth as a proxy. Women who reported being married at the time of pregnancy/birth received a score of 2, women who were cohabiting at the time of pregnancy/birth received a score of 1, and women who were neither married nor cohabiting at the time of pregnancy/birth received a score of 0. Responses to these three domains (friends, religion, and partner support) were summed to create the social support variable with a minimum score of 0 and a maximum score of 6. Tertiles were then created based on the distribution of the social support variable ranging from low (tertile 1) to high (tertile 3).

Covariates

Sociodemographic factors such as maternal age at waves I and IV (continuous), maternal education (high school or vocational training or college or higher), race (White, Black, or other), marital status (married, cohabiting, or other), household income (<$20,000, $20,000-49,999 and ≥$50,000), and maternal insurance (private, Medicaid, or uninsured) were assessed. 'Other' racial category consists of American Indian or Alaska Native, Asian or Pacific Islander. Reproductive factors such as pregnancy intention (intended or unintended), pre-pregnancy body mass index (BMI) [underweight (<18.50), normal weight (18.50-24.99), overweight (25.00-

29.99) or obese (≥30.00)], receipt of prenatal care (yes or no), and low birth weight (yes or no) were also assessed. Risky behaviors such as alcohol drinking and cigarette smoking during pregnancy were assessed and categorized as dichotomous variables (yes or no).

Data Analysis

All analyses were conducted using SAS 9.4 (SAS Institute, Cary, NC) and accounted for the complex nature of the Add Health survey. Descriptive analyses were conducted to describe the characteristics of the study population using percentages for categorical variables and median and interquartile range (IQR) for continuous variables. Differences in characteristics between women with preterm and term births were examined using Chi square test (for categorical variables) and Wilcoxon rank-sum test (for continuous variables). To examine the association between exposure to neighborhood violence and preterm birth, multivariable log-binomial regression using the GENMOD procedure and utilizing maximum likelihood estimation was used. Log-binomial regression was used because the outcome was not rare (>10%) in the study population. The change in estimate strategy[86] was utilized to examine confounders of the association. Potential confounders whose inclusion in the regression model resulted in a change of 10% or more in the unadjusted estimate were retained in the adjusted model. Maternal age, insurance status, marital status, household income, and alcohol drinking in pregnancy were controlled for in the adjusted model. To explore the effect modifying role of maternal social support on the association between neighborhood violence and preterm birth, the interaction between neighborhood violence exposure and maternal social support was included in the adjusted model. Models with and without the interaction were then compared using the likelihood ratio test and the model deviance. Where the interaction term was statistically significant, the adjusted model was explored to describe the modifying effect of maternal social

support on the association between exposure to neighborhood violence and preterm birth. The effect modification analysis involved a categorical-categorical interaction and an approach that estimated simple effects using the least squares means estimates statement was utilized. Statistical significance was set at 5% a priori and results are presented as prevalence ratios and 95% confidence intervals.

RESULTS

Table 3.1 shows the sample-weighted characteristics of the study sample. The median age of women at waves I and IV were 16 (IQR: 15.0-17.0) and 29 (IQR: 28.0-30.0) years, respectively. Over half of the study sample were White (76.5%), had a college education or higher (58.1%), cohabiting (57.4%), and used private health insurance (56.6%). About 53% of pregnancies were unintended, however, majority of women reported receipt of prenatal care (96.7%). The rate of preterm birth in the study sample was 10.7%. About 28% of women reported exposure to neighborhood violence and a lower proportion of women in the upper tertile of social support reported delivery of a preterm baby (p=0.0311)

Table 3.2 shows results of the likelihood ratio tests used to examine the interaction between neighborhood violence exposure and maternal social support. Three competing models were examined – (1) unadjusted model, (2) adjusted model without the interaction term, and (3) the adjusted model with the interaction term. Using the model deviance and associated degrees of freedom to calculate the chi square statistics for the nested models, the adjusted model with the interaction term was determined to have the best fit, indicating a significant interaction ($p<0.0001$).

Results of the multivariable log-binomial regression analyses examining the association between neighborhood violence exposure and preterm birth at the different strata of maternal social support are shown in Table 3.3. Findings from the unadjusted model show that for all tertiles of social support, there was a significant increase in the rate of preterm birth for women who were exposed to neighborhood violence compared to women who were not exposed to neighborhood violence, with women in the lower tertile of social support having higher rates of preterm birth [(Tertile 1: PR=1.19; 95% CI=1.18-1.20, p<.0001); (Tertile 2: PR=1.14; 95% CI=1.15-1.16, p<.0001); (Tertile 3: PR=1.09; 95% CI=1.07-1.10, p<.0001)]. Upon controlling for confounders, the association became attenuated but remained significant at all levels of maternal social support [(Tertile 1: adjusted PR (APR)=1.12; 95% CI=1.11-1.13, p<.0001); (Tertile 2: APR=1.07; 95% CI=1.06-1.08, p<.0001); and (Tertile 3: APR=0.88; 95% CI=0.86-0.89, p<.0001)]. For maternal social support at tertiles 1 and 2, there was a significant increase in the rate of preterm birth in women exposed to neighborhood violence compared to women who were not exposed to neighborhood violence. However, for maternal social support at tertile 3 there was a significant decrease in the rate of preterm birth in women exposed to neighborhood violence compared to women who were not exposed to neighborhood violence.

DISCUSSION

Findings from this study show that maternal exposure to neighborhood violence is significantly associated with preterm birth; and this is in keeping with the study hypothesis. This finding is consistent with previous research that have reported significant increases in the risk of preterm birth in women exposed to neighborhood violence.[104-107] Messer et al. in a study using a sample of women in Raleigh, North Carolina, examined the association between violent crime exposure and adverse birth outcomes.[100] They reported that neighborhood violence exposure was

positively associated with preterm birth among non-Hispanic White and Black women. Similarly, Masho, et al. in a study that examined the association between neighborhood youth violence exposure and preterm birth in women in Richmond city, Virginia, reported that women who were exposed to youth violence in neighborhoods with the highest level of violence had greater odds of very preterm births than women exposed to youth violence in neighborhoods with the lowest level of violence.[107] The effect of neighborhood violence exposure on the risk of preterm birth may be attributable to the impact of maternal stress arising from exposure to neighborhood violence.[111,112] Exposure to neighborhood violence has been shown to increase psychological stress via hormonal and neuroendocrine changes (e.g. changes in cortisol and cortisol-releasing hormone levels) which increases the risk of preterm birth.[72,76] Additionally, maternal stress may increase the risk of preterm birth indirectly through risky maternal health behaviors such as smoking[114] and alcohol drinking.[115] Women who experience stress due to exposure to neighborhood violence may use such risky behaviors as coping mechanisms to alleviate stress and ultimately increase their risk of preterm birth. Research has suggested that the impact of maternal stress on the risk of preterm birth may be due to chronic stress rather than acute stress.[127] In the current study, we measured exposure to neighborhood violence (which triggers maternal stress) cumulatively over different time periods prior to birth so as to effectively capture the effect of chronic maternal stress. Unfortunately, maternal stress in pregnancy could not be ascertained in the current study as the measure of stress in the study data was not captured during the pregnancy period.

Furthermore, this study demonstrates that the receipt of maternal social support modifies the association between neighborhood violence exposure and preterm birth. Women who had lower levels of maternal social support were shown to have higher rates of preterm birth with

exposure to neighborhood violence compared to women who were not exposed to neighborhood violence. Conversely, women who had higher levels of maternal social support were shown to have lower rates of preterm birth with exposure to neighborhood violence compared to women who were not exposed to neighborhood violence. This highlights the buffering effect of maternal social support on the effect of neighborhood violence exposure (through stress) on the risk of preterm birth. Findings from the current study are in contrast to those from previous randomized clinical trials which reported no significant effect of maternal social support in reducing the risk of preterm birth.[39,40] Villar et al. in a randomized controlled trial to evaluate a program of home visits designed to provide psychosocial support during pregnancy to women with high risk pregnancy in four centers in Latin America, reported no evidence that the intervention had any significant effect on reducing the risk of preterm birth[40] Indeed, a systematic review and meta-analysis by Hetherington et al. in 2015 indicated no evidence for a direct association between social support and preterm birth.[38] However, it has been suggested that social support may provide a buffering mechanism between stress and preterm birth.[38] This may partly explain the lack of significant findings observed for the effect of social support on preterm birth in reported randomized clinical trials as participants were selected from women who early-registered for prenatal care, who may have had lower levels of maternal stress.[128] McDonald, et al. in a study to examine the effect of cumulative psychosocial stress and coping resources on preterm birth using the prospective pregnancy cohort study in Alberta, Canada, reported that among women with medium to high levels of perceived social support, cumulative psychosocial stress was not an independent risk factor for preterm birth but was an independent risk factor for preterm birth among women with low levels of social support.[129] This indicates that the effect of maternal social support may only be evident in women with moderate to high levels of stress. In the

current study, we examined the effect of neighborhood violence exposure on the rate of preterm birth in women. Exposure to neighborhood violence has been established as an independent risk factor for maternal stress.[72,76,111,112] Although, we were unable to measure maternal stress during pregnancy in the current study, study findings which showed a buffering effect of maternal social support, suggest high level of stress in women exposed to neighborhood violence in the study population and thus, we were able to examine the effect of maternal social support in reducing the risk of preterm birth in women exposed to neighborhood violence.

Strengths and Limitations

This study has some strengths. First, the study sample is nationally representative and thus, findings can be generalized to women in the US. Second, exposure to neighborhood violence was measured at different time points prior to the birth of the baby. This allowed for the assessment of the cumulative effect of exposure to neighborhood violence and also maintained the prospective nature of the study. This study is not without limitations. First, maternal stress in pregnancy could not be ascertained due to limitations in the data. Because the Add Health data is not exclusively tailored to pregnant women, the measure of stress available in the data was not captured during the pregnancy period and hence, could not be utilized. Second, survey questions that were used to measure neighborhood violence exposure at each survey wave assessed neighborhood violence exposure in the past 12 months only. There may be some periods of neighborhood violence exposure that may not have been captured by the measuring instrument. Third, marital status was used as a proxy to measure partner support for the social support variable. Marital status may not be the best measure for partner support. Fourth, gestational age was calculated based on maternal reported values of how early or late a baby was born. There is the possibility of recall and/or misclassification errors. Lastly, due to limitation in the Add

Health data, distinction could not be made between spontaneous preterm birth and medically-induced preterm birth.

CONCLUSIONS

This study showed that maternal exposure to neighborhood violence was significantly associated with preterm birth in a nationally representative sample of US women. Furthermore, receipt of social support was shown to modify the association between neighborhood violence exposure and preterm birth, such that in women with higher levels of social support, neighborhood violence exposure was associated with decreased rate of preterm birth. Intervention programs to identify and provide social support to pregnant women who are exposed to neighborhood violence are needed to mitigate the risk of preterm birth.

Chapter 4:

Neighborhood Deprivation and Preterm Birth: The Mediating Influence of Neighborhood Violence

ABSTRACT

Background: Neighborhood deprivation has been reported to be associated with preterm birth. Neighborhood violence may mediate the association; however, the mediating influence of neighborhood violence has been unexplored in epidemiologic studies. This study, using a geographically defined cohort of women in Richmond city, Virginia, aims to examine the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth.

Methods: Merged data from the vital statistics live birth records, police crime reports, and census data for Richmond city, Virginia, between 2006 and 2015 was analyzed. Data had a 2-level hierarchical structure with live births nested in 66 census tracts. Neighborhood deprivation was measured using the Neighborhood Deprivation Index (NDI) based on a previously validated algorithm. Multilevel structural equation modeling was used to examine the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth.

Results: Rate of preterm birth in the study population was 10.1% and the violence rate was 114.1 per 1000 youth population in Richmond city during the study period. The median NDI score across all census tracts was 0.09, with an interquartile range of –0.69 to 0.76. There was a significant direct effect between neighborhood deprivation and preterm birth (β=0.304, 95% CI=0.231, 0.377). However, the indirect effect of neighborhood deprivation on preterm birth through neighborhood violence was not significant (β=0.063, 95% CI= –0.025, 0.151).

Conclusions: There is insufficient evidence to show that neighborhood violence mediates the association between neighborhood deprivation and preterm birth in women in Richmond city,

Virginia. However, findings lend support to previous studies that reported increased risk of preterm birth in women resident in deprived neighborhoods, as well as increased risk of neighborhood violence in deprived neighborhoods.

INTRODUCTION

Neighborhood deprivation refers to the state of a neighborhood that arises as a result of negative socioeconomic changes such as economic disadvantage, unemployment, poor education and housing conditions.[97] In contrast to measures of socioeconomic status at an individual level such as an individual's income and educational status, neighborhood deprivation is an aggregate measure at the neighborhood level based on the percentage of residents living with low socioeconomic status, unemployed and/or receiving welfare assistance.[130] It has been well established that residents of deprived neighborhoods in general have poorer health compared to residents of more affluent neighborhoods.[97,131-133] Moreso, neighborhood deprivation has been linked with a host of adverse health outcomes which include cardiovascular diseases (e.g. coronary heart disease[134] and diabetes[135]); mental health conditions (e.g. anxiety[136] and depression[137]); eye diseases[130] (e.g. macular degeneration, cataract and glaucoma); poor birth outcomes (e.g. low birth weight[138] and preterm birth[139-143]), cancer,[144] and death,[145] even after adjusting for individual-level factors.

An important maternal outcome that has been linked with neighborhood deprivation is the delivery of a preterm baby.[139-143] However, findings for this association have been mixed across various studies. Some studies have reported a positive association between neighborhood deprivation and preterm birth,[139-143] and some have not;[146] while others have only demonstrated positive associations among particular racial/ethnic groups.[141,147,148] For example, O'Campo et al. in a study among non-Hispanic Black and White women in eight geographic areas in the US reported that neighborhood deprivation was significantly associated with increased risk of preterm birth among both non-Hispanic White women and non-Hispanic Black women.[139] Conversely, Agyemang et al., examining the association between neighborhood deprivation and

pregnancy outcomes in a sample of Dutch women reported no significant association between neighborhood deprivation and preterm birth.[146] A possible explanation for the inconsistent findings across studies may be due to the use of different indicators to characterize deprivation in neighborhoods and/or different study samples.

Various pathways have been proposed to explain the association between neighborhood deprivation and preterm birth such as reduced access to prenatal care,[149] unhealthy maternal behaviors,[150] and neighborhood disorder.[151]. However, the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth has been unexplored. Majority of epidemiologic studies that have examined the influence of neighborhood violence on preterm birth have often utilized neighborhood violence as a proximal risk factor for preterm birth.[31,32,105] However, neighborhood violence can also be considered as a product of poor socioeconomic conditions[148,152] and disadvantaged state of a neighborhood.[153] For example, neighborhood unemployment, which is a strong indicator of neighborhood deprivation, has been shown to be causally related to neighborhood violence.[154] As such, neighborhood violence may not be causally associated with preterm birth but rather act as an intermediate in the pathway between neighborhood socioeconomic conditions and preterm birth. Understanding the mediating influence of neighborhood violence on the relationship between neighborhood deprivation and preterm birth is therefore of significant importance as intervention programs focusing on neighborhood violence without taking cognizance of distal risk factors such as neighborhood deprivation may not achieve the desired effect.

This study therefore aims to examine the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth using data from a geographically defined cohort of women in Richmond city, Virginia.

Innovation

Previous studies have examined the relationship between neighborhood deprivation and preterm birth and various mechanisms have been suggested to explain the association. Yet it is still not fully understood how neighborhood deprivation influences the risk of preterm birth. Neighborhood violence may act as a mediator of the association between neighborhood deprivation and preterm birth. However, the mediational role of neighborhood violence has not been explored in epidemiologic studies. Reducing violence has been recognized by the Center for Disease Control and Prevention (CDC),[155] the Surgeon General's National Prevention Council (NPC),[156] and Healthy People 2020 as a top priority for improving public health and safety in the United States. Therefore, improving the understanding of how neighborhood violence influences the risk of preterm birth in women resident in deprived neighborhoods can help guide the development of effective intervention programs aimed at reducing the risk of preterm birth.

Conceptual framework

This study utilized an adaptation of the conceptual framework proposed by Kawachi, et al.[157] to investigate the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth. Kawachi et al. posited that neighborhood characteristics such as relative deprivation influence the level of crime in the neighborhood which in turn influences community health, such that as the level of deprivation in the neighborhood increases, neighborhood violence also increases, leading to poorer health of members of the community. As shown in the conceptual diagram in figure 4.1, neighborhood violence positively mediates the association between neighborhood deprivation and preterm

birth, such that neighborhood deprivation will be positively associated with neighborhood violence and neighborhood violence in turn will be positively associated with preterm birth.

METHODS

Data source

This study utilized merged data from the vital statistics live birth records, police crime reports and census data for Richmond city, Virginia, for a ten-year consecutive period of 2006-2015.

Vital statistics live birth records

The live birth records for Richmond city, VA were obtained from the Virginia Department of Health (VDH). A total of 30,527 live births were abstracted for ten consecutive years from 2006 to 2015. Live birth records comprised of individual-level variables such as maternal sociodemographic factors (e.g. age, race/ethnicity and education), reproductive history (e.g. gestational age at delivery, birth weight, and prenatal care attendance) and risky behaviors (e.g. smoking and alcohol use). The data use agreement was reviewed and approved by the VDH Institutional Review Board

Geocoding of maternal addresses

The maternal addresses from the live birth records were geocoded according to the US census's tracts within Richmond city, VA. The geocoding was conducted using the ArcGIS software version 10.5 (Environmental Systems Research Institute, Redlands, CA). Before initiating the geocoding process, accuracy of maternal addresses was assessed using Google Maps and corrections were made to those that were improperly documented. This study used

2015 Topologically Integrated Geographic Encoding and Referencing (TIGER) street map by the US Census Bureau for Richmond city, VA as the street reference file.[158] ArcGIS compares the line segments in the TIGER street reference map to addresses to obtain a match between the two. It then interpolates between line segment nodes (e,g., north and south end of a street), estimates the location of the address along the centerline of that street, and subsequently assigns a latitude/longitude coordinate to that point. Required elements in the geocoding process in ArcGIS include maternal street address and zip code. Geocoding was set at a spelling sensitivity of 80%, minimum candidate score of 75%, and a minimum match score of 80%. These scores allow matches for addresses with minor deviations in spelling and format. Initial geocoding of maternal addresses yielded a match of 77% (23,458/30,527). Further investigation revealed that 1,685, 1,061, and 1,714 maternal addresses were located in Richmond County, Chesterfield County, and Henrico County, VA, respectively (supplemental figs. 4.2, 4.3, and 4.4). After exclusion of these maternal addresses from the sample, the geocoding process was rerun and yielded a match of 99.6% (25,971/26,067) with 37 addresses tied (0.1%) and 59 addresses unmatched (0.2%; supplemental fig. 4.1). The 59 addresses unmatched either had a P.O. Box listed or were missing. For maternal addresses that were tied (i.e., address had more than one candidate with the same best match score, but at different locations), if the location of the candidate matches were in the same census tract, then the tie was included as a match. All 37 addresses had candidate matches that were within the same census tract, and thus were included as matches. This yielded a total of 26,008 matched addresses. After completion of the geocoding process, census tracts were assigned (arranged as polygons) to matched maternal addresses (depicted as points) using the 2010 census tract boundaries for Richmond city, VA. The geocoding sequence of maternal addresses for live births is shown in Figure 4.2.

Police crime report

Police crime report for a consecutive ten-year period of 2006 to 2015 for all incident cases of class A reportable offenses (aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism) involving youths aged 10 to 24 years in Richmond city, VA was obtained from the Richmond Police Department. Crime report was obtained at the census tract level (that is, incident crime cases in each census tract in Richmond city, VA was reported for years 2006 to 2015). Breakdown of incident cases (i.e., type of offense) was not available in the data.

Census data

Because consecutive ten-year data for both live births and police crime report for Richmond city, VA were utilized, census data for Richmond city that encompassed the consecutive ten year period was required. However, census data at the census tract level that encompasses the consecutive ten year period of the study (2006-2015) was not available. Therefore census data at the midpoint was used as an approximate. The 5-year American Community Survey (ACS) data (i.e., 2008-2012) was preferred to the 2010 decennial census data because it captured a wider portion of the midpoint (2008-2012) than the 2010 decennial census data. Census data included neighborhood-level (census tract) variables such as percentage population with less than high school, percentage unemployed population, percentage males in management occupations, percentage crowded housing, percentage households in poverty, percentage female head households with children, percentage households earning less than $30,000 per year, and percentage households on public assistance.

All three data sets (i.e., live birth records, police crime report and census data for Richmond city, VA) were merged by census tract. This created a final data set that had a 2-level hierarchical structure with live births nested in 66 census tracts.

Study sample

All women with singleton live births and complete information on gestational age in Richmond city, VA who were successfully geocoded to a census tract within Richmond city, were included in the study. Women with multifetal births (N=1,039; 4.0%) or incomplete or missing information on gestational age (N=14; 0.05%) were excluded from the study. Women with multifetal births were excluded because they have greater risk of preterm birth than women with singleton births.[159] This yielded a total sample size of 24,955 women.

Measurements

Neighborhood deprivation

Neighborhood deprivation was measured as a continuous variable using the Neighborhood Deprivation Index (NDI). The NDI synthesizes multiple dimensions of the neighborhood socioeconomic context, allowing for comparisons across geographic areas.[160,161] Using an algorithm developed by Messer et al.,[161] the NDI was created for each census tract in Richmond city, VA using principal component analysis to analyze eight neighborhood-level variables from the 5-year estimates (2008–2012) of the American Community Survey (ACS). Variables that were utilized in creating the NDI include percent population with education less than high school level, percent unemployed population, percent males in management occupations, percent crowded housing, percent households in poverty, percent female headed households with children, percent households earning less than $30,000 per year, and percent

households on public assistance. The NDI was predicted based on the loadings of the eight factors in the first principal component.[160] In this study, only the first principal component had an eigenvalue more than 1 (eigenvalue=5.3), accounting for 66.6% of the total variance. Further, this study standardized the NDI to have a mean of 0 and standard deviation of 1. If a mean measure of NDI at a neighborhood is above the standardized mean, this neighborhood is considered as having more neighborhood deprivation; otherwise if a mean is below the standardized mean, the neighborhood is considered as having less deprivation.

Neighborhood violence

Neighborhood violence was measured at the census tract level, utilizing methods suggested by a previous study.[29] Incident cases of all Class A reportable offenses (aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism) involving youths (10-24 years) in Richmond city, VA from 2006 to 2015 in each census tract were summed. Violence rates were calculated for each census tract for the 10 year period (2006-2015) by dividing the total number of incident cases of violence in each census tract from 2006-2015 by the total population of youths (10-24 years) in each census tract for the same time period. Because the complete annual population for each census tract for the 10-year period was not available from the census data, the mean number of incident violence cases in each census tract for the 10-year period was divided by the midyear (2010) youth population for the census tract to give the violence rate (per 1000 youth population) for each census tract (Table 4.2).

Preterm birth

Preterm birth was defined as the birth of a baby before 37 completed weeks of gestation. Preterm birth was measured as a binary variable (yes or no) using the gestational age at delivery. Gestational age was assessed using the obstetric estimate of gestation at delivery which has been reported to have greater validity over the last menstrual period (LMP)-based measure of gestational age.[162] Due to small numbers of women with extremely preterm (N=266; 1.1%) and very preterm (N= 262; 1.1%) births in the study sample, preterm birth was not be classified as such.

Covariates

Sociodemographic variables include maternal age (continuous), maternal race/ethnicity (Non-Hispanic (NH) White, NH Black, Hispanic, NH other), maternal education (high school or college or higher), insurance (private, Medicaid, or self-pay), and marital status (married or not married). Reproductive factors and risky behaviors such as previous live birth (0 and ≥1,), Kotelchuk index of prenatal care utilization (inadequate/intermediate, adequate, and adequate plus), previous preterm birth (yes or no), smoking during pregnancy (yes or no), alcohol use during pregnancy (yes or no), and medical risk factors (pre-pregnancy hypertension, gestational hypertension, pre-pregnancy diabetes, and gestational diabetes) in pregnancy (yes or no) were also measured.

Analytic strategy

Descriptive analyses were conducted to determine the characteristics of the study population. Percentages (for categorical variables) and mean/standard deviation or median/interquartile range (for continuous variables) were calculated. Principal component analysis was conducted using the factor procedure in SAS 9.4 (SAS Institute, Cary, NC) and

multilevel structural equation modeling was conducted using the multilevel package in Mplus 8.1 (Muthén & Muthén, Los Angeles, CA). Multilevel structural equation modeling was used to test the mediation hypothesis across the 2-level nested data and to determine if the current data was a good fit for the model. Maximum likelihood estimation was used to estimate model parameters because random intercepts (TYPE=RANDOM) were included in the model.[163] Because categorical variables were included in the model and maximum likelihood estimation was being utilized, chi-square and other related fit statistics (CFI, TLI, and RMSEA) were not available in Mplus.[163] Therefore, the Akaike information criterion (AIC) and Bayesian information criterion (BIC) were utilized for model selection (model with the lowest AIC and BIC is preferred). The direct effect of the predictor variable (neighborhood deprivation) on the dependent variable (preterm birth) was tested, and the direct path coefficient was recorded. The direct path was adjusted for age, race/ethnicity, parity, insurance, smoking during pregnancy, marital status, and medical morbidity. The indirect effect of neighborhood deprivation on preterm birth through neighborhood violence was tested using the "Model Indirect" command in Mplus. The 'mediator-outcome' path was adjusted for age, race/ethnicity, parity, insurance, smoking during pregnancy, marital status, and medical morbidity. The direct and indirect effects and their associated 95% confidence intervals were recorded to determine the mediational effect of neighborhood violence on the relationship between neighborhood deprivation and preterm birth. Bootstrap 95% confidence intervals for the indirect effect could not be ascertained as it is currently not available for multilevel structural equation modeling in Mplus 8.1; hence, the Wald 95% confidence intervals were utilized. Furthermore, because previous studies have shown racial/ethnic differences in the association between neighborhood deprivation and preterm birth,[139] race/ethnicity was tested for moderation using the index of moderated mediation as

described by Hayes.[164] Race/ethnicity did not moderate the association and race/ethnicity was treated as a confounder. Since neighborhood deprivation and neighborhood violence are both neighborhood-level variables and preterm birth is an individual-level variable, a 2-2-1 structural equation model was utilized and random intercepts and fixed slopes were specified in the model. Because the model utilized a 2-2-1 structure, neighborhood-level variables could not be regressed on individual-level variables while adjusting for covariates. To address this limitation, cluster-level variables were created for such individual-level variables using the cluster-mean option in Mplus.

RESULTS

Table 4.1 shows the characteristics of the study population for both individual- and neighborhood-level factors. Of 24,955 eligible study participants, the average age was 27.1 (SD: 6.2) years. Close to half of the study population were NH Black (45.1%) and 43.3% and 43.7% of study participants had private insurance and Medicaid, respectively. Over half of the study population had completed high school education (63.9%) and were not married (62.1%). Approximately 55% of the study population had at least one previous live birth and 50.8% had adequate prenatal care. The rate of preterm birth in the study population was 10.1% and the neighborhood violence rate for the study period was 114.1 per 1000 youth population.

Table 4.3 shows results from the principal component analysis used to create the NDI. Factor loadings were highest for percent households on public assistance (0.92), and lowest for percent crowded housing (0.54). The NDI was predicted based on the loadings of the eight factors in the first principal component.[160] Only the first principal component had an eigenvalue greater than one in this study (eigenvalue=5.3) and accounted for 66.6% of the total variance

(Figure 4.3). The median NDI score across all census tracts was 0.09 with an interquartile range of –0.69 to 0.76 (Table 4.1). The distribution of NDI as well as the individual components of the NDI across the various census tracts are shown in Table 4.4. Correlation coefficients for the individual components of the NDI showed strong correlations for all variables except for percent crowded housing which showed fair correlations (Table 4.5).

Model selection indices for the best model fit are shown in table 4.6. Three competing models were examined – model 1 was the unadjusted model that did not control for any covariate, model 2 controlled for age, race/ethnicity, parity, insurance, smoking in pregnancy, marital status, and medical morbidity, and model 3 controlled for age, education, race/ethnicity, parity, insurance, smoking in pregnancy, alcohol drinking in pregnancy, marital status, and medical morbidity. For model 1, AIC=16958.052 and BIC=17014.926, model 2, AIC=16536.943 and BIC=16715.348, and for model 3, AIC=16598.285 and BIC=16802.194. Model 2 had the smallest AIC and BIC and was determined to have the best fit.

There was a significant direct effect between neighborhood deprivation and preterm birth (β=0.304, 95% CI=0.231, 0.377), such that the more deprived the neighborhood a woman resided in, the higher the risk of preterm birth (Table 4.7). However, the indirect effect of neighborhood deprivation on preterm birth through neighborhood violence was not significant (β=0.063, 95% CI= –0.025, 0.151; Table 4.7). Breakdown of the indirect effect shows a significant path between neighborhood deprivation and neighborhood violence (β=7.829, 95% CI=5.450, 10.208) and a non-significant path between neighborhood violence and preterm birth (β=0.008, 95% CI= –0.002, 0.018; Figure 4.4).

DISCUSSION

This study examined the mediating effect of neighborhood violence on the association between neighborhood deprivation and preterm birth in Richmond city, VA. It was hypothesized that neighborhood deprivation will influence the level of violence in the neighborhood which in turn will influence the risk of preterm birth, such that as the level of deprivation in the neighborhood increases, neighborhood violence will also increase, leading to greater risk of preterm birth. Findings from the current study show that although neighborhood deprivation was significantly associated with preterm birth, the association was not significantly mediated by the neighborhood violence measure. A possible reason for the lack of mediation effect observed in the current study may be the lack of significant association between neighborhood violence and preterm birth observed in the study population. Results showed a lack of association between neighborhood violence and preterm birth. Previous studies that have examined the association between neighborhood violence and preterm birth have reported mixed findings. Masho et al., in a multilevel study to examine the association between neighborhood youth violence and preterm birth in women in Richmond city, Virginia, reported that women in census tracts with the highest level of violence had 38% higher odds of having very preterm births (<32 weeks gestation) than women in census tracts with the lowest level of violence.[165] Conversely, Clemens and Dibben in a multilevel study in Scotland to examine the association between crime rates and birth weight and prematurity, reported no significant association between neighborhood crime rates and preterm birth.[166] The variability in findings from studies that examined the association between neighborhood violence and preterm birth may be due to differing methods of measuring and classifying neighborhood violence. For example, Koppensteiner and Manacorda, while examining the impact of in-utero exposure to neighborhood violence on preterm birth, used homicide rates as a measure of neighborhood violence.[104] On the other hand, Masho et al.,

measured neighborhood violence using class A reportable offences (aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism).[165] Furthermore, Messer et al.[167] limited measurement of neighborhood violence to violent crimes only (homicides, assaults, sexual assaults and kidnappings), while Clemens and Dibben[166] restricted measurement of neighborhood violence to domestic house breaking, drugs offences, minor assault, and vandalisms. A standardized measurement index of neighborhood violence may be necessary to allow for uniform measurement of neighborhood violence and comparison of findings across studies.

In the current study, all class A reportable offenses (aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism) were used to measure the rate of neighborhood violence in the different census tracts. This method of measuring neighborhood violence was similar to that reported by Masho et al. in a study in Richmond city, VA,[165] which showed significantly higher odds of very preterm birth (<32 weeks gestation) for census tracts with the highest rates of violence. The noted difference in the odds of preterm birth with the current study may be due to categorization of preterm birth by Masho et al. into very preterm birth (<32 weeks gestation) and moderately preterm birth (32-36 weeks gestation). Significant association was observed only between neighborhood violence and very preterm birth by Masho et al. (but not between neighborhood violence and moderately preterm birth). Sensitivity analysis (see Table 4.8) in the current study conducted with a 3-level preterm birth variable (very preterm birth (<32 weeks gestation), moderately preterm birth (32-36 weeks gestation), and term birth (≥37 weeks gestation) to examine the association between neighborhood violence and preterm birth, however, did not show any significant association between neighborhood violence and preterm birth. Reasons for the differences are unclear but

may be due to differences in the time period examined for both studies (i.e., 2004-2013 for Masho et al. and 2006-2015 for the current study), given that violence rate in Richmond city has seen a steady decline over the past decade.

Although, the current study did not find evidence to support the mediating effect of neighborhood violence on the association between neighborhood deprivation and preterm birth in women in Richmond city, VA, findings are consistent with previous studies that have reported significant association between neighborhood deprivation and preterm birth,[139-143] as well as neighborhood deprivation and neighborhood violence.[168,169]

Strengths and Limitations

This study utilized data across a ten-year period from Richmond city, VA to study the mediation effect of neighborhood violence on the association between neighborhood deprivation and preterm birth. Richmond city, VA has one of the highest rates of violent crime in the US[170] and this enabled adequate capturing of neighborhood violence. Also, neighborhood violence in the census tracts were measured as actual rates of reported crime in Richmond city, VA. This helped to avoid subjective measurement of neighborhood violence obtained from participants' self-report of exposure to neighborhood violence. Furthermore, the use of robust statistical methods which accounted for the hierarchical nature of the data ensured for accurate calculations of standard errors and variance which helped to maintain the internal validity of the study. This study however, has some limitations. First, measurement of neighborhood violence is based on reported cases of violence only. Hence, cases of violence that were not reported to the police were not captured. Second, measurement of neighborhood violence was limited to class A reportable offenses involving youths between 10 and 24 years, and did not include violence perpetrated by older adults (>24 years). The impact of this limitation may however be minimal as

adolescents and young adults have been reported to have the highest rates of violence perpetration in the US.[171] Also, class A reportable offenses constitute over 80% of all reportable offences.[170] Third, the use of the Wald 95% confidence interval for the indirect effect may not have been the most accurate option as bootstrap 95% confidence intervals have been shown to be more accurate than the Wald 95% confidence interval.[172] However, bootstrap 95% confidence interval is not available for multilevel analysis in Mplus 8.1. Lastly, findings from this study can only be generalized to women in Richmond city, Virginia.

CONCLUSIONS

This study did not find sufficient evidence to show that neighborhood violence mediates the association between neighborhood deprivation and preterm birth in women in Richmond city, VA. However, findings lend support to previous studies that reported increased risk of preterm birth in women resident in deprived neighborhoods, as well as increased risk of neighborhood violence in deprived neighborhoods. Interventions to address deprivation in disadvantaged neighborhoods are needed to reduce the risk of preterm birth.

Chapter 5: Summary

Preterm birth continues to be a major public health concern in the US and has been associated with infant morbidity[46],[47] and mortality,[52] and negatively impacts families with preterm infants. Data from the National Center for Health Statistics indicate that there has been an upward trend in the rate of preterm birth over the past three years (2014-2017), with majority of the increment being observed in NH Black and Hispanic women.[2] The relationship between the mother and father of the baby, maternal receipt of social support, and neighborhood factors during pregnancy have been suggested to impact preterm birth. However, findings from prior research have been equivocal. The aim of this dissertation project was to examine the impact of the quality of the mother–father relationship, social support, and neighborhood context on preterm birth.

Chapter 2, entitled "The modifying effect of perceived residential environment on the association between quality of mother–father relationship and preterm birth in a sample of African-American women", examined the association between the quality of mother–father relationship and preterm birth in a sample of African-American women from three metropolitan counties in Detroit, Michigan, and whether maternal perception of the residential environment modified the association. Multivariable log-binomial regression was used to examine the association between quality of mother–father relationship and preterm birth because the rate of preterm birth in the study sample was relatively common (>10%). Three domains of the mother–father relationship were identified from a set of 14 items using exploratory factor analysis, and maternal perception of the residential environment was measured using five validated scales. The modifying effect of the perceived residential environment was assessed using two-way continuous-continuous interactions between domains of the mother–father relationship and perceived residential environment. In this study sample, no significant association was observed

between quality of mother-father relationship and preterm birth. Similarly, no evidence was found to show that maternal perception of the residential environment modified the association between quality of mother-father relationship and preterm birth. These results suggest that there is insufficient evidence to support an association between the quality of mother-father relationship and preterm birth, as well as the modifying effect of maternal perception of the residential environment on the association. Future studies with different study populations are recommended to confirm the results of the current study.

Chapter 3 entitled, "Does the receipt of social support modify the association between neighborhood violence exposure and preterm birth?" examined the association between neighborhood violence exposure and preterm birth, and how the receipt of social support modified the association between neighborhood violence exposure and preterm birth. The association was examined using multivariable log-binomial regression and the modifying effect of social support was examined using a two-way continuous-continuous interaction. Results revealed that neighborhood violence exposure was significantly associated with the rate of preterm birth. Furthermore, maternal receipt of social support was shown to modify the association between neighborhood violence exposure and preterm birth, such that in women with higher levels of social support, neighborhood violence exposure was associated with decreased rate of preterm birth. These findings suggest that provision of adequate social support to women who are exposed to neighborhood violence may reduce the rate of preterm birth.

The final chapter, Chapter 4 entitled, "Neighborhood deprivation and preterm birth: the mediating influence of neighborhood violence", examined the mediational role of neighborhood violence on the association between neighborhood deprivation and preterm birth. Multilevel structural equation modeling was used to examine the mediating influence of neighborhood

violence on the association between neighborhood deprivation and preterm birth. A neighborhood deprivation index, created using principal component analysis, was used to measure neighborhood deprivation. Neighborhood violence was measured using class A reportable offenses in youths. Findings showed a significant direct effect between neighborhood deprivation and preterm birth. However, the indirect effect between neighborhood deprivation and preterm birth through neighborhood violence was not significant. These findings suggest that although neighborhood deprivation was significantly associated with increased risk of preterm birth, there was insufficient evidence to support the mediational effect of neighborhood violence on the association between neighborhood deprivation and preterm birth.

IMPLICATIONS FOR PUBLIC HEALTH

In December 2010, the Department of Health and Human Services launched Healthy People 2020 with one of its objectives being to reduce the rate of preterm birth in the US to a target rate of 9.4%.[173] Although, preterm birth rates in the US declined from 11.99% in 2010[174] to 9.57% in 2014,[3] the rate of preterm birth has steadily increased from 9.57% in 2014[3] to 9.93% in 2017.[2] Given the adverse health effects associated with preterm birth and the economic burden that it places on the healthcare system, effective intervention programs are needed to reduce the rate of preterm birth.

Findings from this study showed that maternal receipt of adequate levels of social support reduced the rate of preterm birth in women who were exposed to neighborhood violence. Exposure to neighborhood violence has been shown to be a risk factor for preterm birth across different racial/ethnic groups.[139] Identification of women during prenatal care visits who are exposed to neighborhood violence and the provision of adequate social support to such women may help to reduce the rate of preterm birth. Furthermore, the importance of the receipt of social

support during the pregnancy period was buttressed in supplemental findings which showed that the receipt of social support during pregnancy in women with low levels of relationship trust with the father of the baby, was associated with lower rate of preterm birth. Therefore, provision of social support (e.g. centering pregnancy) to women with poor relationship quality with the father of the baby may help to mitigate the risk of preterm birth.

Lastly, although neighborhood violence was not shown to mediate the association between neighborhood deprivation and preterm birth, neighborhood deprivation was shown to increase the risk of preterm birth. This supports findings from previous studies[139] and emphasizes the need for focused intervention on women resident in deprived neighborhoods to reduce the risk of preterm birth.

FUTURE RESEARCH

Future studies with larger sample size are needed to examine the modifying effect of perceived residential environment on the association between quality of the mother-father relationship and preterm birth. In the current study, there was insufficient evidence to support the modifying effect of maternal perception of the residential environment on the association between quality of the mother-father relationship and preterm birth. This may have been due to inadequate sample size in the study to detect such effect modification. Fleiss, J.L. reported that the sample size required to detect an interaction is four times that for a main effect of the same magnitude;[92] and as such, the sample size for the current study may not have been sufficient to detect significant interaction. Furthermore, information on the mother-father relationship was obtained from study participants at only one time point (the immediate delivery period). The relationship between the mother and father of the baby is dynamic. Therefore, future studies

should measure the mother-father relationship at various time points during pregnancy to get a better understanding of the mother-father relationship.

In the study that examined the modifying effect of social support on the association between neighborhood violence exposure and preterm birth, maternal stress during pregnancy could not be ascertained due to its unavailability in the data. Future studies are needed to examine how maternal stress influences the modifying effect of social support on the association between neighborhood violence exposure and preterm birth.

Lastly, future studies using alternate measurements of neighborhood violence are needed to examine the mediational effect of neighborhood violence on the association between neighborhood deprivation and preterm birth. In the current study, neighborhood violence was measured using Class A reportable offenses and future studies are needed to confirm the study findings.

REFERENCES

1. Ananth CV, Ananth CV, Vintzileos AM. Epidemiology of preterm birth and its clinical subtypes. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2006;19(12):773-782.

2. Hamilton BE, Martin JA, Osterman MJK, Driscoll AK, Rossen LM. Births: Provisional data for 2017. *Vital Statistics Rapid Release; no 4. Hyattsville, MD: National Center for Health Statistics.* May 2018. Available from: https :// www.cdc. gov/nchs/data/vsrr/report004.pdf

3. Hamilton BE, Martin JA, Osterman MJ, Curtin SC, Matthews TJ. Births: Final data for 2014. *Natl Vital Stat Rep*. 2015;64(12):1-64.

4. World Health Organization (WHO). Preterm birth. http://www.who.int/mediacentre/factsheets/fs363/en/. Accessed 1/26/2016.

5. Wen SW, Smith G, Yang Q, Walker M. Epidemiology of preterm birth and neonatal outcome. *Semin Fetal Neonatal Med.* 2004;9(6):429-435.

6. Saigal S, Doyle LW. An overview of mortality and sequelae of preterm birth from infancy to adulthood. *The Lancet*. 2008;371(9608):261-269.

7. van Noort-van der Spek IL, Franken MC, Weisglas-Kuperus N. Language functions in preterm-born children: A systematic review and meta-analysis. *Pediatrics*. 2012;129(4):745-754. doi: 10.1542/peds.2011-1728 [doi].

8. Misund AR, Nerdrum P, Braten S, Pripp AH, Diseth TH. Long-term risk of mental health problems in women experiencing pre-term birth: A longitudinal study of 29 mothers. *Ann Gen Psychiatry*. 2013;12(33):2-9.

9. Barroso NE, Hartley CM, Bagner DM, Pettit JW. The effect of preterm birth on infant negative affect and maternal postpartum depressive symptoms: A preliminary examination in an underrepresented minority sample. *Infant Behavior and Development*. 2015;39:159e165.

10. Candelori C, Trumello C, Babore A, Keren M, Romanelli R. The experience of premature birth for fathers: The application of the clinical interview for parents of high-risk infants (CLIP) to an Italian sample. *Frontiers in psychology*. 2015;6:1444

11. Hamilton BE, Martin JA, Osterman MJ. Births: Preliminary data for 2015. *Natl Vital Stat Rep*. 2016;65(3):1-15.

12. Osypuk TL, Acevedo-Garcia D. Are racial disparities in preterm birth larger in hypersegregated areas? *Am J Epidemiol*. 2008;167(11):1295-1304. doi: 10.1093/aje/kwn043 [doi].

13. Behrman RE, Butler AS. Institute of medicine (US) committee on understanding premature birth and assuring healthy outcomes. Preterm birth: Causes, consequences, and prevention. National Academies Press (US); 2007.

14. Fiscella K. Racial disparities in preterm births. the role of urogenital infections. *Public Health Rep*. 1996;111(2):104-113.

15. Kramer MS. Determinants of low birth weight: Methodological assessment and meta-analysis. *Bull World Health Organ*. 1987;65(5):663-737.

16. Liu C, Cnattingius S, Bergstrom M, Ostberg V, Hjern A. Prenatal parental depression and preterm birth: A national cohort study. *BJOG*. 2016. doi: 10.1111/1471-0528.13891 [doi].

17. Palomar L, DeFranco EA, Lee KA, Allsworth JE, Muglia LJ. Paternal race is a risk factor for preterm birth. *Obstet Gynecol*. 2007;197(2):152. e1-152. e7.

18. Shah PS, Knowledge Synthesis Group on Determinants of Preterm/Low Birthweight Births. Paternal factors and low birthweight, preterm, and small for gestational age births: A systematic review. *Obstet Gynecol*. 2010;202(2):103-123.

19. Bloch JR, Webb DA, Mathews L, Dennis EF, Bennett IM, Culhane JF. Beyond marital status: The quality of the mother–father relationship and its influence on reproductive health behaviors and outcomes among unmarried low income pregnant women. *Matern Child Health J*. 2010;14(5):726-734.

20. Alio AP, Kornosky JL, Mbah AK, Marty PJ, Salihu HM. The impact of paternal involvement on feto-infant morbidity among whites, blacks and hispanics. *Matern Child Health J*. 2010;14(5):735-741.

21. Hobel CJ, Goldstein A, Barrett ES. Psychosocial stress and pregnancy outcome. *Clin Obstet Gynecol*. 2008;51(2):333-348. doi: 10.1097/GRF.0b013e31816f2709 [doi].

22. Misra DP, Caldwell C, Young AA, Abelson S. Do fathers matter? paternal contributions to birth outcomes and racial disparities. *Obstet Gynecol*. 2010;202(2):99-100.

23. Haug K, Irgens LM, Skjærven R, Markestad T, Baste V, Schreuder P. Maternal smoking and birthweight: Effect modification of period, maternal age and paternal smoking. *Acta Obstet Gynecol Scand*. 2000;79(6):485-489.

24. Teitler JO. Father involvement, child health and maternal health behavior. *Children and Youth Services Review*. 2001;23(4):403-425.

25. Kassel JD, Stroud LR, Paronis CA. Smoking, stress, and negative affect: Correlation, causation, and context across stages of smoking. *Psychol Bull*. 2003;129(2):270.

26. Stults-Kolehmainen MA, Sinha R. The effects of stress on physical activity and exercise. *Sports medicine*. 2014;44(1):81-121.

27. Yau YH, Potenza MN. Stress and eating behaviors. *Minerva Endocrinol*. 2013;38(3):255-267. doi: R07Y2013N03A0255 [pii].

28. Alio AP, Richman AR, Clayton HB, Jeffers DF, Wathington DJ, Salihu HM. An ecological approach to understanding Black–White disparities in perinatal mortality. *Matern Child Health J*. 2010;14(4):557-566.

29. Masho SW, Munn MS, Archer PW. Multilevel factors influencing preterm birth in an urban setting. *Urban, planning and transport research*. 2014;2(1):36-48.

30. Vinikoor-Imler LC, Messer LC, Evenson KR, Laraia BA. Neighborhood conditions are associated with maternal health behaviors and pregnancy outcomes. *Soc Sci Med*. 2011;73(9):1302-1311. doi: 10.1016/j.socscimed.2011.08.012 [doi].

31. Messer LC, Kaufman JS, Dole N, Herring A, Laraia BA. Violent crime exposure classification and adverse birth outcomes: A geographically-defined cohort study. *Int J Health Geogr*. 2006;5:22. doi: 1476-072X-5-22 [pii].

32. Messina LC, Kramer MR. Multilevel analysis of small area violent crime and preterm birth in a racially diverse urban area. *International Journal on Disability and Human Development*. 2013;12(4):445-455.

33. Sealy-Jefferson S, Giurgescu C, Helmkamp L, Misra DP, Osypuk TL. Perceived physical and social residential environment and preterm delivery in african-american women. *Am J Epidemiol*. 2015;182(6):485-493. doi: 10.1093/aje/kwv106 [doi].

34. Miranda ML, Messer LC, Kroeger GL. Associations between the quality of the residential built environment and pregnancy outcomes among women in north carolina. *Environ Health Perspect.* 2012;120(3):471-7. doi: 10.1289/ehp.1103578.

35. Lilliecreutz C, Larén J, Sydsjö G, Josefsson A. Effect of maternal stress during pregnancy on the risk for preterm birth. *BMC pregnancy and childbirth*. 2016;16(1):1.

36. Dole N, Savitz DA, Hertz-Picciotto I, Siega-Riz AM, McMahon MJ, Buekens P. Maternal stress and preterm birth. *Am J Epidemiol*. 2003;157(1):14-24.

37. Ghosh JKC, Wilhelm MH, Dunkel-Schetter C, Lombardi CA, Ritz BR. Paternal support and preterm birth, and the moderation of effects of chronic stress: A study in Los Angeles county mothers. *Archives of women's mental health*. 2010;13(4):327-338.

38. Hetherington E, Doktorchik C, Premji SS, McDonald SW, Tough SC, Sauve RS. Preterm birth and social support during pregnancy: A systematic review and Meta-Analysis. *Paediatr Perinat Epidemiol*. 2015;29(6):523-535.

39. Bryce RL, Stanley FJ, Garner JB. Randomized controlled trial of antenatal social support to prevent preterm birth. *BJOG: An International Journal of Obstetrics & Gynaecology*. 1991;98(10):1001-1008.

40. Villar J, Farnot U, Barros F, Victora C, Langer A, Belizan JM. A randomized trial of psychosocial support during high-risk pregnancies. *N Engl J Med*. 1992;327(18):1266-1271.

41. Mattison DR, Wilson S, Coussens C, Gilbert D. *The role of environmental hazards in premature birth: Workshop summary*. National Academies Press; 2003.

42. Harris KM, Halpern CT, Whitsel E, Hussey J, Tabor J, Entzel P, Udry JR. 2009. The National Longitudinal Study of Adolescent to Adult Health: Research Design. URL: http://www.cpc.unc.edu/projects/addhealth/design.

43. Hamilton BE, Martin JA, Osterman MJK, Curtin SC, Mathews T. Births: Final data for 2014. *National vital statistics reports*; vol 64 no 12. Hyattsville, MD: National Center for Health Statistics. 2015.

44. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Mathews T. Births: Final data for 2015. *National vital statistics report*; vol 66, no 1. Hyattsville, MD: National Center for Health Statistics. 2017

45. Martin JA, Hamilton BE, Osterman MJK, Driscoll AK, Drake P. Births: Final data for 2016. *National Vital Statistics Reports*; vol 67 no 1. Hyattsville, MD: National Center for Health Statistics. 2018.

46. Baraldi E, Filippone M. Chronic lung disease after premature birth. *N Engl J Med*. 2007;357(19):1946-1955.

47. Dodrill P. Feeding difficulties in preterm infants. *ICAN: Infant, Child, & Adolescent Nutrition*. 2011;3(6):324-331.

48. Platt MJ, Cans C, Johnson A, et al. Trends in cerebral palsy among infants of very low birthweight (< 1500 g) or born prematurely (< 32 weeks) in 16 European centres: A database study. *The Lancet*. 2007;369(9555):43-50.

49. Potijk MR, Kerstjens JM, Bos AF, Reijneveld SA, de Winter AF. Developmental delay in moderately preterm-born children with low socioeconomic status: Risks multiply. *J Pediatr*. 2013;163(5):1289-1295.

50. O'Connor A, Wilson C, Fielder A. Ophthalmological problems associated with preterm birth. *Eye*. 2007;21(10):1254.

51. Hirvonen M, Ojala R, Korhonen P, et al. Visual and hearing impairments after preterm birth. *Pediatrics*. 2018;142(2). pii: e20173888. doi: 10.1542/peds.2017-3888

52. Callaghan WM, MacDorman MF, Rasmussen SA, Qin C, Lackritz EM. The contribution of preterm birth to infant mortality rates in the United States. *Pediatrics*. 2006;118(4):1566-1573. doi: 118/4/1566 [pii].

53. Grosse SD, Waitzman NJ, Yang N, Abe K, Barfield WD. Employer-sponsored plan expenditures for infants born preterm. *Pediatrics*. 2017;140(4):10.1542/peds.2017-1078. doi: e20171078 [pii].

54. Fuchs F, Monet B, Ducruet T, Chaillet N, Audibert F. Effect of maternal age on the risk of preterm birth: A large cohort study. *PloS one*. 2018;13(1):e0191002.

55. Ruiz M, Goldblatt P, Morrison J, et al. Mother's education and the risk of preterm and small for gestational age birth: A DRIVERS meta-analysis of 12 European cohorts. *J Epidemiol Community Health*. 2015;69(9):826-833. doi: 10.1136/jech-2014-205387 [doi].

56. Reagan PB, Salsberry PJ. Race and ethnic differences in determinants of preterm birth in the USA: Broadening the social context. *Soc Sci Med*. 2005;60(10):2217-2228.

57. Schempf AH, Branum AM, Lukacs SL, Schoendorf KC. Maternal age and parity-associated risks of preterm birth: Differences by race/ethnicity. *Paediatr Perinat Epidemiol*. 2007;21(1):34-43.

58. Ihongbe TO, Wallenborn JT, Rozario S, Masho SW. Short interpregnancy interval and adverse birth outcomes in women of advanced age: A population-based study. *Ann Epidemiol*. 2018;28(9):605-611. doi: 10.1016/j.annepidem.2018.06.007

59. Goldenberg RL, Culhane JF, Iams JD, Romero R. Epidemiology and causes of preterm birth. *The Lancet*. 2008;371(9606):75-84. doi: http://dx.doi.org/10.1016/S0140-6736(08)60074-4.

60. Kyrklund-Blomberg NB, Granath F, Cnattingius S. Maternal smoking and causes of very preterm birth. *Acta Obstet Gynecol Scand*. 2005;84(6):572-577.

61. Albertsen K, Andersen AM, Olsen J, Gronbaek M. Alcohol consumption during pregnancy and the risk of preterm delivery. *Am J Epidemiol*. 2004;159(2):155-161.

62. Shah PS, Zao J, Ali S. Maternal marital status and birth outcomes: A systematic review and meta-analyses. *Matern Child Health J*. 2011;15(7):1097-1109.

63. Mohd Zain N, Low WY, Othman S. Impact of maternal marital status on birth outcomes among young Malaysian women: A prospective cohort study. *Asia Pac J Public Health*. 2015;27(3):335-347. doi: 10.1177/1010539514537678 [doi].

64. Masho SW, Chapman D, Ashby M. The impact of paternity and marital status on low birth weight and preterm births. *Marriage & Family Review*. 2010;46(4):243-256.

65. Lim D, Park S. Risk factors for preterm birth and low birth weight in extramarital birth: 2008-2012 birth certificated data. *The Korean Journal of Health Service Management*. 2014;8(3):137-145.

66. Hobel CJ, Goldstein A, Barrett ES. Psychosocial stress and pregnancy outcome. *Clin Obstet Gynecol*. 2008;51(2):333-348. doi: 10.1097/GRF.0b013e31816f2709 [doi].

67. Campbell A, Converse PE, Rodgers WL. *The quality of American life: Perceptions, evaluations, and satisfactions.* Russell Sage Foundation; 1976.

68. Weden MM, Carpiano RM, Robert SA. Subjective and objective neighborhood characteristics and adult health. *Soc Sci Med*. 2008;66(6):1256-1270.

69. Cummins S, Macintyre S, Davidson S, Ellaway A. Measuring neighbourhood social and material context: Generation and interpretation of ecological data from routine and non-routine sources. *Health Place*. 2005;11(3):249-260.

70. Cummins S, Macintyre S. Food environments and obesity—neighbourhood or nation? *Int J Epidemiol*. 2006;35(1):100-104.

71. Bhatia N, Chao SM, Higgins C, Patel S, Crespi CM. Association of mothers' perception of neighborhood quality and maternal resilience with risk of preterm birth. *International journal of environmental research and public health*. 2015;12(8):9427-9443.

72. Giurgescu C, Zenk SN, Templin TN, Engeland CG, Kavanaugh K, Misra DP. The impact of neighborhood conditions and psychological distress on preterm birth in African-American women. *Public Health Nursing*. 2017;34(3):256-266.

73. Dole N, Savitz DA, Hertz-Picciotto I, Siega-Riz AM, McMahon MJ, Buekens P. Maternal stress and preterm birth. *Am J Epidemiol*. 2003;157(1):14-24.

74. Wadhwa PD, Entringer S, Buss C, Lu MC. The contribution of maternal stress to preterm birth: Issues and considerations. *Clin Perinatol*. 2011;38(3):351-384.

75. Sealy-Jefferson S, Giurgescu C, Helmkamp L, Misra DP, Osypuk TL. Perceived physical and social residential environment and preterm delivery in African-American women. *Am J Epidemiol*. 2015;182(6):485-493.

76. Giurgescu C, Zenk SN, Dancy BL, Park CG, Dieber W, Block R. Relationships among neighborhood environment, racial discrimination, psychological distress, and preterm birth in African American women. *Journal of Obstetric, Gynecologic & Neonatal Nursing*. 2012;41(6):E51-E61.

77. Berenson AB, Wiemann CM, McCombs S. Exposure to violence and associated health-risk behaviors among adolescent girls. *Arch Pediatr Adolesc Med*. 2001;155(11):1238-1242.

78. Shareck M, Ellaway A. Neighbourhood crime and smoking: The role of objective and perceived crime measures. *BMC Public Health*. 2011;11(1):930.

79. Brennan PA, Raine A. Biosocial bases of antisocial behavior: Psychophysiological, neurological, and cognitive factors. *Clin Psychol Rev*. 1997;17(6):589-604.

80. Antonnuci T. Social support networks: A hierarchical mapping technique. *Generations*. 1986:10.10-12.

81. Kahn RL. Convoys over the life course: Attachment roles and social support. *Life-span development and behavior*. 1980;3:253-286.

82. Hu L, Bentler PM. Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychol Methods*. 1998;3(4):424.

83. Steiger JH. Structural model evaluation and modification: An interval estimation approach. *Multivariate behavioral research*. 1990;25(2):173-180.

84. Bentler PM. Comparative fit indexes in structural models. *Psychol Bull*. 1990;107(2):238.

85. Tucker LR, Lewis C. A reliability coefficient for maximum likelihood factor analysis. *Psychometrika*. 1973;38(1):1-10.

86. Maldonado G, Greenland S. Simulation study of confounder-selection strategies. *Am J Epidemiol*. 1993;138(11):923-36.

87. Nkansah-Amankra S, Luchok KJ, Hussey JR, Watkins K, Liu X. Effects of maternal stress on low birth weight and preterm birth outcomes across neighborhoods of South Carolina, 2000–2003. *Matern Child Health J*. 2010;14(2):215-226.

88. Elsenbruch S, Benson S, Rucke M, et al. Social support during pregnancy: Effects on maternal depressive symptoms, smoking and pregnancy outcome. *Hum Reprod*. 2007;22(3):869-877. doi: del432 [pii].

89. Schwab-Reese LM, Schafer EJ, Ashida S. Associations of social support and stress with postpartum maternal mental health symptoms: Main effects, moderation, and mediation. *Women Health*. 2016:1-18.

90. Shishehgar S, Dolatian M, Majd HA, Teimouri Z, Alavi ST, Halvaei P. Social support and maternal stress during pregnancy: A PATH model. *International Journal of Healthcare*. 2015;2(1):p44.

91. Sealy–Jefferson S, Messer L, Slaughter-Acey J, Misra DP. Inter-relationships between objective and subjective measures of the residential environment among urban african american women. *Ann Epidemiol*. 2017;27(3):164-168.

92. Fleis JL. The design and analysis of clinical experiments. John Wiley & Sons.1986.

93. Snyder HN. Arrest in the United States, 1990-2010. U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Statistics. 2012;NCJ 239423.

94. Truman J, Langton L. National crime victimization survey: Criminal victimization, 2014. *Retrieved September*. 2015;NCJ 248973:2003.

95. Morgan RE, Kena G. Criminal victimization, 2016. *Department of Justice, Office of*. 2017. https://www.bjs.gov/content/pub/pdf/cv16.pdf.

96. US Department of Justice. Uniform crime report: Crime in the United States, 2016. *Federal Bureau of Investigation*. 2017. https://ucr.fbi.gov/crime-in-the-u.s/2016/crime-in-the-u.s.-2016/topic-pages/persons-arrested.pdf. Accessed 7/22/2018.

97. Gale SL, Magzamen SL, Radke JD, Tager IB. Crime, neighborhood deprivation, and asthma: A GIS approach to define and assess neighborhoods. *Spatial and spatio-temporal epidemiology*. 2011;2(2):59-67.

98. Clark C, Ryan L, Kawachi I, Canner MJ, Berkman L, Wright RJ. Witnessing community violence in residential neighborhoods: A mental health hazard for urban women. *Journal of Urban Health*. 2008;85(1):22-38.

99. Löfving–Gupta S, Lindblad F, Stickley A, Schwab-Stone M, Ruchkin V. Community violence exposure and severe posttraumatic stress in suburban american youth: Risk and protective factors. *Soc Psychiatry Psychiatr Epidemiol*. 2015;50(4):539-547.

100. Messer LC, Kaufman JS, Dole N, Herring A, Laraia BA. Violent crime exposure classification and adverse birth outcomes: A geographically-defined cohort study. *International journal of health geographics*. 2006;5(1):1.

101. Yonas MA, O'Campo P, Burke JG, Gielen AC. Neighborhood-level factors and youth violence: Giving voice to the perceptions of prominent neighborhood individuals. *Health Educ Behav*. 2007;34(4):669-685. doi: 1090198106290395 [pii].

102. Wilkinson RG, Kawachi I, Kennedy BP. Mortality, the social environment, crime and violence. *Sociol Health Illn*. 1998;20(5):578-597.

103. Krug EG, Dahlberg L, Mercy JA, Zwi AB, Lozano R. *World report on violence and health.geneva, Switzerland: World Health Organization*. 2002.

104. Koppensteiner MF, Manacorda M. Violence and birth outcomes: Evidence from homicides in Brazil. *J Dev Econ*. 2016;119:16-33.

105. Messer LC, Kaufman JS, Dole N, Savitz DA, Laraia BA. Neighborhood crime, deprivation, and preterm birth. *Ann Epidemiol*. 2006;16(6):455-462.

106. Mayne SL, Pool LR, Grobman WA, Kershaw KN. Associations of neighbourhood crime with adverse pregnancy outcomes among women in chicago: Analysis of electronic health records from 2009 to 2013. *J Epidemiol Community Health*. 2018;72(3):230-236. doi: 10.1136/jech-2017-209801 [doi].

107. Masho SW, Cha S, Chapman DA, Chelmow D. Understanding the role of violence as a social determinant of preterm birth. *Obstet Gynecol*. 2017;216(2):183. e1-183. e7.

108. Clemens T, Dibben C. Living in stressful neighbourhoods during pregnancy: An observational study of crime rates and birth outcomes. *Eur J Public Health*. 2017;27(2):197-202.

109. Masi CM, Hawkley LC, Piotrowski ZH, Pickett KE. Neighborhood economic disadvantage, violent crime, group density, and pregnancy outcomes in a diverse, urban population. *Soc Sci Med*. 2007;65(12):2440-2457.

110. Cheng H, Wang Y, Lo H, et al. Trauma during pregnancy: A population-based analysis of maternal outcome. *World J Surg*. 2012;36(12):2767-2775.

111. Epstein-Ngo Q, Maurizi LK, Bregman A, Ceballo R. In response to community violence: Coping strategies and involuntary stress responses among latino adolescents. *Cultural diversity and ethnic minority psychology*. 2013;19(1):38.

112. Aiyer SM, Heinze JE, Miller AL, Stoddard SA, Zimmerman MA. Exposure to violence predicting cortisol response during adolescence and early adulthood: Understanding moderating factors. *Journal of youth and adolescence*. 2014;43(7):1066-1079.

113. Wadhwa PD, Entringer S, Buss C, Lu MC. The contribution of maternal stress to preterm birth: Issues and considerations. *Clin Perinatol*. 2011;38(3):351-384.

114. Nelson CC, Li Y, Sorensen G, Berkman LF. Assessing the relationship between work–family conflict and smoking. *Am J Public Health*. 2012;102(9):1767-1772.

115. Keyes KM, Hatzenbuehler ML, Grant BF, Hasin DS. Stress and alcohol: Epidemiologic evidence. *Alcohol Res*. 2012;34(4):391-400.

116. Torche F, Villarreal A. Prenatal exposure to violence and birth weight in Mexico: selectivity, exposure, and behavioral responses. *Am Sociol Rev*. 2014;79(5):966-992.

117. Tayebi T, Zahrani ST, Mohammadpour R. Relationship between adequacy of prenatal care utilization index and pregnancy outcomes. *Iran J Nurs Midwifery Res*. 2013;18(5):360-366.

118. Picklesimer AH, Billings D, Hale N, Blackhurst D, Covington-Kolb S. The effect of CenteringPregnancy group prenatal care on preterm birth in a low-income population. *Obstet Gynecol*. 2012;206(5):415. e1-415. e7.

119. Cobb S. Social support as a moderator of life stress. *Psychosom Med*. 1976;38(5):300-314.

120. Harville EW, Madkour AS, Xie Y. Predictors of birth weight and gestational age among adolescents. *Am J Epidemiol*. 2012;176(suppl_7):S150-S163.

121. Nkansah-Amankra S, Tettey G. Association between depressive symptoms in adolescence and birth outcomes in early adulthood using a population-based sample. *Preventive medicine reports*. 2015;2:371-378.

122. Chen W, Propp J, Lee Y. Connection between adolescent's exposure to community violence and future civic engagement behaviors during their young adulthood. *Child Adolescent Soc Work J*. 2015;32(1):45-55.

123. Fox KA, Bouffard LA. Violent victimization vulnerability: Testing a conceptual model of personality, social, and community factors. *Deviant Behav*. 2015;36(11):910-934.

124. Guterman NB, Hahm HC, Cameron M. Adolescent victimization and subsequent use of mental health counseling services. *Journal of adolescent Health*. 2002;30(5):336-345.

125. Richters JE, Martinez P. Children as victims of and witnesses to violence in a Washington, DC neighborhood. 1993. In L. A. Leavitt & N. A. Fox (Eds.), The psychological effects of war and violence on children (pp. 243-278). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

126. Selner-O'Hagan MB, Kindlon DJ, Buka SL, Raudenbush SW, Earls FJ. Assessing exposure to violence in urban youth. *The Journal of Child Psychology and Psychiatry and Allied Disciplines*. 1998;39(2):215-224.

127. McEwen BS, Seeman T. Protective and damaging effects of mediators of stress: Elaborating and testing the concepts of allostasis and allostatic load. *Ann N Y Acad Sci*. 1999;896(1):30-47.

128. Pagnini DL, Reichman NE. Psychosocial factors and the timing of prenatal care among women in new jersey's HealthStart program. *Fam Plann Perspect*. 2000:56-64.

129. McDonald SW, Kingston D, Bayrampour H, Dolan SM, Tough SC. Cumulative psychosocial stress, coping resources, and preterm birth. *Archives of women's mental health*. 2014;17(6):559-568.

130. Hamano T, Li X, Tanito M, et al. Neighborhood deprivation and risk of age-related eye diseases: A follow-up study in Sweden. *Ophthalmic Epidemiol*. 2015;22(5):308-320.

131. Diez Roux AV. Investigating neighborhood and area effects on health. *Am J Public Health*. 2001;91(11):1783-1789.

132. Pickett KE, Pearl M. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: A critical review. *J Epidemiol Community Health*. 2001;55(2):111-122.

133. Yen IH, Syme SL. The social environment and health: A discussion of the epidemiologic literature. *Annu Rev Public Health*. 1999;20(1):287-308.

134. Sundquist K, Malmström M, Johansson S. Neighbourhood deprivation and incidence of coronary heart disease: A multilevel study of 2.6 million women and men in Sweden. *J Epidemiol Community Health*. 2004;58(1):71-77.

135. Cox M, Boyle PJ, Davey P, Morris A. Does health-selective migration following diagnosis strengthen the relationship between type 2 diabetes and deprivation? *Soc Sci Med*. 2007;65(1):32-42.

136. Truong KD, Ma S. A systematic review of relations between neighborhoods and mental health. *Journal of Mental Health Policy and Economics*. 2006;9(3):137.

137. Kim D. Blues from the neighborhood? neighborhood characteristics and depression. *Epidemiol Rev*. 2008;30:101-117. doi: 10.1093/epirev/mxn009 [doi].

138. Metcalfe A, Lail P, Ghali WA, Sauve RS. The association between neighbourhoods and adverse birth outcomes: A systematic review and meta-analysis of multi-level studies. *Paediatr Perinat Epidemiol*. 2011;25(3):236-245.

139. O'Campo P, Burke JG, Culhane J, et al. Neighborhood deprivation and preterm birth among non-Hispanic Black and White women in eight geographic areas in the United States. *Am J Epidemiol*. 2008;167(2):155-163. doi: kwm277 [pii].

140. Masi CM, Hawkley LC, Piotrowski ZH, Pickett KE. Neighborhood economic disadvantage, violent crime, group density, and pregnancy outcomes in a diverse, urban population. *Soc Sci Med*. 2007;65(12):2440-2457.

141. Kaufman JS, Dole N, Savitz DA, Herring AH. Modeling community-level effects on preterm birth. *Ann Epidemiol*. 2003;13(5):377-384.

142. Messer LC, Kaufman JS, Dole N, Savitz DA, Laraia BA. Neighborhood crime, deprivation, and preterm birth. *Ann Epidemiol*. 2006;16(6):455-462.

143. Janevic T, Stein CR, Savitz DA, Kaufman JS, Mason SM, Herring AH. Neighborhood deprivation and adverse birth outcomes among diverse ethnic groups. *Ann Epidemiol*. 2010;20(6):445-451.

144. Li X, Sundquist J, Zöller B, Sundquist K. Neighborhood deprivation and lung cancer incidence and mortality: A multilevel analysis from Sweden. *Journal of Thoracic Oncology*. 2015;10(2):256-263.

145. Major JM, Doubeni CA, Freedman ND, et al. Neighborhood socioeconomic deprivation and mortality: NIH-AARP diet and health study. *PLoS One*. 2010;5(11):e15538.

146. Agyemang C, Vrijkotte TG, Droomers M, van der Wal MF, Bonsel GJ, Stronks K. The effect of neighbourhood income and deprivation on pregnancy outcomes in Amsterdam, The Netherlands. *J Epidemiol Community Health*. 2009;63(9):755-760. doi: 10.1136/jech.2008.080408 [doi].

147. Messer LC, Vinikoor LC, Laraia BA, et al. Socioeconomic domains and associations with preterm birth. *Soc Sci Med*. 2008;67(8):1247-1257.

148. Pickett KE, Ahern JE, Selvin S, Abrams B. Neighborhood socioeconomic status, maternal race and preterm delivery: A case-control study. *Ann Epidemiol*. 2002;12(6):410-418.

149. Bissonnette L, Wilson K, Bell S, Shah TI. Neighbourhoods and potential access to health care: The role of spatial and aspatial factors. *Health Place*. 2012;18(4):841-853.

150. Macintyre S. Deprivation amplification revisited; or, is it always true that poorer places have poorer access to resources for healthy diets and physical activity? *International Journal of Behavioral Nutrition and Physical Activity*. 2007;4(1):1.

151. Giurgescu C, Zenk SN, Dancy BL, Park CG, Dieber W, Block R. Relationships among neighborhood environment, racial discrimination, psychological distress, and preterm birth in African American women. *Journal of Obstetric, Gynecologic, & Neonatal Nursing*. 2012;41(6):E51-E61.

152. Wood S, McNeil D, Yee W, Siever J, Rose S. Neighbourhood socio-economic status and spontaneous premature birth in Alberta. *Canadian Journal of Public Health*. 2014;105(5):E383.

153. Peterson RD, Krivo LJ, Harris MA. Disadvantage and neighborhood violent crime: Do local institutions matter? *J Res Crime Delinquency*. 2000;37(1):31-63.

154. Papps K, Winkelmann R. Unemployment and crime: New evidence for an old question. *New Zealand Economic Papers*. 2000;34(1):53-71.

155. Centers for Disease Prevention and Control (CDC). Understanding youth violence. Available at https://www.cdc.gov/violenceprevention/pdf/youthviolence-factsheet.pdf. Accessed 11/2/2016.

156. Healthy and safe community environments. surgeon general's national prevention council. http://www.surgeongeneral.gov/priorities/prevention/strategy/healthy-and-safe-community-environments.html. Updated 2016. Accessed 3/23/2016.

157. Kawachi I, Kennedy BP, Wilkinson RG. Crime: Social disorganization and relative deprivation. *Soc Sci Med*. 1999;48(6):719-731. doi: http://dx.doi.org/10.1016/S0277-9536(98)00400-6.

158. U.S. Census Bureau. Technical documentation: 2015 TIGER/Line Shapefiles (machine readable data files) / prepared by the U.S. Census Bureau, 2015

159. Su R, Zhu W, Wei Y, et al. Maternal and neonatal outcomes in multiple pregnancy: A multicentre study in the beijing population. *Chronic Diseases and Translational Medicine*. 2015;1(4):197-202.

160. Ma X, Fleischer NL, Liu J, Hardin JW, Zhao G, Liese AD. Neighborhood deprivation and preterm birth: An application of propensity score matching. *Ann Epidemiol*. 2015;25(2):120-125.

161. Messer LC, Laraia BA, Kaufman JS, et al. The development of a standardized neighborhood deprivation index. *Journal of Urban Health*. 2006;83(6):1041-1062.

162. Martin JA, Osterman MJ, Kirmeyer SE, Gregory EC. Measuring gestational age in vital statistics data: Transitioning to the obstetric estimate. *Natl Vital Stat Rep*. 2015;64(5):1-20.

163. Muthén LK, Muthén BO. Mplus user's guide. eighth edition. Los Angeles, CA: Muthén & muthén. . 1998-2017. https://www.statmodel.com/download/usersguide/MplusUserGuideVer_8.pdf.

164. Hayes AF. An index and test of linear moderated mediation. *Multivariate Behavioral Research*. 2015;50(1):1-22.

165. Masho SW, Cha S, Chapman DA, Chelmow D. Understanding the role of violence as a social determinant of preterm birth. *Am J Obstet Gynecol.* 2017 Feb;216(2):183.e1-183.e7. doi: 10.1016/j.ajog.2016.10.001

166. Clemens T, Dibben C. Living in stressful neighbourhoods during pregnancy: An observational study of crime rates and birth outcomes. *Eur J Public Health.* 2017;27(2):197-202.

167. Messer LC, Kaufman JS, Dole N, Herring A, Laraia BA. Violent crime exposure classification and adverse birth outcomes: A geographically-defined cohort study. *International journal of health geographics*. 2006;5(1):22.

168. Peterson RD, Krivo LJ, Harris MA. Disadvantage and neighborhood violent crime: Do local institutions matter? *J Res Crime Delinquency*. 2000;37(1):31-63.

169. Papps K, Winkelmann R. Unemployment and crime: New evidence for an old question. *New Zealand Economic Papers*. 2000;34(1):53-71.

170. Uniform Crime Reporting Program Data. Crime in the United States by metropolitan statistical area, 2015. 2016. https://ucr.fbi.gov/crime-in-the-u.s/2015/crime-in-the-u.s.-2015/tables/table-6.

171. Oudekerk BA, Morgan RE, Bureau of Justice Statistics (BJS), US Dept of Justice, Office of Justice Programs, United States of America. Co-offending among adolescents in violent victimizations, 2004–13. . 2016;NCJ 249756.

172. Mantalos P, Zografos K. Interval estimation for a binomial proportion: A bootstrap approach. *Journal of Statistical Computation and Simulation*. 2008;78(12):1251-1265.

173. Department of Health and Human Services. Healthy people 2020: Objectives - maternal, infant, and child health. Available at https://www.healthypeople.gov/2020/topics-objectives/topic/maternal-infant-and-child-health/objectives

174. Martin JA, Hamilton BE, Ventura SJ, Osterman MJ, Wilson EC, Mathews T. Births: Final data for 2010. *National vital statistics reports*; vol 61 no 1. Hyattsville, MD: National Center for Health Statistics. 2012.

TABLES

Table 2.1. Characteristics of study population, Life Influences on Fetal Environments Study, 2009–2011

Characteristics	**Total N=1,140 N (%)**	**Term delivery N=941 N (%)**	**Preterm delivery N=199 N (%)**	**p-value[a]**
Age [median (IQR)]	26.0 (22.0-31.0)	26.0 (22.0-31.0)	27.0 (23.0-33.0)	0.0606[b]
Maternal education (years)				0.6453[c]
≤12	353 (31.0)	294 (31.3)	59 (29.7)	
>12	785 (69.0)	645 (68.7)	140 (70.4)	
Marital status				0.7936 [c]
Married	321 (28.3)	262 (27.9)	59 (29.8)	
Cohabitating	296 (26.1)	250 (26.7)	46 (23.2)	
Widowed, divorced, or separated	46 (4.1)	38 (4.1)	8 (4.0)	
Never married	473 (41.6)	388 (41.4)	85 (42.9)	
Household income				0.1143[c]
< 20,000	285 (28.0)	229 (27.4)	56 (30.6)	
20,000-49,999	417(41.0)	335 (40.1)	82 (44.8)	
≥50,000	316 (31.0)	271 (32.5)	45 (24.6)	
Insurance				0.7430[d]
Private	449 (39.4)	5 (0.53)	1 (0.50)	
Medicaid	623 (54.7)	373 (39.6)	76 (38.2)	
Multiple	62 (5.4)	509 (54.1)	114 (57.3)	
No coverage	6 (0.5)	54 (5.7)	8 (4.0)	
Place of birth				0.2227[d]
US-born	1122 (98.4)	928 (98.6)	194 (97.5)	
Foreign-born	18 (1.6)	13 (1.4)	5 (2.5)	
Prepregnancy Body mass index (kg/m^2)				0.7228[d]
Underweight	28 (2.5)	23 (2.5)	5 (2.6)	
Normal	366 (32.9)	303 (32.9)	63 (32.8)	
Overweight	299 (26.9)	253 (27.5)	46 (24.0)	
Obesity	419 (37.7)	341 (37.1)	78 (40.6)	
Previous live birth				0.9371[c]

0	507 (44.5)	419 (44.5)	88 (44.2)	
≥1	633 (55.5)	522 (55.5)	111 (55.8)	
Smoking	184 (16.1)	147 (15.6)	37 (18.6)	0.3006 [c]
Alcohol drinking	194 (17.1)	162 (17.3)	32 (16.1)	0.6807 [c]
Marijuana use	518 (45.6)	432 (46.0)	86 (43.4)	0.5090 [c]
Physical activity	411 (37.3)	357 (39.4)	54 (27.7)	0.0022 [c]
Maternal stress [median (IQR)]	23 (19.0-28.0)	23.0 (19.0-28.0)	24.0 (19.0-29.0)	0.3211[b]
General social support [median (IQR)]	51 (45.0-54.0)	51.0 (45.0-54.0)	50.0 (46.0-54.0)	0.8495[b]
Quality of mother–father relationship [median (IQR)]				
Trust domain	14.0 (12.0-15.0)	14.0 (11.0-15.0)	14.0 (12.0-15.0)	0.0904[b]
Dependability domain	14.0 (12.0-15.0)	14.0 (12.0-15.0)	14.0 (12.0-15.0)	0.6014[b]
Criticism domain	10.0 (8.0-12.0)	10.0 (8.0-12.0)	10.0 (8.0-12.0)	0.1537[b]
Residential environment [median (IQR)]				
Social cohesion and trust	18.0 (15.0-21.0)	18.0 (15.0-21.0)	17.0 (14.0-21.0)	0.8012[b]
Healthy food availability	4.0 (3.0-6.0)	4.0 (3.0-6.0)	4.0 (4.0-6.0)	0.5004[b]
Walking environment	12.0 (10.0-15.0)	12.0 (10.0-15.0)	12.0 (11.0-15.0)	0.7663[b]
Social disorder	22.0 (18.0-24.0)	23.0 (18.0-24.0)	22.0 (17.0-24.0)	0.6325[b]
Danger/safety	14.0 (12.0-19.0)	14.0 (11.0-18.0)	14.0 (12.0-19.0)	0.4618[b]
Length of stay in current residential environment (years) [median (IQR)]	2.0 (0.6-5.0)	2.0 (0.7-5.0)	2.0 (0.5-5.0)	0.9053[b]
Medical morbidity	279 (24.5)	225 (23.9)	54 (27.1)	0.3364[c]

IQR=Interquartile range
[a] p-value for difference between term and preterm delivery
[b] Wilcoxon rank-sum test between term and preterm delivery
[c] Chi square test between term and preterm delivery
[d] Fisher's test between term and preterm delivery

Table 2.2. Fit measures and residual variance for exploratory factor analysis of mother-father relationship questions, Life Influences on Fetal Environments study, 2009–2011 (N=1,140)

Factor	Chi square χ^2	df	p	RMSEA	CFI	TLI	RMSR	AIC	BIC	Negative residual variance
1	1592.37	(77)	0.000	0.131	0.870	0.846	0.076	43564.621	43776.250	No
2	953.48	(64)	0.000	0.110	0.924	0.891	0.034	42951.732	43228.865	No
3	380.74	(52)	0.000	0.074	0.972	0.951	0.023	42402.991	42740.589	No
4	189.78	(41)	0.000	0.056	0.987	0.972	0.019	42234.033	42627.058	No
5	71.31	(31)	0.000	0.034	0.997	0.990	0.007	42135.560	42578.973	Yes

RMSEA – Root Mean Square Error of Approximation; CFI – Comparative Fit Index; TLI – Tucker Lewis Index; RMSR – Root Mean Square Residual; AIC – Akaike information criterion; BIC – Bayesian information criterion

Table 2.3. Exploratory factor analysis for mother-father relationship questions using maximum likelihood estimation, Life Influences on Fetal Environments study, 2009–2011 (N=1,140)

Item	Factor Loadings[a]		
	Factor 1 (Trust)	**Factor 2 (Dependability)**	**Factor 3 (Criticism)**
1. Father-of-baby is always there when I need him.	0.095	**0.788***	-0.012
2. I feel that I can tell Father-of-baby just about everything.	**0.820***	0.021	-0.014
3. I feel that Father-of-baby and I can share our problems with each other.	**0.948***	0.016	0.069
4. I feel that Father-of-baby and I can share our feelings with each other.	**0.924***	-0.009	0.054
5. Father-of-baby and I are much closer than most couples.	0.474*	0.389*	-0.072*
6. I have a lot of respect for Father-of-baby.	0.254*	0.661*	0.016
7. Father-of-baby and I have a good relationship	0.308*	0.609*	-0.091*
8. Father-of-baby is someone I can count on for financial support if I need it.	-0.070	**0.888***	0.027
9. Father-of-baby is someone I can count on to take care of my baby.	0.008	**0.886***	0.124*
10. Father-of-baby is often critical (disapproving) of me.	-0.238*	0.014	0.467*
11. I sometimes fight or argue with Father-of-baby.	-0.021	0.161*	**0.599***
12. My relationship with Father-of-baby sometimes makes me feel tense.	-0.166*	-0.040	**0.599***
13. Father-of-baby often criticizes my friends.	0.033	0.036	**0.563***
14. Father-of-baby often criticizes my (mother).	0.192*	-0.127	0.457*
Eigenvalues	7.284	1.776	0.934

[a] Geomin rotation utilized
*significant at 5% level
Factor loadings appear in bold.

Table 2.4. Scales assessing neighborhood residential environment, Life Influences on Fetal Environments study, 2009–2011 (N=1,140)

Scale	Mean score	Standard deviation	Median score	Interquartile Range	Range of scores	Cronbach's alpha
Social cohesion and trust	17.8	4.8	18.0	15.0-21.0	7.0-35.0	0.84
Healthy food availability	4.6	2.2	4.0	3.0-6.0	2.0-10.0	0.90
Walking environment	12.6	4.2	12.0	10.0-15.0	6.0-30.0	0.80
Social disorder	20.3	4.6	22.0	18.0-24.0	8.0-24.0	0.93
Danger/safety	14.8	5.5	14.0	12.0-19.0	6.0-30.0	0.91

Table 2.5. Correlation between mother-father relationship domains and perceived residential environment

	Neighborhood social cohesion and trust [r (p-value)]	Neighborhood healthy food availability [r (p-value)]	Neighborhood walking environment [r (p-value)]	Neighborhood social disorder [r (p-value)]	Neighborhood danger/safety [r (p-value)]
Trust domain	-0.09649 (0.0011)	-0.08196 (0.0056)	-0.08540 (0.0039)	0.07649 (0.0098)	-0.11194 (0.0002)
Dependability domain	-0.11018 (0.0002)	-0.09296 (0.0017)	-0.11698 (<.0001)	0.06730 (0.0231)	-0.13207 (<.0001)
Criticism domain	-0.12187 (<.0001)	-0.06426 (0.0300)	-0.09699 (0.0010)	0.12017 (<.0001)	-0.13103 (<.0001)

Abbreviation: r = correlation coefficient

Table 2.6. Interaction between quality of mother–father relationship and perceived residential environment, N=1140

Quality of mother–father relationship	**Interaction between quality of mother–father relationship and perceived residential environment**		
Trust domain	**β**	**95% CI**	**p-value**
	Social cohesion and trust		
	0.0037	(-0.0044, 0.0118)	0.3674
	Healthy food availability		
	0.0070	(-0.0106, 0.0247)	0.4281
	Walking environment		
	-0.0006	(-0.0094, 0.0082)	0.8952
	Social disorder		
	0.0007	(-0.0070, 0.0083)	0.8650
	Danger/safety		
	0.0009	(-0.0056, 0.0075)	0.7747
Dependability domain	**β**	**95% CI**	**p-value**
	Social cohesion and trust		
	0.0022	(-0.0056, 0.0099)	0.5817
	Healthy food availability		
	0.0119	(-0.0059, 0.0296)	0.1800
	Walking environment		
	0.0060	(-0.0031, 0.0152)	0.1949
	Social disorder		
	-0.0062	(-0.0148, 0.0025)	0.1454
	Danger/safety		
	0.0065	(-0.0005, 0.0134)	0.0659
Criticism domain	**β**	**95% CI**	**p-value**
	Social cohesion and trust		
	0.0006	(-0.0072, 0.0084)	0.8880
	Healthy food availability		
	-0.0020	(-0.0188, 0.0148)	0.8412
	Walking environment		
	0.0070	(-0.0025, 0.0166)	0.1453
	Social disorder		
	-0.0022	(-0.0102, 0.0058)	0.5877
	Danger/safety		
	-0.0001	(-0.0072, 0.0070)	0.9828

Table 2.7. Association between quality of mother–father relationship and preterm birth, Life Influences on Fetal Environments study, 2009–2011 (N=1,140)

Quality of mother–father relationship	**Preterm birth**			
	Unadjusted PR (95% CI)	**p-value**	**Adjusted PR[a] (95% CI)**	**p-value**
Trust domain	1.03 (0.99-1.07)	0.1575	1.03 (0.99-1.07)[a]	0.1522
Dependability domain	1.01 (0.98-1.05)	0.4804	1.01 (0.98-1.06)[a]	0.4798
Criticism domain	1.03 (0.99-1.07)	0.1116	1.03 (0.99-1.07)[c]	0.1228

[a] adjusted for age, education, parity, alcohol drinking, and smoking

Table 2.8. Modifying effect of maternal social support on the association between quality of mother-father relationship (trust domain) and preterm birth, Life Influences on Fetal Environments study, 2009–2011 (N=1,140)

Quality of mother–father relationship (Trust domain)	Preterm birth					
	Maternal social support @ Mean – SD		Maternal social support @ Mean		Maternal social support @ Mean + SD	
	Adjusted PR[a] 95% CI	p-value	Adjusted PR[a] 95% CI	p-value	Adjusted PR[a] 95% CI	p-value
	0.93 (0.88-0.98)*	0.0118	0.97 (0.94-1.02)	0.2162	1.02 (0.96-1.08)	0.5043

Maternal social support @ Mean – SD: 42.2
Maternal social support @ Mean: 48.8
Maternal social support @ Mean + SD: 55.4
*p < .05
p-value for mother-father relationship (trust domain)*maternal social support interaction = 0.0171
[a] adjusted for age, education, parity, alcohol drinking, and smoking

Table 3.1. Sample-weighted characteristics of study population, National Longitudinal Study of Adolescent to Adult Health, 1994–2008

Characteristics	**Total N=4,419[a] (%)**	**Preterm birth N=454[a] (%)**	**Term birth N=3,965[a] (%)**	**p-value[b]**
All participants	100	10.7	89.3	-
Age at wave I [median (IQR)]	16.0 (15.0-17.0)	16.0 (14.0-17.0)	16.0 (15.0-17.0)	0.1342[c]
Age at wave IV [median (IQR)]	29.0 (28.0-30.0)	29.0 (27.0-30.0)	28.0 (28.0-30.0)	0.0585[c]
Maternal education				0.4758 [d]
High school or vocational training	41.9	44.9	41.6	
College or higher	58.1	55.1	58.4	
Race				0.1550 [d]
White	76.5	72.1	77.1	
Black	20.7	26.0	20.1	
Other	2.8	1.9	2.9	
Marital status				0.0865 [d]
Married	23.2	17.9	23.8	
Cohabitating	57.4	61.1	56.9	
Other	19.4	21.0	19.2	
Household income				0.2412 [d]
<$20,000	20.1	25.8	19.5	
$20,000-49,999	37.5	38.0	37.4	
≥$50,000	42.4	36.2	43.1	
Insurance				0.0984 [d]
Private	56.6	20.8	23.2	
Medicaid	20.4	51.1	57.3	
No coverage	23.0	28.1	19.5	
Prepregnancy Body mass index (kg/m^2)				0.3310 [d]
Underweight	2.9	3.7	2.9	
Normal	31.3	35.9	30.8	

Overweight	25.4	18.9	26.2	
Obesity	40.3	41.4	40.2	
Pregnancy intention				0.9781 [d]
Intended	47.3	47.2	47.3	
Unintended	52.7	52.8	52.7	
Receipt of prenatal care	96.7	91.7	97.3	0.0112 [d]
Low birth weight	13.4	63.5	7.8	<.0001 [d]
Smoking during pregnancy	25.1	28.2	24.7	0.4081 [d]
Alcohol drinking during pregnancy	7.1	9.8	6.8	0.4386 [d]
Exposure to neighborhood violence				0.5871[d]
Yes	28.1	26.2	28.3	
No	71.9	73.8	71.7	
Maternal social support				0.0311[d]
Tertile 1	38.9	34.4	39.4	
Tertile 2	47.0	55.3	46.0	
Tertile 3	14.2	10.2	14.6	

IQR: Interquartile Range
[a] Unweighted Frequency
[b] difference between preterm birth and term birth
[c] Wilcoxon rank-sum test
[d] Chi square test

Table 3.2. Likelihood ratio tests for best model fit

Model	Deviance	df	ΔDeviance	Δdf	value
Model 1	105311530.78	11	—	—	—
Model 2	1361692408.5	417	1256380877.72	406	<0.0001
Model 3**	2111904173.7	762	750211765.2	345	<0.0001

**Best fitting model
Model 1: Unadjusted model
Model 2: Adjusted model without interaction term
Model 3: Adjusted model with interaction term
Δ = difference

Table 3.3. Log-binomial regression showing the modifying effect of maternal social support on the association between neighborhood violence exposure and preterm birth, National Longitudinal Study of Adolescent to Adult Health, 1994–2008 (N=4,419)

Exposure to neighborhood violence	**Preterm birth**			
	Unadjusted PR (95% CI)	**p-value**	**Adjusted PR (95% CI)[a]**	**p-value**
	Maternal social support (Tertile 1)			
Yes	1.19 (1.18-1.20)	<.0001	1.12 (1.11-1.13)	<.0001
No	Ref.	-	Ref.	-
	Maternal social support (Tertile 2)			
Yes	1.14 (1.13-1.15)	<.0001	1.07 (1.06-1.08)	<.0001
No	Ref.	-	Ref.	-
	Maternal social support (Tertile 3)			
Yes	1.09 (1.07-1.10)	<.0001	0.88 (0.86-0.89)	<.0001
No	Ref.	-	Ref.	-

[a] adjusted for maternal age, insurance, marital status, household income, and alcohol drinking during pregnancy
p-value for interaction term (neighborhood violence exposure*social support): <.0001
PR=Prevalence Ratio, SD=Standard Deviation

Table 4.1. Distribution of individual and neighborhood-level characteristics of study population, Richmond city, Virginia, 2006-2015

Characteristics	Total N (%)	Term birth N (%)	Preterm birth N (%)	p-value[a]
All participants	24,955 (100)	22430 (89.9)	2525 (10.1)	-
Individual-level characteristics				
Age [mean (SD)]	27.1 (6.2)	27.1 (6.1)	26.9 (6.4)	0.1645 [f]
Race/ethnicity				<.0001[g]
Non-Hispanic White	6063 (24.3)	5650 (25.2)	413 (16.4)	
Non-Hispanic Black	11229 (45.1)	9792 (43.7)	1437 (57.1)	
Hispanic	2276 (9.1)	2092 (9.3)	184 (7.3)	
Non-Hispanic other[b]	5351 (21.5)	4866 (21.7)	485 (19.3)	
Education				<.0001 [g]
High school	15823 (63.9)	14069 (63.1)	1754 (70.6)	
More than high school	8946 (36.1)	8216 (36.9)	730 (29.4)	
Marital status				<.0001 [g]
Married	9466 (37.9)	8779 (39.1)	687 (27.2)	
Not married	15489 (62.1)	13651 (60.9)	1838 (72.8)	
Insurance				<.0001 [g]
Private	10742 (43.3)	9414 (42.3)	1328 (53.0)	
Medicaid	10829 (43.7)	9972 (44.8)	857 (34.2)	
Self-pay	3219 (13.0)	2897 (13.0)	322 (12.8)	
Smoked during pregnancy	1825 (7.5)	1562 (7.1)	263 (10.7)	<.0001 [g]
Alcohol drinking during pregnancy	164 (0.7)	142 (0.7)	22 (0.9)	0.1605 [g]
Previous live birth				0.0132 [g]
None	11155 (44.7)	10085 (45.0)	1070 (42.4)	
≥1	13799 (55.3)	12344 (55.0)	1455 (57.6)	
Adequacy of prenatal care[c]				<.0001 [g]
Inadequate/intermediate	5964 (23.9)	4665 (20.8)	904 (35.8)	
Adequate	12677 (50.8)	11731 (52.3)	1018 (40.3)	
Adequate plus	6314 (25.3)	6034 (26.9)	603 (23.9)	
Previous preterm birth	172 (0.7)	113 (0.5)	59 (2.3)	<.0001 [g]
Low birth weight	2340 (9.4)	824 (3.7)	1516 (60.0)	<.0001 [g]

Medical morbidity[d]	2757 (11.1)	2314 (10.3)	443 (17.5)	<.0001 [g]
Neighborhood-level characteristics*				
Number of census tracts	66	66	66	-
Neighborhood violence rate[e]	114.1	110.3	132.8	<.0001 [h]
Neighborhood deprivation index [median (IQR)]	0.09 (–0.69, 0.76)	0.09 (–0.69, 0.60)	0.35 (–0.57, 0.87)	<.0001 [h]
Population with less than high school, % [median (IQR)]	25.1 (11.9-31.9)	24.8 (11.9-31.9)	26.6 (15.1-36.6)	<.0001 [h]
Unemployed population, % [median (IQR)]	12.0 (7.0-19.0)	11.3 (7.0-19.0)	14.7 (7.4-20.3)	<.0001 [h]
Males in management occupations, % [median (IQR)]	3.4 (1.0-6.3)	3.5 (1.0-6.3)	3.1 (0.9-5.6)	<.0001 [h]
Crowded housing, % [median (IQR)]	2.3 (0.6-4.2)	2.3 (0.5-4.2)	2.3 (0.8-4.7)	0.4518 [h]
Households in poverty, % [median (IQR)]	18.7 (8.0-35.7)	17.0 (7.9-35.7)	25.1 (11.4-37.1)	<.0001 [h]
Female headed households with children, % [median (IQR)]	17.1 (4.7-23.1)	17.1 (4.7-23.1)	20.4 (8.5-24.4)	<.0001 [h]
Households earning <$30,000 per year, % [median (IQR)]	42.9 (29.5-56.6)	42.9 (28.3-56.6)	45.2 (34.4-57.4)	<.0001 [h]
Households on public assistance, % [median (IQR)]	17.2 (6.5-30.9)	17.2 (6.5-30.4)	25.5 (13.0-32.3)	<.0001 [h]

IQR=Interquartile Range

* Neighborhood data were derived from the American Community Survey 5-year estimates (2008–2012)

[a] difference between term and preterm birth

[b] American Indian or Alaskan Native Tribe(s), Chinese, Japanese, Native Hawaiian, Filipino, Other Asian or Pacific Islander, Asian Indian, Korean, Samoan, Vietnamese, Guamanian or Chamorro, Other Asian, Other Pacific Islander

[c] Kotelchuk index (Adequacy of Prenatal Care Utilization)

[d] Pre-pregnancy hypertension, gestational hypertension, pre-pregnancy diabetes, and gestational diabetes

[e] per 1000 of population

[f] t-test for difference of means

[g] Chi square test

[h] Wilcoxon rank-sum test

Table 4.2. Crime incidents and rates by census tract for Group A offenses among youths, Richmond City, Virginia, 2006 – 2015*

Census Tract	Crime Incidents (Group A offenses)										Total Crime Incidents (N)	Total Youth Population at Midpoint (2010)	Crime Rate per 1000
	2006 (N)	2007 (N)	2008 (N)	2009 (N)	2010 (N)	2011 (N)	2012 (N)	2013 (N)	2014 (N)	2015 (N)			
10200	42	36	40	47	28	21	34	42	56	41	387	462	83.8
10300	44	43	36	50	42	48	44	42	93	87	529	370	143.0
10401	122	88	133	140	133	116	124	139	55	57	1107	490	225.9
10402	44	41	39	44	52	43	35	42	44	70	454	634	71.6
10500	61	30	26	24	26	67	56	43	70	68	471	283	166.4
10600	50	36	50	63	46	60	34	44	49	28	460	401	114.7
10700	132	127	127	140	112	94	102	102	102	97	1135	592	191.7
10800	165	134	113	160	132	143	132	121	114	117	1331	1071	124.3
10900	195	180	140	122	132	131	125	124	105	120	1374	805	170.7
11000	88	112	103	102	106	74	84	73	65	65	872	565	154.3
11100	163	117	101	134	134	114	143	164	124	165	1359	1303	104.3
20100	148	167	135	123	144	120	71	114	107	99	1228	618	198.7
20200	317	334	259	292	251	252	284	227	181	191	2588	1422	182.0
20300	72	64	66	74	60	63	59	59	74	58	649	368	176.4
20400	310	268	270	253	271	250	296	266	204	197	2585	1676	154.2
20500	258	238	192	188	174	221	205	173	132	121	1902	1060	179.4
20600	35	31	33	51	27	24	26	16	19	19	281	303	92.7
20700	52	43	48	46	44	39	48	52	35	51	458	230	199.1
20800	41	31	24	21	20	26	19	18	20	18	238	251	94.8
20900	114	99	113	88	83	92	98	76	77	71	911	575	158.4
21000	121	101	96	89	68	74	46	57	55	55	762	506	150.6
21100	35	39	38	38	29	25	23	28	36	33	324	402	80.6
21200	46	36	33	46	37	26	26	32	30	30	342	433	79.0
30100	340	329	314	298	386	322	321	271	196	201	2978	1103	270.0

30200	219	209	209	296	298	318	333	288	294	222	2686	1022	262.8
30500	246	243	254	299	339	379	372	294	276	272	2974	2008	148.1
40200	259	349	315	335	268	269	337	341	309	355	3137	2515	124.7
40300	125	139	155	158	117	109	114	85	75	55	1132	3884	29.1
40400	192	213	132	136	128	122	146	102	124	95	1390	2266	61.3
40500	76	103	79	92	65	79	61	43	35	41	674	953	70.7
40600	52	43	48	25	27	24	30	18	16	26	309	585	52.8
40700	33	32	39	21	28	20	24	17	24	19	257	567	45.3
40800	44	34	25	23	17	26	24	19	25	19	256	226	113.3
40900	53	54	59	55	52	45	36	35	28	33	450	600	75.0
41000	74	75	53	46	37	45	20	34	29	33	446	764	58.4
41100	230	247	212	226	239	190	235	196	165	173	2113	1662	127.1
41200	21	44	45	40	46	32	39	30	45	30	372	506	73.5
41300	96	102	98	99	112	87	121	135	120	110	1080	1033	104.5
41400	46	38	57	37	29	41	26	39	44	26	383	556	68.9
41600	18	16	15	16	16	9	15	12	17	6	140	214	65.4
50100	40	42	43	46	39	30	43	49	24	26	382	399	95.7
50200	17	12	12	16	17	5	12	6	17	8	122	419	29.1
50300	5	5	5	1	2	2	5	4	4	2	35	225	15.6
50400	10	17	9	12	20	8	3	7	6	9	101	554	18.2
50500	12	11	7	17	6	7	5	10	15	15	105	3260	3.2
50600	4	9	3	4	9	1	6	8	2	4	50	623	8.0
60200	91	127	96	74	105	84	132	86	63	34	892	538	165.8
60400	287	262	267	245	246	278	256	206	221	204	2472	1488	166.1
60500	176	214	171	178	187	137	135	147	162	155	1662	1081	153.7
60600	17	25	28	23	20	19	17	17	16	17	199	333	59.8
60700	420	426	432	336	401	323	358	338	245	253	3532	1710	206.5
60800	211	195	203	157	168	140	153	120	135	145	1627	1159	140.4
60900	113	94	101	66	55	65	61	61	42	55	713	320	222.8
61000	172	142	177	231	179	160	178	151	133	194	1717	1131	151.8
70100	19	17	22	25	19	27	13	23	18	11	194	700	27.7
70300	123	125	157	139	113	114	89	89	109	120	1178	670	175.8

70400	80	82	54	46	38	35	42	46	47	34	504	505	99.8
70601	305	391	249	281	247	195	205	191	179	213	2456	1599	153.6
70602	112	114	104	101	107	91	92	99	143	141	1104	687	160.7
70700	207	188	166	177	172	163	147	135	185	159	1699	1309	129.8
70801	209	213	195	183	191	169	153	155	185	155	1808	2139	84.5
70802	186	129	97	97	90	88	74	77	32	29	899	750	119.9
70900	232	225	203	171	129	168	168	163	152	173	1784	1831	97.4
71001	143	174	149	141	125	125	145	101	94	116	1313	1541	85.2
71002	147	105	120	158	121	93	87	86	57	56	1030	852	120.9
71100	100	75	54	75	74	58	63	60	83	108	750	1000	75.0
Total	8217	8084	7448	7537	7235	6825	7010	6448	6038	6010	70852	62107	114.1

* Group A offenses: aggravated assault, kidnapping, homicide, sexual assault, robbery, theft, burglary, larceny, arson, destruction of property, and vandalism; Youths: 10 – 24 year old

Table 4.3. Factor loadings for first principal component of neighborhood deprivation index for Richmond city, Virginia*

Items	Factor loading
Population with less than high school, %	0.83
Unemployed population, %	0.86
Males in management occupations, %	0.71
Crowded housing, %	0.54
Households in poverty, %	0.87
Female headed households with children, %	0.90
Households earning <$30,000 per year, %	0.89
Households on public assistance, %	0.92
% variance explained by first principal component	66.6

* Neighborhood data were derived from the American Community Survey 5-year estimates (2008–2012)

Table 4.4. Distribution of neighborhood deprivation index and individual components of the neighborhood deprivation index by census tract, Richmond city, Virginia*

Census Tract	Unemployed population, %	Households in poverty, %	Population with less than high school, %	Households earning <$30,000 per year, %	Crowded housing, %	Female headed households with children, %	Households on public assistance, %	Males in management occupations, %	Neighborhood deprivation index
10200	5.1	11.6	8.3	33.99	0	2.63	5.26	8.66	-0.68
10300	22.8	26.9	27.4	52.65	4.30	28.34	30.43	0	1.01
10401	8.9	5.6	5.0	40.4	0	5.06	15.86	5.19	-0.2
10402	7.1	8.6	16.0	30.89	0	3.94	10.08	11.23	-0.8
10500	4.4	18.1	25.3	30.95	0	6.96	12.38	3.34	-0.16
10600	10.9	3.6	13.6	28.33	0.80	5.43	14.87	5.25	-0.37
10700	16.2	18.7	30.5	43.95	2.1	24.79	17.39	2.02	0.51
10800	19.4	25.1	30.5	46.65	2.6	21.95	37.86	1.4	0.86
10900	18.2	12.5	36.8	47.35	0.6	19.45	32.34	0.59	0.86
11000	8.4	14.9	21.3	39.52	3.9	17.27	24.34	5.2	-0.22
11100	12.2	16.1	16.5	42.94	0.4	8.5	13.91	1.86	0.28
20100	24.8	67.5	46.3	79.46	1.7	48.11	73.04	0	2.69
20200	21.5	70.4	36.6	82.06	4.7	55.03	55.37	0	2.3
20300	11.3	31.9	35.4	55.37	0.8	15.43	25.26	1.95	0.76
20400	25.7	67.4	48.9	82.02	1.5	44.54	55.09	1.03	2.51
20500	5.3	26.5	14.8	34.4	1.3	1.26	6.3	9.98	-0.69
20600	4.3	10.1	20.7	25.06	0	4.72	7.62	6.28	-0.6
20700	7	20	25.3	54.05	2	4.86	25.22	2.39	0.22
20800	10.4	7.9	5.7	17.64	3.7	4.45	4.63	7.59	-0.99
20900	14.6	6.7	22.2	41.28	1.2	12.45	15.03	1.79	0.23
21000	15.7	44.5	15.9	60.05	4.5	22.3	31.77	3.07	0.79
21100	6.7	6.4	15	33.8	0	16	14	0	0.12
21200	12	16	17.1	34.47	9	18.85	20.57	9.38	-0.9
30100	31	68.7	43	92.56	2.9	50.22	70.98	3.41	2.72

30200	14.3	9.5	8.1	41.89	0.4	7.5	7.9	3.43	0.07
30500	13.6	25.9	5.4	60.12	3.5	2.34	6.48	10.41	-0.33
40200	12.2	19.9	23.2	55.74	0.5	3.6	9.94	0.47	0.51
40300	32.1	89.3	4.7	82.31	0	0	0	0	2.17
40400	14.4	12.5	15.1	64.33	1.6	3.69	9.42	2.89	0.33
40500	7.8	0	4.7	37.82	0	0	3.47	6.77	-0.59
40600	7.4	0	0.8	39.03	0	0	6.8	6.2	-0.53
40700	3.4	8	6.2	25.15	1.6	3.51	2.34	7.47	-0.96
40800	9.9	13.5	11.1	29.51	5.3	1.92	12.14	1.21	-0.43
40900	6.3	4	5.8	22.99	6.1	0	4.56	6.33	-1.25
41000	4.5	0	2.7	19.47	0	0	3.83	6.85	-0.94
41100	6.7	13.8	8.1	43.14	0.4	2.78	3.71	9	-0.55
41200	13.9	21.8	7.9	40.61	0	1.14	1.14	5.46	-0.03
41300	7.9	28.3	23.1	54.68	0.5	13.44	25.5	4.1	0.44
41400	15.3	13.5	11.5	40.27	3.8	13.1	11.81	4.38	-0.12
41600	3.7	0	9.9	19.91	0	2.39	4.04	3.51	-0.69
50100	2.3	3.2	2.7	20.12	0	2.71	2.29	8.24	-1.05
50200	0.5	2.2	1.8	9.62	0	4.77	1.17	13.57	-1.61
50300	1.4	6.5	2.9	20.84	0	3	4.94	5.42	-0.81
50400	10	5.8	9.2	12.15	0	3.61	2.02	7.61	-0.82
50500	7.8	1.3	1.1	17	0	3.53	2.94	9.53	-1.02
50600	0.7	2.8	1.1	5.77	0	0	0	12.16	-1.61
60200	7.4	36	27	46.31	5.4	22.4	27.96	1.73	0.27
60400	20.3	35.7	21.2	57.35	3	24.35	26.97	4.1	0.84
60500	7	9.2	24.8	35.43	0.7	14.01	13.02	2.13	-0.02
60600	3.9	1.2	3.2	12.04	0.7	0.56	0.65	6.37	-1.08
60700	26	47.5	26.6	71.32	7.4	32.65	48.33	0	1.52
60800	14.8	33.6	34	51.34	5.8	24.19	27.66	1.87	0.52
60900	14.9	35.7	42.9	46.24	1.4	21.84	26.62	0	0.97
61000	15.7	35.4	25.1	51.74	4.1	17.91	24.16	3.26	0.51

70100	2.6	0	3.2	18.71	0	1.1	2.7	10.07	-1.23
70300	9.5	5.3	13	21.41	3.9	12.45	3.42	5.73	-0.81
70400	4.4	3.7	3.5	14.39	0	1.62	2.74	7.99	-1.04
70601	14.7	37.1	58.2	56.6	21.3	20.4	30.91	5.63	-0.87
70602	15.5	11.4	39.6	27.62	3.9	11.25	20	7.59	-0.42
70700	10.6	17	31.9	32.53	4.2	16.02	13.73	0.91	-0.03
70801	19	27.3	29.5	38.45	4.8	23.08	26.42	3.66	0.34
70802	10.4	11.7	27.5	27.58	4	18.31	12.06	6.1	-0.5
70900	10.6	24.1	27.4	42.91	2.3	22.69	26.39	0.92	0.5
71001	4.4	13.3	11.9	45.16	2.3	22.73	17.21	1.15	0.09
71002	15.8	22	26.9	45.07	1.9	17.09	16.05	0.36	0.59
71100	7.4	6	13.7	27.43	0	4.74	6.45	6.52	-0.56

* Data were derived from the American Community Survey 5-year estimates (2008–2012) for Richmond city, Virginia

Table 4.5. Correlation between individual components of the neighborhood deprivation index

	Percent households <30k/year [r (p-value)]	**Percent population with less than high school [r (p-value)]**	**Percent households on public assistance [r (p-value)]**	**Percent households in poverty [r (p-value)]**	**Percentage crowded housing [r (p-value)]**	**Percent female-headed households with children [r (p-value)]**	**Percent males in management occupations [r (p-value)]**	**Percent unemployed population [r (p-value)]**
Percent households <30k/year	1.00000	0.68605 (<.0001)	0.91177 (<.0001)	0.92419 (<.0001)	0.31449 (<.0001)	0.86494 (<.0001)	-0.62800 (<.0001)	0.83695 (<.0001)
Percent population with less than high school	0.68605 (<.0001)	1.00000	0.73483 (<.0001)	0.71306 (<.0001)	0.63836 (<.0001)	0.68810 (<.0001)	-0.50903 (<.0001)	0.66080 (<.0001)
Percent households on public assistance	0.91177 (<.0001)	0.73483 (<.0001)	1.00000	0.92866 (<.0001)	0.30208 (<.0001)	0.93538 (<.0001)	-0.60714 <.0001	0.86615 (<.0001)
Percent households in poverty	0.92419 (<.0001)	0.71306 (<.0001)	0.92866 (<.0001)	1.00000	0.34157 (<.0001)	0.91116 (<.0001)	-0.52895 (<.0001)	0.83009 (<.0001)
Percentage crowded housing	0.31449 (<.0001)	0.63836 (<.0001)	0.30208 (<.0001)	0.34157 (<.0001)	1.00000	0.25594 (<.0001)	-0.37645 (<.0001)	0.28688 (<.0001)
Percent female-headed	0.86494 (<.0001)	0.68810 (<.0001)	0.93538 (<.0001)	0.91116 (<.0001)	0.25594 (<.0001)	1.00000	-0.64892 (<.0001)	0.81615 (<.0001)

	Percent households <30k/year [r (p-value)]	Percent population with less than high school [r (p-value)]	Percent households on public assistance [r (p-value)]	Percent households in poverty [r (p-value)]	Percentage crowded housing [r (p-value)]	Percent female-headed households with children [r (p-value)]	Percent males in management occupations [r (p-value)]	Percent unemployed population [r (p-value)]
households with children								
Percent males in management occupations	-0.62800 (<.0001)	-0.50903 (<.0001)	-0.60714 (<.0001)	-0.52895 (<.0001)	-0.37645 (<.0001)	-0.64892 (<.0001)	1.00000	-0.58131 (<.0001)
Percent unemployed population	0.83695 (<.0001)	0.66080 (<.0001)	0.86615 (<.0001)	0.83009 (<.0001)	0.28688 (<.0001)	0.81615 (<.0001)	-0.58131 (<.0001)	1.00000

Abbreviation: r = correlation coefficient

Table 4.6. Model fit indices for three competing models

Model	Akaike information criterion	Bayesian information criterion
Model 1[a]	16958.052	17014.926
Model 2[b**]	16536.943	16715.348
Model 3[c]	16598.285	16802.194

[a] Unadjusted model
[b] adjusted for age, race/ethnicity, parity, insurance, smoking in pregnancy, marital status, and medical morbidity
[c] adjusted for age, education, race/ethnicity, parity, insurance, smoking in pregnancy, alcohol drinking in pregnancy, marital status, and medical morbidity
** Best model fit

Table 4.7. Direct and indirect effects of neighborhood deprivation on preterm birth, Richmond city, Virginia, 2006-2015

Neighborhood deprivation	Preterm birth	
	β	95% CI
Total effect	0.367	0.239, 0.495*
Direct Effect	0.304	0.231, 0.377*
Indirect Effect	0.063	–0.025, 0.151

* 95% CI does not contain 0

Table 4.8. Sensitivity analysis for the association between neighborhood violence and preterm birth, Richmond city, Virginia, 2006-2015

Neighborhood violence	Preterm birth	
	Very preterm birth	Moderately preterm birth
	AOR (95% CI) [a]	AOR (95% CI) [a]
	0.99 (0.89-1.09)	0.96 (0.85-1.07)

* Term birth is reference category
[a] adjusted for age, race/ethnicity, parity, insurance, smoking during pregnancy, marital status, and medical morbidity
Very preterm birth: <32 weeks gestation, Moderately preterm birth: 32 - <37 weeks gestation

FIGURES

Figure 2.1. Conceptual model for the modifying effect of residential environment on the association between quality of mother–father relationship and preterm birth in a sample of African-American women

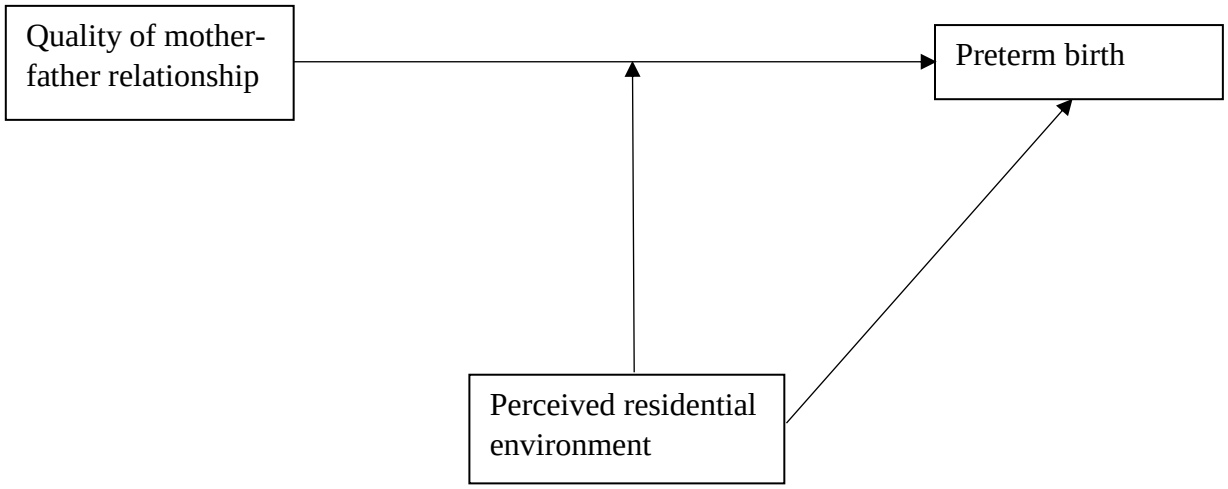


Figure 2.2. Scree plot for exploratory factor analysis of father-of-baby relationship scale, Life Influences on Fetal Environments study, 2009–2011

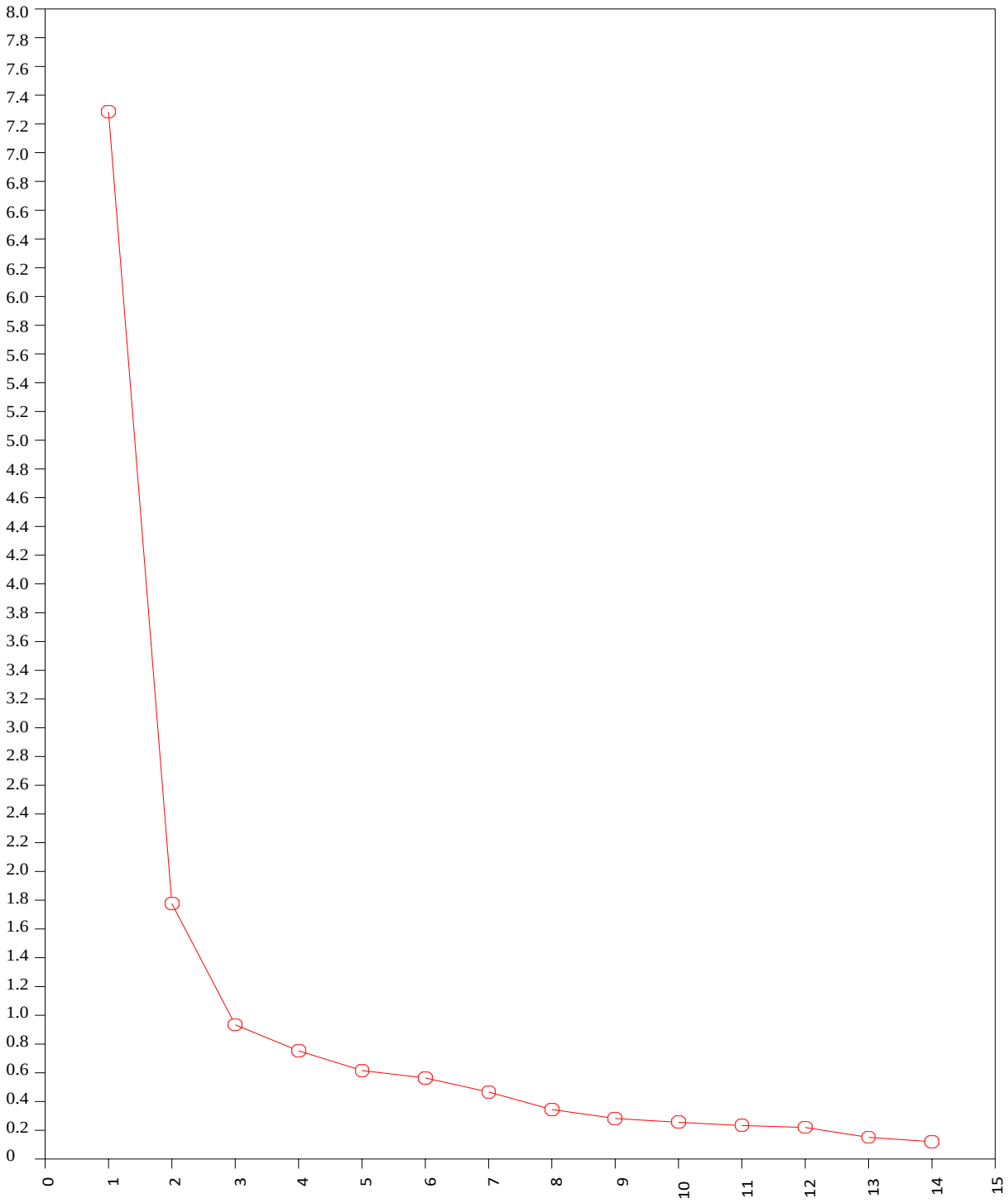
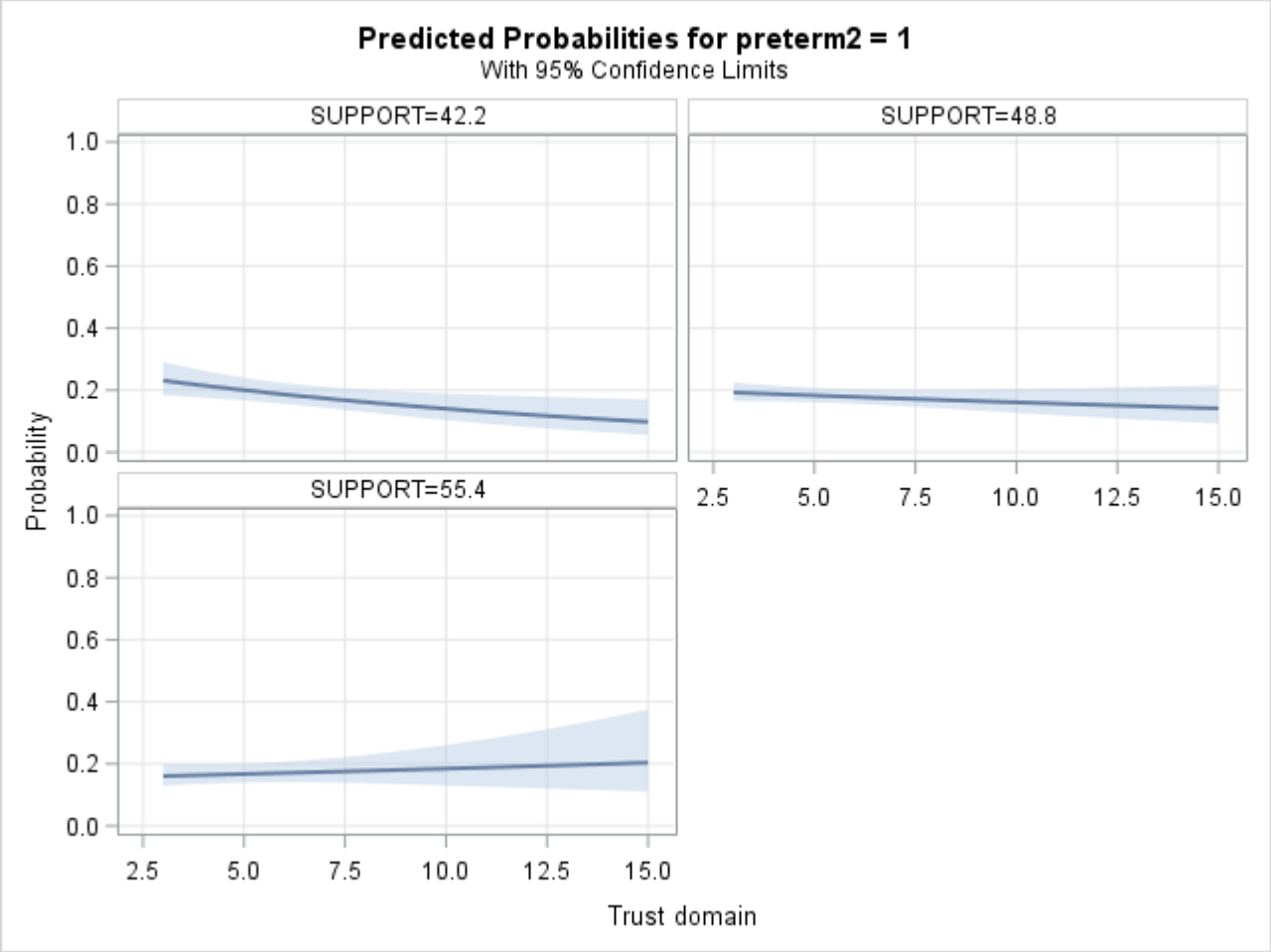


Figure 2.3. Interaction plot showing modifying effect of maternal social support on the association between quality of mother–father relationship (trust domain) and preterm birth



Maternal social support @ Mean – SD: 42.2
Maternal social support @ Mean: 48.8
Maternal social support @ Mean + SD: 55.4

Figure 3.1. Conceptual model for the modifying effect of social support on the association between neighborhood violence exposure and preterm birth

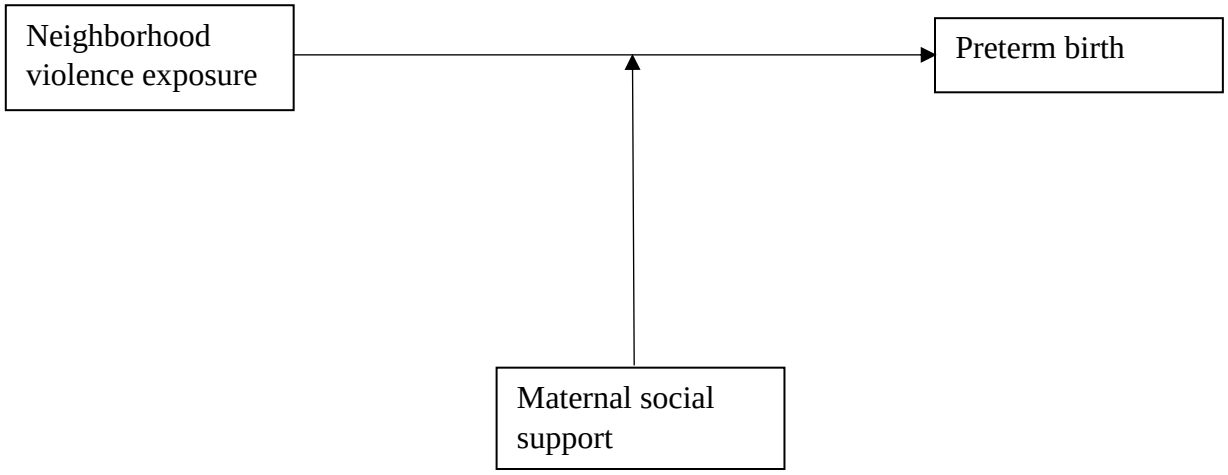


Figure 3.2. Sequence of study sample selection

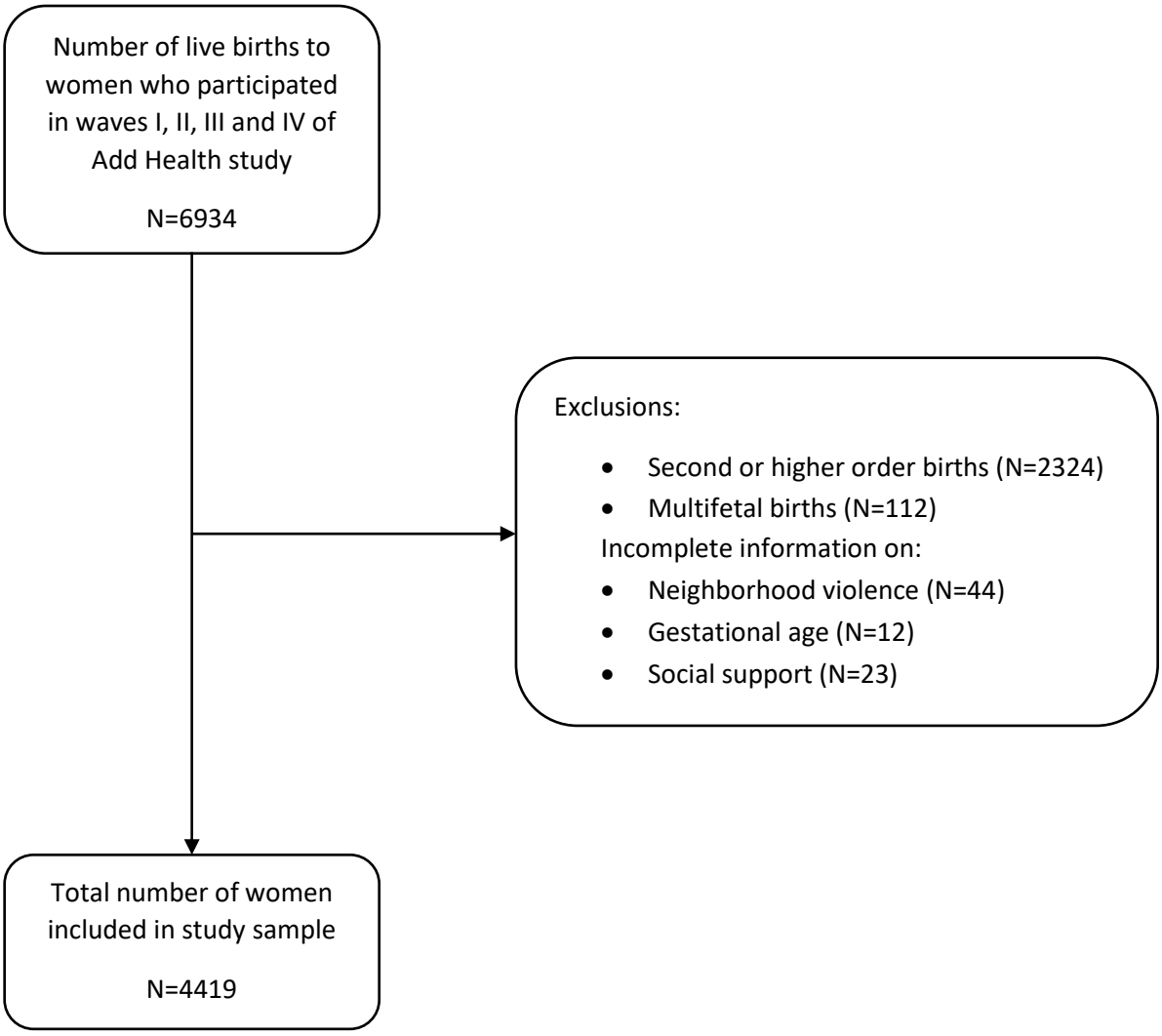


Figure 4.1. Conceptual model for the mediating influence of neighborhood violence on the association between neighborhood deprivation and preterm birth

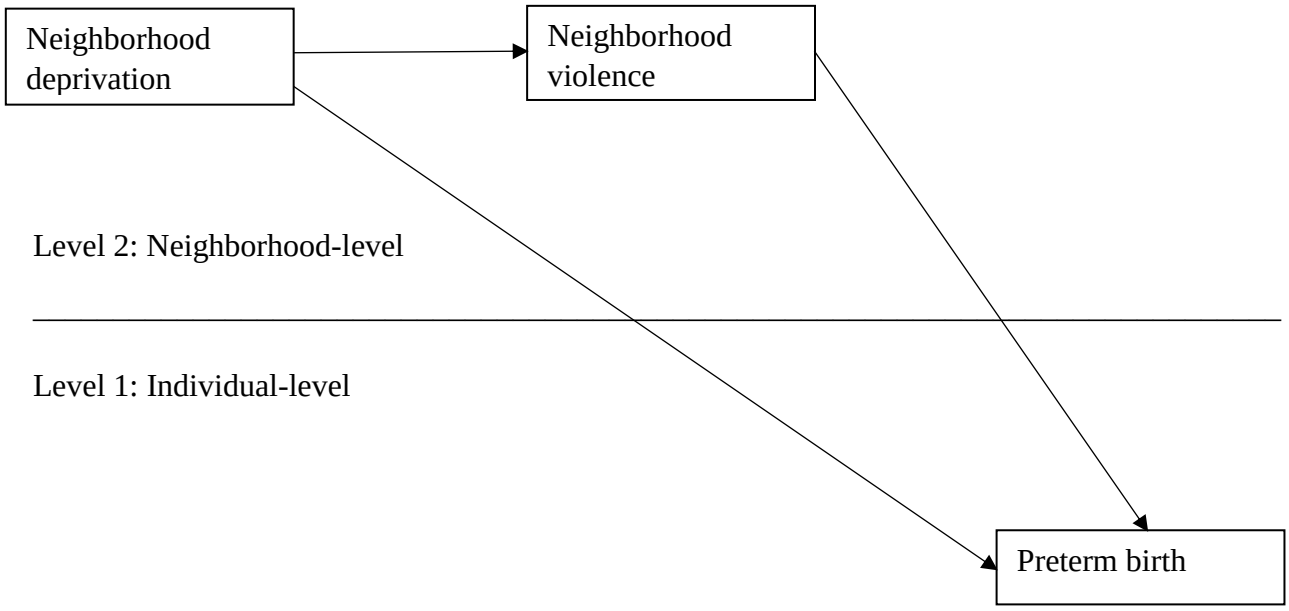


Figure 4.2. Geocoding sequence of maternal addresses for livebirths, Richmond city, Virginia, 2006-2015

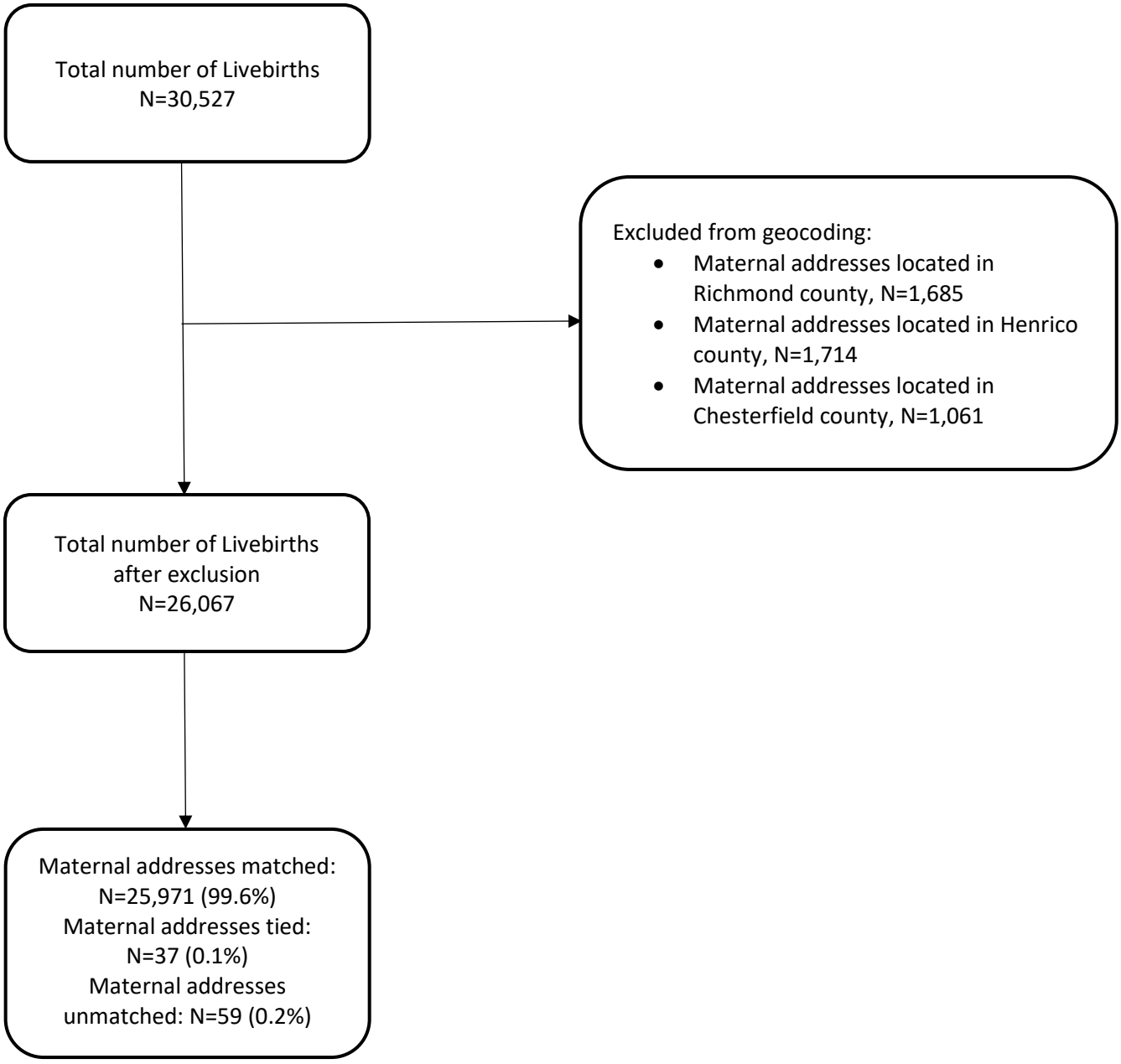


Figure 4.3. Principal Component Analysis: Scree plot and amount of variance explained

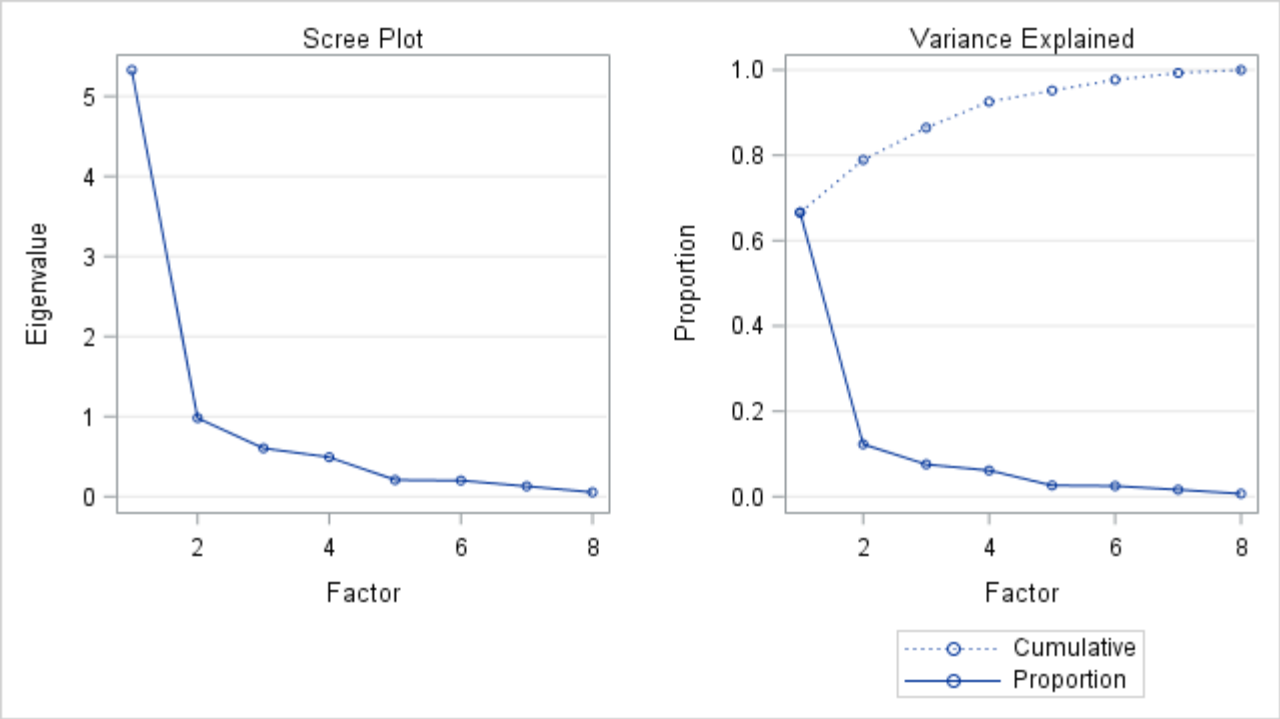
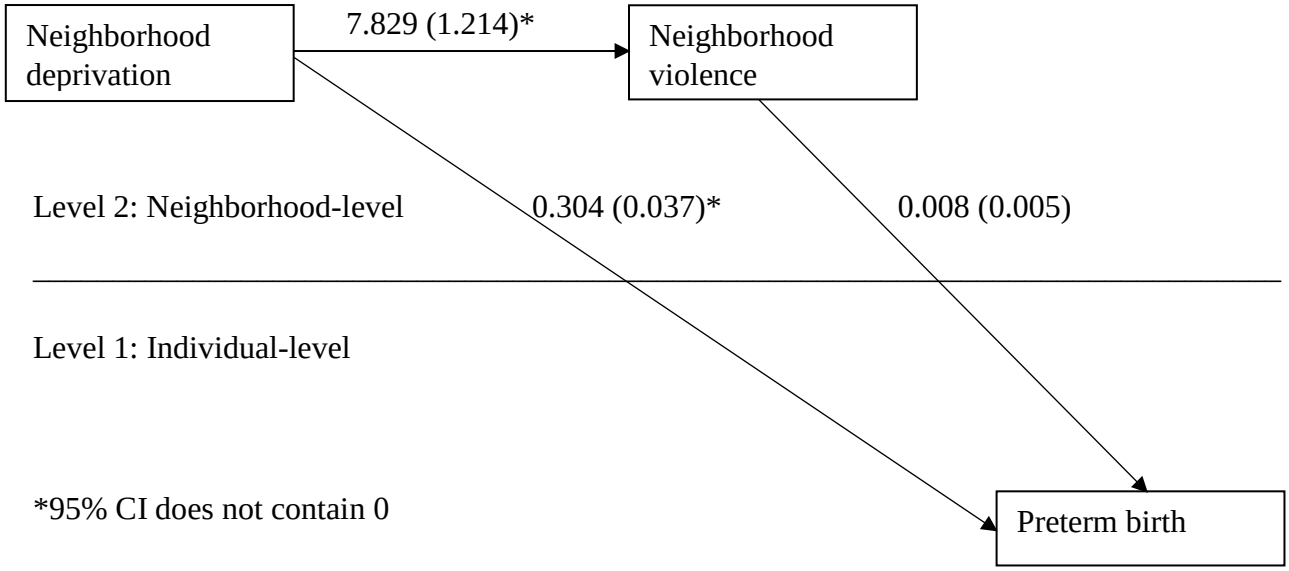
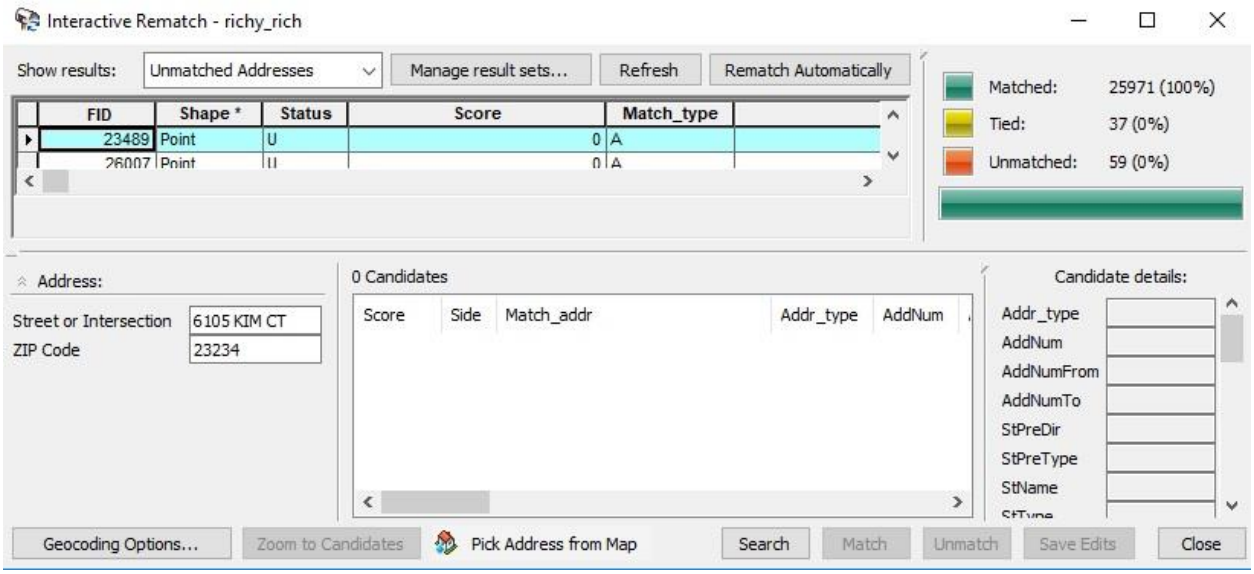


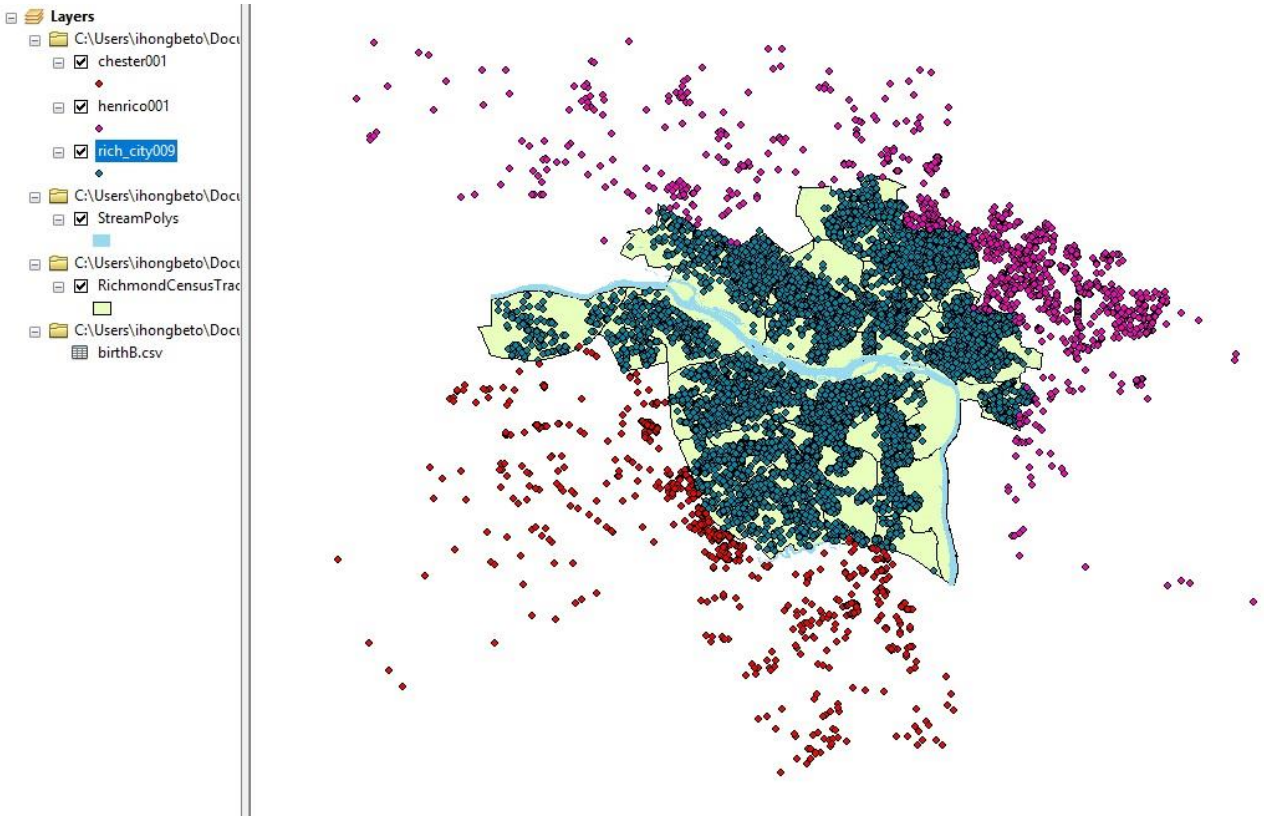
Figure 4.4. Unstandardized effects (β and SE) of neighborhood deprivation on preterm birth



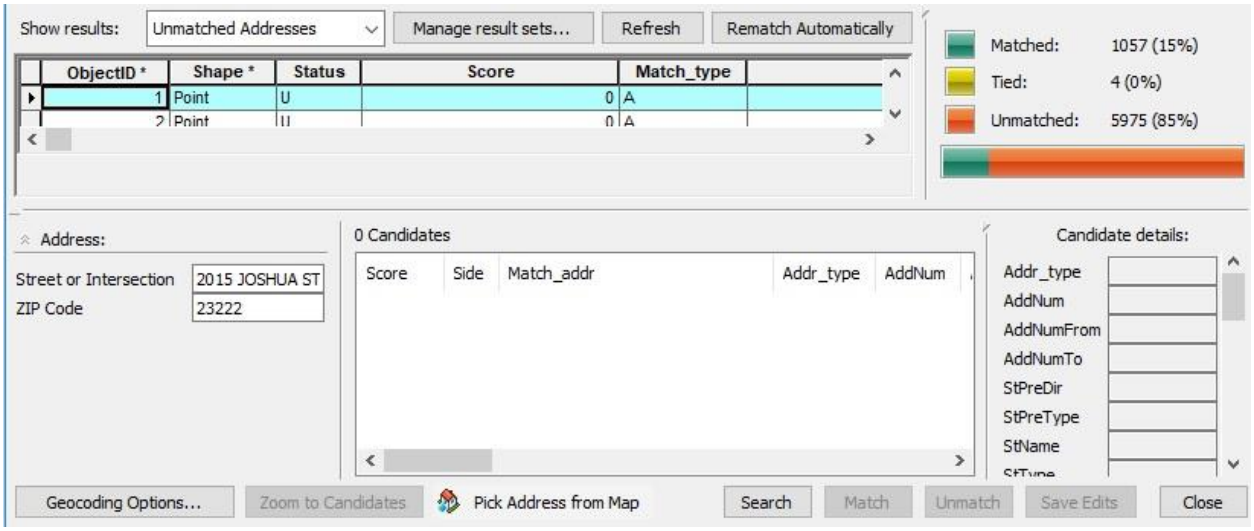
Supplemental Figure 4.1. Print screen of final geocoded birth record



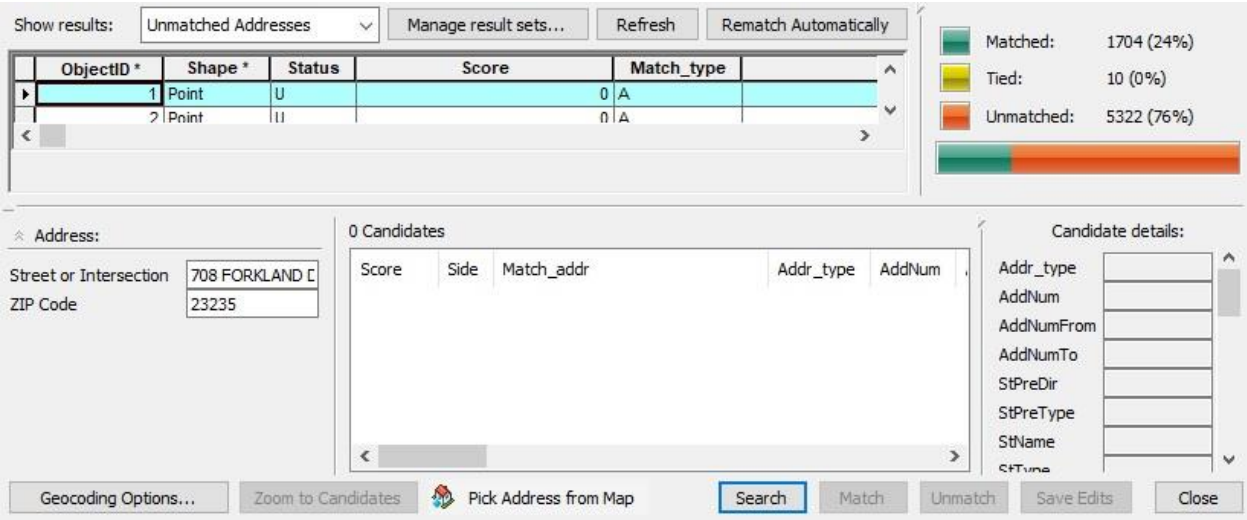
Supplemental Figure 4.2. Maternal addresses matched to Henrico county, Richmond city, and Chesterfield county



Supplemental Figure 4.3. Print screen showing maternal addresses matched to Chesterfield County



Supplemental Figure 4.4. Print screen showing maternal addresses matched to Henrico County



Appendix 1. Mother-Father relationship question

5-point Likert scale: strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree

1. Father-of-baby is always there when I need him.
2. I feel that I can tell Father-of-baby just about everything.
3. I feel that Father-of-baby and I can share our problems with each other.
4. I feel that Father-of-baby and I can share our feelings with each other.
5. Father-of-baby and I are much closer than most couples.
6. I have a lot of respect for Father-of-baby.
7. Father-of-baby and I have a good relationship
8. Father-of-baby is someone I can count on for financial support if I need it.
9. Father-of-baby is someone I can count on to take care of my baby.
10. Father-of-baby is often critical (disapproving) of me.
11. I sometimes fight or argue with Father-of-baby.
12. My relationship with Father-of-baby sometimes makes me feel tense.
13. Father-of-baby often criticizes my friends.
14. Father-of-baby often criticizes my (mother).

Vita

Timothy Oseaga Ihongbe was born on May 15, 1981 in Abeokuta, Nigeria. He graduated from Greater Tomorrow Secondary School in Benin City, Edo State, Nigeria in 1997. He received his degree in Medicine from the University of Benin, Nigeria in 2006 and practiced as a physician in various clinical settings from 2006 to 2011. Timothy earned his Master of Public Health degree from the University of South Carolina Arnold School of Public Health in 2013 and subsequently commenced his doctoral program at the Virginia Commonwealth University in 2013.

RESEARCH EXPERIENCE

2015 – 2017	Graduate Research Assistant AHRQ–funded randomized controlled trial – "Effectiveness of shortened time interval to postpartum visit in improving postpartum attendance". Virginia Commonwealth University, Division of Epidemiology, Richmond, VA
2013 – 2017	Graduate Research Assistant Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA
2012 – 2013	Graduate Research Assistant South Carolina Department of Health and Environmental Control, Columbia, SC

TEACHING EXPERIENCE

2017	Teaching Assistant, Applied Data Analysis in Public Health Lab II, Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA
2015 - 2016	Guest Lecturer, Principles of Epidemiology, Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA
2013	Teaching Assistant, Principles of Epidemiology, Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA

PEER-REVIEWED PUBLICATIONS

1. **Ihongbe, T. O.,** Wallenborn, J. T., Rozario, S., & Masho, S. W. (2018). Short interpregnancy interval and adverse birth outcomes in women of advanced age: A population-based study. Annals of Epidemiology, 28(9), 605-611. doi:10.1016/j.annepidem.2018.06.007

2. **Ihongbe, T. O**., & Masho, S. W. (2018). Gender differences in the association between synthetic cannabinoid use and teen dating violence victimization. *Violence and Gender*, 5(2), 103-109.

3. **Ihongbe, T. O.**, & Masho, S. W. (2018). Changes in the use of long-acting reversible contraceptive methods among US nulliparous women: results from the 2006–2010, 2011–2013, and 2013–2015 National Survey of Family Growth. *Journal of Women's Health*, 27(3), 245-252.

4. **Ihongbe, T. O.**, & Masho, S. W. (2018). Child sexual abuse and intimate partner violence victimization in adulthood: sex-differences in the mediating influence of age of sexual initiation. *Journal of Child Sexual Abuse*, 27(1), 53-69.

5. Ihongbe, F. A., **Ihongbe, T. O.**, Masho, S. W., & Petrov, K. (2018). Association between synthetic cannabinoid use and depressive symptomology: Analysis of a US national survey of high-school seniors. *Journal of Substance Use*, 23(2), 113-119.

6. **Ihongbe, T. O.**, & Masho, S. W. (2017). Racial/ethnic differences in the modifying effect of community violence on the association between paternity status and preterm birth. *Journal of Environmental and Public Health*, 2017. doi:10.1155/2017/3479421

7. **Ihongbe, T. O.**, & Masho, S. W. (2017). Do successive preterm births increase the risk of postpartum depressive symptoms? *Journal of Pregnancy*, 2017, 4148136. doi:10.1155/2017/4148136 [doi]

8. Wallenborn, J. T., **Ihongbe, T.**, Rozario, S., & Masho, S. W. (2017). Knowledge of breastfeeding recommendations and breastfeeding duration: A survival analysis on Infant Feeding Practices II. *Breastfeeding Medicine*, 12(3), 156-162.

9. **Ihongbe, T. O.**, Cha, S., & Masho, S. W. (2017). Age of sexual debut and physical dating violence victimization: sex differences among US high school students. *Journal of school health*, 87(3), 200-208.

10. **Ihongbe, T. O.**, & Masho, S. W. (2016). Prevalence, correlates and patterns of heroin use among young adults in the United States. *Addictive behaviors*, 63, 74-81.

11. Cha, S., **Ihongbe, T. O.**, & Masho, S. W. (2016). Racial and gender differences in dating violence victimization and disordered eating among US high schools. *Journal of Women's Health*, 25(8), 791-800.

12. Varner, S. B., **Ihongbe, T.**, & Masho, S. W. (2016). The impact of prior poor birth outcomes on smoking behavior on subsequent pregnancies: Analysis of the national PRAMS data. *Maternal and child health journal*, 20(3), 583-592.

13. Isah E. C., Ofili A. N., Ihenyen A. E., & **Ihongbe T. O.** (2009). Burnout level and psychological wellbeing of healthcare providers in a mental health hospital in Nigeria. *Journal of Medicine and Biomedical Research*, 8 (1), 24-34

INVITED ORAL PRESENTATIONS

1. **Ihongbe TO,** Masho SW. "Paternal absenteeism and preterm birth: The moderating role of neighborhood violence". Oral presentation at the 144th American Public Health Association (APHA) annual meeting and exposition, October 29 - November 2, 2016. Abstract number 358293

2. **Ihongbe TO**, Masho SW. Do successive poor birth outcomes increase the risk of postpartum depressive symptoms? Presented at the American Public Health Association 143rd Annual Meeting and Exposition, October 31 - November 4, 2015. Abstract number 333117

3. **Ihongbe TO**, Masho SW, Cha S. Determinants of physical dating violence victimization among high school adolescents. Presented at the American Public Health Association 142nd Annual Meeting and Expo November 15-19, 2014. Abstract number 307384

4. **Ihongbe TO**, Masho SW. Changes in the use of long-acting reversible contraceptive methods among U.S. nulliparous adolescents and young adult women, 2006 to 2015: Results from the National Survey of Family Growth. Department of Family Medicine and Population Health Seminar, Virginia Commonwealth University School of Medicine, Richmond, VA. February 2017.

5. **Ihongbe TO**, Masho SW. Childhood sexual abuse and intimate partner violence victimization in adulthood: Sex-differences in the mediating influence of age of sexual debut. Department of Family Medicine and Population Health Seminar, Virginia Commonwealth University School of Medicine, Richmond, VA. October 2016.

6. **Ihongbe TO**, Masho SW. Do successive poor birth outcomes increase the risk of postpartum depressive symptoms? Department of Family Medicine and Population Health Seminar, Virginia Commonwealth University School of Medicine, Richmond, VA. October 2015.

INVITED POSTER PRESENTATIONS

1. **Ihongbe TO**, Masho SW. The impact of postpartum care visit attendance on maternal smoking behavior. Presented at the Society for Epidemiologic Research 51st Annual Meeting, June 9-22, 2018.

2. **Ihongbe TO**, Masho SW. Childhood sexual abuse and intimate partner violence victimization in adulthood: Sex-differences in the mediating influence of age of sexual debut. Presented at the Society for Epidemiologic Research 50th Annual Meeting, June 20-23, 2017.

3. **Ihongbe T.O.**, Masho S.W. "Changes in the use of long-acting reversible contraceptive methods among U.S. nulliparous adolescents and young adult women, 2006 to 2015: Results from the National Survey of Family Growth". Poster presentation at the 25th Congress on Women's Health, April 28 - 30, 2017.

4. Ihongbe F.A., **Ihongbe T.O.**, Masho S.W. & Petrov K. "Association between synthetic cannabinoid use and depressive symptomology: Analysis of a US national survey of high school seniors ". Poster presentation at the American Pharmacists Association (APhA) Annual Meeting & Exposition, March 24-27, 2017.

5. **Ihongbe, T. O.**, Rozario, S., Wallenborn, J. T., & Masho, S. W." Interpregnancy interval and adverse birth outcomes in women of advanced age: A population–based study". Poster presentation at the 144th American Public Health Association (APHA) annual meeting and exposition, October 29 - November 2, 2016. Abstract number 359400

6. **Ihongbe T.O.**, Masho S.W. "Prevalence, Correlates and Patterns of Heroin use among Young Adults in the United States". Poster presentation at the 2016 Epidemiology Congress of the Americas, June 21-24, 2016. Abstract number 37883

7. **Ihongbe TO**, Masho SW. Unintended pregnancy and postpartum depressive symptoms among rural and urban women in the United States. Presented at the American Public Health Association 143rd Annual Meeting and Exposition, October 31 - November 4, 2015. Abstract number 335334

8. **Ihongbe TO**, Masho SW. Stressful life events in pregnancy and postpartum depressive symptoms. Presented at the Society for Epidemiologic Research 48th Annual Meeting, June 16-19, 2015.

9. Cha S, **Ihongbe TO**, Masho SW. Adolescent Dating Violence, Disordered Eating, and Gender Differences in U.S. High Schools. Presented at the American Public Health Association 142nd Annual Meeting and Expo November 15-19, 2014. Abstract number 315022

10. **Ihongbe TO**, Masho SW, Cha S. Age of sexual debut and physical dating violence victimization: gender differences among us high school students. Presented at the American Public Health Association 142nd Annual Meeting and Expo November 15-19, 2014. Abstract number 315031

PROFESSIONAL SERVICE

2018 - Present	Ad hoc reviewer, Journal of School Violence
2017 - Present	Ad hoc reviewer, American Journal on Addictions
2016 - Present	Ad hoc reviewer, Addictive Behaviors
2016 - Present	Ad hoc reviewer, PLoS ONE
2016 - Present	Reviewer for the American Public Health Association (APHA) and Society for Epidemiologic Research (SER) national conferences
2015 - 2016	Member, Master of Public Health Assessment Committee, Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA
2013 - 2014	Member, Master of Public Health Curriculum Committee, Division of Epidemiology, Department of Family Medicine and Population Health, School of Medicine, Virginia Commonwealth University, Richmond, VA
2004 - 2005	Editor-in-Chief, Medical journal, University of Benin Medical Students Association

PROFESSIONAL ORGANIZATION MEMBERSHIPS

2011 - Present	Member, American Public Health Association (APHA)
2011 - Present	Member, Society for Epidemiologic Research (SER)
2011 - Present	Member, International Epidemiology Association (IEA)

AWARDS AND HONORS

2017	Certificate of appreciation for extraordinary effort in teaching, Applied Data Analysis in Public Health Lab II, Department of Family Medicine and Population Health, Division of Epidemiology, Virginia Commonwealth University, Richmond, VA
2016	Virginia Commonwealth University Graduate School Travel Grant award, American Public Health Association annual Conference, 2016
2012	Golden Key International Honors Society, University of South Carolina, Columbia, SC

2011 - 2013	Dean's Fellowship award, Arnold School of Public Health, University of South Carolina, Columbia, SC