ILLICIT DRUG USE AND BIRTH OUTCOMES:
A CONTEXTUAL EXAMINATION IN BALTIMORE, MARYLAND

By
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ABSTRACT

Background: Despite prevalent perceptions of devastating consequences, the neonatal impact of illicit drug use is less established than for tobacco or alcohol. The objectives of this study were to evaluate the effect of drug use on birth outcomes independent of surrounding contextual factors and to determine the role of the neighborhood environment on birth outcomes.

Methods: Data are from a clinic-based study of low-income women who delivered infants at Johns Hopkins Hospital in 1995 and 1996 (n=808). Use of marijuana, cocaine, and opiates was determined by the medical record, urine toxicology screens at delivery, and self-report. A postpartum interview gathered detailed information on various sociodemographic, psychosocial, and behavioral factors. The independent effect of drug use on birth weight and low birth weight (LBW, <2,500 grams) was determined in multiple regression models. Multilevel analyses were performed to evaluate the impact of neighborhood context on birth weight.

Results: In unadjusted results, cocaine and opiate use were related to mean birth weight (-329 and -239 grams, p<0.01) and LBW (ORs: 1.93 and 2.06, p<0.05). After adjusting for all associated factors, only the effect of cocaine on mean birth weight remained significant (-143 grams, p<0.05); no drug was significantly related to LBW. Most of the unadjusted effects of drug use were explained by stress, smoking, and lack of early prenatal care. The effect of moderate to severe stress was particularly large (-244 grams, OR LBW: 2.2, p<0.01). In multilevel models, a birth weight difference of nearly 300 grams separated the best and worst neighborhoods (p=0.01) independent of sociodemographic characteristics. The neighborhood effect was no longer significant
after adjusting for smoking, drug use, and prenatal care utilization, suggesting that neighborhoods may influence birth outcomes by shaping behavioral risks.

**Conclusions:** Given that associated psychosocial and behavioral factors explained most of the effect of illicit drugs on birth outcomes, prevention efforts that aim to improve newborn health in treatment programs and more generally must address surrounding factors in addition to drug use. Interventions targeting the neighborhoods in which women live should be considered as a population-based strategy to address multiple maternal and infant health risks.

**Advisor:** Donna Strobino, PhD

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Introduction

Prenatal substance abuse is a significant public health concern given the potential risk of adverse effects on fetal and infant health and development. While the deleterious effects of licit substances—tobacco and alcohol—are well established, effects of illicit drugs are not as consistently observed in epidemiologic studies. A major issue complicating the examination of drug-related effects is the many risk factors for poor birth outcomes associated with drug use, such as poverty, stress, depression, lack of social support, physical abuse, inadequate nutrition, and adverse neighborhood conditions. Determining the social, psychosocial, and behavioral characteristics associated with drug use that account for some or all of the crude effect of illicit drugs on birth outcomes could identify factors that merit special focus in treatment programs. Such research also holds general significance in identifying the relative importance of factors that must be simultaneously addressed along with drug use to improve newborn outcomes in poor, urban areas. It may not be sufficient to focus solely on drug cessation if other surrounding adverse contextual exposures are stronger and more widely prevalent risk factors. Additional exploration of the broader neighborhood characteristics related to birth outcomes and their pathways hold promise to inform population-based multilevel prevention strategies.

The specific aims of this dissertation are as follows:

1) To critically review the literature regarding the neonatal consequences of prenatal drug use.

2) To evaluate the impact of prenatal drug use on birth outcomes and the degree to which associated individual level social, psychosocial, behavioral, and biomedical factors account for the observed relation.
3) To examine the role of the neighborhood environment on birth outcomes, and whether drug use is confounded by, moderated by, or mediates neighborhood effects on birth outcomes.

**Background**

*Prevalence, Patterns, and Correlates of Prenatal Drug Use*

Recent national estimates obtained from the 2002-2003 National Survey on Drug Use and Health indicate that 4.3% of pregnant women aged 15-44 reported illicit drug use within the past month (1). Although this is a conservative estimate that reflects point prevalence rather than period prevalence of use at any time during pregnancy, it suggests that nearly 200,000 infants born each year have been exposed to illicit substances prenatally. Using post-partum interviews to assess any use during pregnancy, the 1992 National Pregnancy and Health Survey found that 5.5% of women reported use of an illicit substance (2). Marijuana was the most commonly reported substance (2.9%) and an estimated 1.1% of women used cocaine. State-based studies utilizing urine screens at delivery have similarly reported that between 4.4% to 7.5% of women test positive for illicit substances (3-5), suggesting a degree of underreporting in survey-based data given that urine screens capture only recent use.

Studies of high-risk, urban populations relying on single or multiple detection methods, however, report much higher prevalence estimates of illicit substance use ranging from 15-30% (6-10), with cocaine use alone between 10-20% (6, 8, 11-14). Marijuana and cocaine are usually the most prevalent illicit substances used, while opiate use is less common (8, 13, 14).

Drug use during pregnancy is related to a variety of sociodemographic, psychosocial, behavioral and biological risk factors for adverse pregnancy outcomes.
Women who use illicit drugs during pregnancy are more often of low socioeconomic status, unmarried, and of Black race/ethnicity (15). Prenatal drug use also is related to higher rates of sexually transmitted infections, poor nutritional status, and delayed or no prenatal care (8, 10, 16-18). Moreover, pregnant drug users often use multiple substances, including tobacco, alcohol, and other illicit drugs (10, 13, 17), making it difficult to determine the effect of single versus polydrug use.

Psychosocial risk factors related to prenatal drug use include a history of sexual abuse or violence, stressful life events, depression and other psychiatric disorders, unwanted pregnancy, less social support, and less stable living situations (7, 19-23). Although there is conflicting evidence as to whether many of these psychosocial risks are causes, consequences, or correlates of drug use, it is generally argued that psychosocial factors play a role in the onset and/or continuation of drug use. Depression is known to have substantial comorbidity with substance dependence. While the temporal sequencing can occur in both directions, depression more commonly precedes substance abuse (24, 25) and is a major predictor of relapse among former users (26). These findings are consistent with the self-medication hypothesis. Similarly, stressful life events and chronic stress may precipitate drug use in an attempt to alleviate stress and strain (27). Although most evidence is correlational, a longitudinal study of adolescents found that cumulative life events predicted the initiation and escalation of drug use (28).

Neonatal Consequences of Prenatal Drug Use

A critical and comprehensive review of the neonatal effects of drug use is covered in Chapter 4 under the first specific aim. To summarize, a clear biological basis is only
suggested for an effect of cocaine and amphetamines on fetal growth via vasoconstriction and reduced uteroplacental transfer (29, 30). Neonatal effects of marijuana and opiate use are less founded biologically but may affect fetal oxygenation and maternal nutrition. A recent conference report from the National Institute on Drug Abuse concluded that there is much more to be learned about placental biology and how drug use and various comorbidities, including stress, infection, and poor nutrition, may independently and interactively influence fetal development (31).

Available evidence from epidemiological studies that control for social and behavioral confounders, particularly cigarette smoking, show weak or unreliable effects of marijuana and opiate use on newborn growth parameters such as birth weight, small for gestational age, and head circumference (30, 32, 33). However, transitory neurobehavioral symptoms stemming from opiate withdrawal are common among infants born to opiate-addicted women (34). Consistent with greater biologic plausibility, cocaine use is generally associated with reductions in fetal growth (35) and placental abruption (36), though not all studies have noted effects (37). As of yet, no studies have controlled for multiple social and psychosocial confounding factors, including material hardship, stress, and exposure to physical abuse.

Long term follow-up of children prenatally exposed to illicit drugs show subtle if any effects on cognitive and behavioral development, apart from the postnatal caregiving environment (30, 38). These follow-up studies, however, have not yet tracked outcomes beyond elementary school and do not account for drug effects via fetal growth restriction and low birth weight. Although the impact of in utero exposure to illicit drug use is uncertain, it is likely to be less than the postnatal risks related to maternal drug use of
neglect, abuse, and disruptions in the home environment (39). Thus, primary and secondary prevention of drug abuse is necessary irrespective of potential neonatal consequences.

**Neighborhood Contextual Influences on Health**

In contrast to individually-based risk models, examining the influence of the broader neighborhood context in which women live is appealing given the potential for population-based intervention to prevent a variety of health problems for entire groups of people. Moreover, lack of consideration for contextual factors—which are often underlying determinants of health—may undermine the effectiveness of traditional risk factor intervention strategies. While a focus on the residential environment is not new in public health (e.g. host, agent, environment), new statistical techniques that properly adjust for the clustering of observations within neighborhoods and partition variance at both individual and neighborhood levels have spawned a renewed interest in examining the influence of neighborhood factors on health (40). With this resurgence in research, there is growing recognition that the neighborhood environment has an impact on numerous health outcomes and behaviors, including chronic disease, mortality, substance use, dietary patterns, and violence, independent of individual socioeconomic status (41, 42). Neighborhood effects on maternal health and birth outcomes have also been reported (43, 44).

The mechanisms through which neighborhood characteristics influence health have been mostly proposed to operate along psychosocial and behavioral pathways (45). Influential neighborhood features have been conceptualized in terms of the social,
physical, and service environments (42). Crime, noise pollution, crowding, dilapidated or vacant homes, vandalism, loitering, and litter, are all aspects of the social and physical environment that can be sources of acute and chronic stress. Stress in turn has direct biological influences on a variety of illnesses and indirect effects through negative coping behaviors (46). In particular, the experience or threat of crime can be a significant stressor that may promote social isolation and restrict physical activity due to fear of harm. Studies have shown that perceived neighborhood disorder (e.g. vandalism, violence, drug use, litter, vacant houses) and the resulting stress may mediate the effects of neighborhood disadvantage on powerlessness (47), depression (48-52), chronic disease and poor self-rated health (53-56).

Conversely, civic participation, reciprocal exchange, social cohesion, and residential stability are positive aspects of the social environment (57). Social support and social ties are generally health-promoting and may buffer the effects of stress (58). Neighborhood social cohesion, commonly defined as the extent to which neighbors communicate and help one another, has also been related to depressive symptoms and physical functioning (49, 54, 59), and may mitigate the fear and mistrust that stem from neighborhood disorder (60). Residential stability, often measured as the proportion of residents who have lived in the neighborhood at least five years and the percent of home ownership, is also considered to be an asset in fostering community investment and supportive ties with neighbors. Residential stability has been linked to lower crime rates through greater levels of collective efficacy, a concept composed of social cohesion and social control (61), as well as reduced depressive symptoms (49) and greater physical health (62).
In addition, individual behaviors may be influenced by the health-related norms and attitudes of those around them (63). The proportion of area residents who smoke, for example, is strongly associated with the average quantity smoked, above and beyond individual socioeconomic status, which tends to support the role of normative transmission (64). Finally, neighborhood resources and service infrastructure such as the availability and quality of health services, food markets, and recreational resources for physical activity, may also impact health. For example, there are fewer supermarkets in less affluent areas and the presence of more neighborhood supermarkets is associated with greater consumption of fruits and vegetables, independent of individual income and education (65, 66).

It is important to recognize that multilevel research is not without controversy and limitations (57, 67). Chief among these are inferential problems related to selection bias and reverse causality. However, available evidence from one randomized housing experiment—Moving to Opportunity—supports a causal role in relating neighborhood poverty to mental health indicators (68). Although experimental designs offer improved inference through random assignment to neighborhood location, there are still problems stemming from differential compliance and the inability to determine the mechanisms accounting for observed effects. Intervention studies that aim to alter aspects of the neighborhood environment may provide a promising alternative to experiments and observational studies. In addition to inferential concerns, health effects may depend on the timing and duration of exposure, which have yet to be explored. There is also appropriate debate about what constitutes a neighborhood and the corresponding geographic designation of neighborhoods. These issues and limitations provide areas for
advancement, but do not preclude important efforts to examine pathways and test theories with extant data.

**Neighborhood Effects on Birth Outcomes**

Neighborhood influences have been noted for a variety of birth outcomes, including birth weight, LBW, and preterm delivery (69-82). Neighborhood socioeconomic characteristics have been shown to have both direct and interactive effects on birth outcomes. For example, indicators of the neighborhood socioeconomic context have been found to modify the effect of maternal age, such that older age carries added risk in more disadvantaged environments (73, 74). Several other studies have observed effects of neighborhood disadvantage on adverse birth outcomes among Black but not White women (71, 72, 75, 76, 78). However, a common limitation of these studies is that the observed neighborhood effects may be partly capturing unmeasured individual level characteristics, since most have not included multiple or parallel socioeconomic indicators at the individual level due to limited socioeconomic information on the US birth certificate. Nevertheless, Pearl et al (2001) utilized survey data and still observed a birth weight decrement of over 100 grams for a 10% increase in neighborhood unemployment among Black and Asian women, independent of individual income, education, timely prenatal care, parity, and smoking.

An additional limitation of neighborhood research on birth outcomes is that the mechanisms and pathways for these effects generally have not been examined. For example, the impact of the social and physical environment on birth outcomes may be mediated through psychosocial and behavioral risk factors, or may be modified by them.
Ahern et al (2003) postulated that women who smoke and reside in disadvantaged neighborhoods may experience synergistic effects on preterm delivery from the combination of stress and smoking on catecholamine levels, but did not find that smoking mediated or moderated the effect of neighborhood conditions. In addition, two studies of Chicago neighborhood clusters examined social processes as mediators of neighborhood disadvantage. Buka et al (2003) found that neighborhood social support, as assessed by a random sample of residents in each cluster, was independently related to birth weight from vital statistics data only among white infants. Maternal smoking and prenatal care were potential mediators that were controlled for as confounders. Morenoff (2003) examined violent crime rates and social exchange/voluntary participation as measures of stressors and social relations at the neighborhood level. Both factors entirely mediated the effect of structural indicators (% poverty, % residential stability) on birth weight and remained significant after controlling for individual level sociodemographic, behavioral, and biomedical factors. However, neither stress nor social support was measured at the individual level.

Illicit drug use has been examined in only two multilevel studies of birth outcomes. Controlling for substance abuse and sociodemographic factors, a study using New York City birth certificate data reported a significant main effect of community poverty on moderately LBW among Black women only (72). The effect of substance abuse, however, was not reported. In contrast, an analysis of the National Longitudinal Survey of Youth found that self-reported drug use was independently related to very PTB (<33 weeks), while census tract poverty was not related to either very or moderately preterm birth (78). Even though census tract poverty was found to predict greater drug
use, independent of individual income and education, the authors failed to quantify the extent of potential mediation on preterm birth. In both of these studies, drug use was not determined by multiple methods and individual drug effects were not assessed.

In summary, the mediating or moderating effects of psychosocial and behavioral variables, including illicit substances, generally have not been incorporated in multilevel studies of birth outcomes. Although many studies have hypothesized that the effects of neighborhood characteristics operate through heightened stress levels and reduced social support (44), none have actually tested this hypothesis with individual level measures.
Dissertation Overview

The specific aims of this dissertation are organized in stand-alone manuscript form, each including separate introduction, methods, results, and discussion sections. The following chapter describes the conceptual framework used to guide the examination of specific aims. The research design and methods for the analytic aims are then detailed in Chapter 3.

Chapter 4 contains the first specific aim—to critically review the literature regarding the neonatal consequences of prenatal drug use. There have not been any recent reviews of the neonatal impact of illicit drug exposure incorporating studies published in the last five years. The goal of this paper was to summarize the extant epidemiologic literature on the relationship between illicit drug use and newborn outcomes, placing emphasis on recent research that has employed multiple methods of drug use ascertainment and controlled for multiple confounding factors.

Chapter 5 contains an empirical examination of the effects of illicit drug use on adverse birth outcomes. Using data from a low-income, inner city Baltimore sample, the effects of drug use on birth weight were examined before and after adjustment for surrounding social, psychosocial, behavioral, and biomedical factors. Thus, the extent to which drug-related effects can be explained by associated factors was determined, thereby identifying the factors that warrant intervention to improve outcomes.

Chapter 6 contains the final specific aim—to examine the role of the neighborhood environment on birth outcomes. Potential psychosocial and behavioral pathways through which neighborhood conditions may influence birth outcomes were evaluated. Substance use, including illicit drug use, is among those behavioral factors.
Conclusions, integrating the results of all three specific aims, are provided in the final chapter. Implications for research and practice are discussed along with the strengths and limitations of findings. Suggestions for future research are also provided.
References


CHAPTER TWO

CONCEPTUAL FRAMEWORK AND SPECIFIC AIMS
Conceptual Framework

A multiple determinants, biopsychosocial framework was used to guide this dissertation (Figure 2.1). Adapted from the work of James (1993) and Misra, O'Campo, & Strobino (2001), the model places social and contextual factors as distal determinants that affect an individual’s psychosocial characteristics and, in turn, influence the proximal determinants of behavioral and biomedical risk factors that ultimately result in low birth weight. Although there may be some reciprocity or feedback between variables, the arrows represent the most probable direction of effects. Aim 2 involves an individual level model of drug use and birth outcomes focusing on the effect of drug use independent of social, psychosocial, behavioral, and biomedical factors. Aim 3 employs multilevel models incorporating neighborhood effects on birth outcomes and assesses mediational pathways.

Figure 2.1. Biopsychosocial Framework of Birth Outcomes

- **Social Factors**
  - SES
  - race/ethnicity
  - marital status

- **Neighborhood Context**
  - physical environment
  - social environment
  - access to services

- **Psychosocial Factors**
  - stress
  - depression
  - social support
  - self-efficacy
  - locus of control
  - physical violence
  - unwanted pregnancy

- **Behavior**
  - smoking, alcohol use
  - illicit drug use
  - prenatal care

- **Biomedical Factors**
  - nutritional status
  - infection
  - chronic and acute conditions

- **Birth Weight**

**Individual Level Determinants**

Prenatal drug use often accompanies other social, psychosocial, behavioral, and biomedical risk factors for adverse birth outcomes. Some biomedical factors that are
correlated with drug use and low socioeconomic status include poor nutrition, sexually transmitted infections, and chronic and acute medical conditions (1, 2).

Behavioral risk factors for poor infant health that are strongly related to illicit drug use include smoking and alcohol use, and delayed or no prenatal care utilization. Smoking has robust effects on LBW and fetal growth restriction (3). Alcohol use, particularly heavy alcohol use, is also related to fetal growth restriction (4). While the causal effects of prenatal care utilization are difficult to evaluate, comprehensive prenatal care is likely to be of greatest benefit to women with chronic health conditions and psychosocial risks (5).

Psychosocial factors have also been related to birth outcomes, both directly and through health behaviors, including licit and illicit substance use, nutritional status, and prenatal care utilization. For example, a study of the effects of physical abuse during pregnancy on birth weight reported significant mediation through smoking and low weight gain (6). Likewise, other studies have noted that maternal depression, stress, and low social support are significantly associated with smoking, alcohol use, poor weight gain, and delayed or inadequate prenatal care utilization (7, 8).

Psychosocial factors may also have direct effects on birth outcomes via neuroendocrine, immune, and vascular mechanisms that respectively influence the timing of delivery, susceptibility to infection, and hypertensive disorders (9). Both stress and social support have been connected to neuroendocrine parameters that regulate parturition and uteroplacental transfer (10). Stress, in particular, is most consistently related to LBW and preterm delivery, with between 1.5 to 2-fold increased risks observed in both prospective and retrospective studies (11-13). Chronic stress, as opposed to acute life-
event stress, is considered to be most detrimental given its cumulative toll on multiple physiologic systems, known as allostatic load (14). In contrast, social support and other psychological resources, such as mastery and internal locus of control, have been shown to have either positive main effects or stress-buffering effects on birth outcomes (15-18).

In addition, the prevalence of prenatal substance abuse has been shown in some studies to be higher among women of low socioeconomic status, who are Black, and unmarried (19). These factors are associated with a greater risk of adverse pregnancy outcomes and are thought to largely operate through social and psychosocial processes (20).

**Aim 2 (Chapter 4): To evaluate the impact of prenatal drug use on birth outcomes and the degree to which associated individual level social, psychosocial, behavioral, and biomedical factors account for the observed relation.**

To date, no studies assessing the effect of prenatal drug use on birth outcomes have controlled for the full spectrum of risk factors associated with drug use, particularly adverse psychosocial exposures such as stress, depression, and physical abuse. Determining the independent effect of drug use on birth outcomes and the characteristics that account for some or all of the association is important to identify factors that should be addressed through treatment and prevention strategies to improve outcomes both among drug users and more generally. Because some biomedical factors may be partly caused by drug use (i.e. poor nutrition, sexually transmitted infections), results from fully adjusted models were described as direct effects of drug use. And while the temporality of some social and psychosocial factors is also unknown, it is likely that they are at most
exacerbated and not fundamentally caused by drug use. Moreover, all of the surrounding social, psychosocial, behavioral, and biomedical factors that may be found to explain drug-related effects would need to be addressed directly given that they all have multiple determinants exclusive of drug use (i.e. drug use is not a necessary or sufficient cause).

Based on prior studies and biologic plausibility, specific hypotheses concern the presence and magnitude of drug-related effects on birth outcomes before and after controlling for associated risk factors. Data are too limited to generate hypotheses regarding the relative role of associated factors in accounting for drug-related effects.

Hypothesis 2a: Marijuana, cocaine, and opiate use are strongly associated with adverse birth outcomes in crude comparisons.

Hypothesis 2b: Only cocaine use has a modest effect on adverse birth outcomes, independent of associated social, psychosocial, behavioral, and biomedical factors.

A Psychosocial and Behavioral Model of Neighborhood Effects

Neighborhood disadvantage, characterized by socioeconomic and racial stratification, poor housing quality, and high rates of crime, may lead to greater psychosocial risk factors and health-compromising behaviors as coping strategies or as part of collective socialization. These psychosocial factors include greater exposure to the chronic stressors of physical and social disorder and stressful life events (21) including violent crime and victimization (22, 23), greater symptoms of distress and
depression (24, 25), and diminished social and psychological resources such as social support, self-efficacy, and internal locus of control (26-28), which may have direct physiologic consequences (10).

In a life stress paradigm, health-compromising behaviors, including drug abuse, also may be promoted as a coping strategy for individuals with these psychosocial risks (29, 30). Previous research suggests that positive social and psychological resources may have direct effects on reducing the propensity for drug use and may buffer the negative effects of stress and distress (31). Two neighborhood studies support the role of stress and distress in mediating neighborhood effects on drug use and drug-related behaviors (32, 33).

Alternatively or additionally, health behaviors may be directly influenced by shared norms or social contagion and access to goods and services at the neighborhood level (34). For example, substance use, nutritional status, and prenatal care utilization may be influenced by social norms as well as drug availability, the quality of food outlets, and access to health care services, respectively (35-37).

Aim 3 (Chapter 5): To examine the role of the neighborhood environment on birth outcomes, and whether drug use is confounded by, moderated by, or mediates neighborhood effects on birth outcomes.

An emerging body of research has linked various indicators of the neighborhood environment to both drug use and birth outcomes, independent of individual characteristics. Few multilevel studies of birth outcomes, however, have incorporated the effect of illicit drug use and none have examined potential mediation or moderation. Illicit drug use may be among the behavioral pathways through which the neighborhood
context influences birth outcomes. It is also possible that the impact of illicit drug use may be magnified in the presence of contextual stressors. Alternatively, the effect of the illicit drug use may be confounded by direct deleterious effects of neighborhood disadvantage on birth outcomes. To evaluate this range of possibilities, specific drug effects found to be significant in the second aim were re-examined after controlling for the residential context. If the effects were not confounded by a stronger direct effect of neighborhood characteristics, mediation and moderation were then explored. Based on existing theories, mediation of neighborhood effects by psychosocial, behavioral, and biological factors was evaluated.

Hypothesis 3a: Indicators of neighborhood disadvantage are related to adverse birth outcomes above and beyond individual-level sociodemographic composition.

Hypothesis 3b: The effect of neighborhood context on birth outcomes is mediated through psychosocial, behavioral, and biological pathways, including substance use.
References


CHAPTER THREE

RESEARCH DESIGN AND METHODS
Study Design and Sample

The major analytic objectives of this dissertation were to evaluate the impact of drug use and the neighborhood environment on birth outcomes. Data for these aims come from a hospital-based study designed to examine the patterns and barriers to prenatal care in a low-income urban population, and whether they may vary by maternal drug use (1). The study design is a nonconcurrent cohort in which women were identified on admission to labor and delivery and interviewed during their postpartum hospital stay. The study sample consists of low-income women, aged 19 or older, who delivered a live birth or fetal death at the Johns Hopkins Hospital (JHH) between February 16, 1995 and May 31, 1996. All drug users and all women with one or no prenatal care visits were sampled. Drug use and prenatal care were determined by labor and delivery logs, medical records, maternal toxicology reports, or during a screening interview prior to selection. Two out of three of the remaining women with no evidence of drug use during pregnancy and more than one prenatal visit were systematically sampled in temporal order.

Excluded women were identified in the labor and delivery log as those who had received care from private physicians or who were transferred to the JHH for delivery, those ages 18 and under, and those who delivered a live birth or fetal death before 20 weeks’ estimated gestation or weighing less than 500 grams. Private or transferred patients were excluded because they were few and highly different from local area clientele, consisting of professional employees at Johns Hopkins or high risk women referred for specialty care. Women ages 18 and under were excluded because many of
the instruments used in the study have unknown validity in adolescent respondents and because young teens have lower rates of substance use during pregnancy.

Eligible women were approached in the postpartum unit by trained survey staff and, once consenting to participate, were briefly screened to determine their selection probability. Those selected were then administered the approximately 1 hour postpartum interview and compensated with $15 for the time. Mothers were assured of confidentiality with a NIDA certificate of confidentiality and a guarantee that no information obtained from the interview would be provided to hospital staff or affect their care.

Figure 3.1 illustrates the sampling flow diagram. Of 1201 eligible women, 72 women refused to participate and 4 women ended interviews in progress. Interviewers missed 8 eligible women and judged 3 women incapable of completing the questionnaire. Thus, approximately 93% of eligible women consented to participate. Upon completion of the screening questionnaire, a total of 290 women with no evidence of drug use and at least one prenatal care visit were not selected for the study as per the sampling scheme. Complete data are therefore available for 824 women, including 281 women with evidence of drug use. The overall prevalence of drug use, at 25% (281/1114), is consistent with other estimates in similar urban, low-income populations. There were no differences between participants and non-participants in maternal age or infant birth weight.

Analyses were restricted to women who delivered singleton, live births (n=808). Reflective of an urban, poor population, 45% had less than a high school education, 35%
lived in public or subsidized housing, 94% were Black, and only 28% were living with
the father of the baby.

Data Sources

Data were collected from three sources: medical records, laboratory reports, and the
postpartum interview.

Medical Records: Maternal medical records were abstracted for the date and timing of
prenatal care visits, noted indications of drug use, and pregnancy and other
complications. Length of pregnancy, infant birth weight, Apgar scores, and admission of
the baby to the Neonatal Intensive Care Unit were also abstracted from maternal records.

Laboratory Reports: Universal urine toxicology screening at labor and delivery was
instituted at JHH in the early 1990s. Positive toxicological screens were defined by the
following immunoassay levels: cannabinoids (100 ng/ml), cocaine metabolite (600
ng/ml), and opiates (300 ng/ml). Laboratory results were incorporated into the medical
record within 24 hours of screening.

Postpartum Interview: A structured postpartum interview gathered data on drug use and
related behavioral, psychosocial, and sociodemographic factors. A detailed drug history
collected information on the types and frequency of drugs used by trimester and in the
months before pregnancy. Various psychosocial characteristics, including stress,
 depressive symptoms, physical abuse, social support, mastery, and locus of control, were
collected with standardized instruments.
Key Measures and Variables

Neonatal Outcome Variables

Birth weight is the primary neonatal outcome of interest, assessed as LBW (<2500 grams) and mean birth weight. Birth weight, particularly LBW and VLBW, is highly predictive of infant morbidity and mortality (2), as well as later developmental deficits (3, 4). Almost two-thirds of all infant deaths in the U.S. occur to the less than 8% of infants born LBW (2), and the immediate and ongoing care for survivors poses substantial social and economic costs. The principal goal of the analysis was to determine the impact of drug use and contextual factors on birth weight, an accurately measured and predictive composite newborn outcome, rather than to examine mechanisms through fetal growth and/or gestational duration. Moreover, gestational age estimation is complicated among women with no prenatal care, who are overrepresented in the sample. A total of 137 (17%) women delivered a LBW infant. The number of VLBW infants (35) was not sufficient for analysis.

Drug Use Variables

Prenatal drug use was determined by positive evidence on any of three measures: reports in the medical record, urine toxicological screens at delivery, or self-report (screener questionnaire or postpartum interview). Urine toxicological screens at delivery were not performed on 91 women (11%) as a result of clinic staff oversight. However, urine screens were not a critical source of detection in this sample. The proportion of women with a positive urine screen at delivery who were also identified by any other
source was 100% (21/21) for marijuana, 95% (112/118) for cocaine, and 94% (83/88) for opiates.

Of the 281 women identified as drug users, 123 (44%) used marijuana, 191 (68%) used cocaine, 153 (54%) used opiates, and 54 (19%) used other substances. In terms of the number of drugs used, 123 (44%) used one, 96 (34%) used two, and 62 (22%) used three or more drugs. Among the 1114 women who consented to participate, the estimated prevalence of drug use was 25% overall. Cocaine was the most commonly used drug (17%) followed by opiates (14%) and marijuana (11%).

Table 3.1 describes the sensitivity of the medical record, urine toxicological screen at labor and delivery, and self-report (screener or interview). Report in the medical record includes self-report to medical professionals and possible prenatal toxicological screens obtained at prenatal visits. Overall, the medical record was the most sensitive method of detection (92%) followed by post-partum self-report (82%). The urine screen at admission to labor and delivery was the least sensitive method of detection. Except for marijuana, where post-partum self-report was the most sensitive source of information, the sensitivity ranking of methods was consistent according to the type of drug used. The lower medical record sensitivity for marijuana use may be because clinicians are more inclined to ask about the harder drugs than marijuana and/or because prenatal urine screens are less likely to capture the occasional use common to marijuana. The relatively high sensitivity of the medical record and self-report suggests that women are generally forthcoming about their use. The lower sensitivity of the L&D toxicological screen is consistent with other research and understandable given the narrow exposure window that drug metabolites remain in urine. A recent study of
cocaine use, albeit of a small sample (n=51), similarly reported that detailed maternal interviews identified more users than urine screens (75% v. 63% sensitivity) (5).

Combinations of Drug Use

Table 3.2 describes the bivariate co-occurrence of other substance use according to the type of drug used. Almost three-fourths of all drug users smoked cigarettes during pregnancy and over a third drank alcohol. The prevalence of smoking was highest among cocaine and opiate users while the prevalence of drinking was highest among marijuana and cocaine users. Among cocaine users, 62% also used opiates. Among opiate users, 77% also used cocaine.

Table 3.3 presents the number of drugs used according to the type of drug used. Marijuana users were most likely to use only 1 drug, followed by cocaine, opiates, and other drugs. This table importantly shows that there were indeed women who used only marijuana, cocaine, or opiates, making it possible to examine independent drug effects. Cocaine and opiate users were most likely to use 2 drugs and those who used other substances were most likely to use 3 or more drugs. Table 3.4 alternatively shows the type of drugs used according to the number of drugs used. Of women using only 1 drug, most were using marijuana or cocaine. Polydrug users, especially those using 3 or more drugs, often used cocaine and opiates.

Table 3.5 shows the prevalence of all possible combinations of drug use. The most common combination was the use of cocaine and opiates (18%), followed closely by exclusive use of marijuana (17%) and opiates (17%). Combining all possible permutations including cocaine and opiates revealed that 39% of all drug users used both
cocaine and opiates. Among women who used 2 substances, 54% used cocaine and opiates, and 22% used marijuana and cocaine. Among women who used 3 substances, 61% used marijuana, cocaine, and opiates, and 33% used cocaine, opiates, and other drugs.

Patterns and Frequency of Drug Use

Data on the timing and frequency of drug use during pregnancy were available for the 82% of identified drug users who reported drug use in the postpartum interview (see Table 3.1 for the proportion by each type of drug use). Figure 3.2 illustrates the self-reported percentage of drug use, including tobacco and alcohol, before and during pregnancy. Comparing the three months prior to pregnancy to the trimesters of pregnancy, there was very little change in the prevalence of smoking, cocaine, and heroin use. Only alcohol and marijuana use appeared to have substantial declines with the onset of pregnancy.

Table 3.6 provides intra-individual cumulative and trimester-specific cessation estimates among women who reported using drugs within the previous year. Alcohol (47%) and marijuana (37%) had the highest cessation rates prior to pregnancy (i.e. women who reported use in the past year but did not report use in the first trimester), followed by cocaine (18%), tobacco (12%), and opiates (10%). Cessation during pregnancy was limited for these latter substances such that the cumulative cessation rates prior to the 3rd trimester were not substantially greater than the cessation rate prior to pregnancy. The cumulative cessation rates for alcohol and marijuana increased to 66% and 55%, respectively in the 3rd trimester. The alcohol cessation rates are consistent with
findings from a nationally representative survey which estimated cessation rates by comparing point prevalence estimates between non-pregnant and pregnant respondents (6). However, the cessation rates prior to the first and third trimesters were substantially higher for illicit drug use (28% and 93%) and smoking (28% and 47%) in the national survey. These differences may be attributed to differences in the study samples and also to differences in study design. The general finding that declines in drug use before and during pregnancy are less pronounced for more addictive substances (i.e. cocaine, tobacco) is consistent with data from the National Pregnancy and Health Survey—a 1992 NIDA hospital-based study that interviewed women following delivery (7).

Table 3.7 describes the frequency of self-reported drug use according to trimester. The majority of women who used marijuana during pregnancy used it monthly rather than weekly or daily. In contrast, the majority of women who used cocaine and heroin used them weekly or daily. Across the trimesters, the proportion of women who used illicit substances daily did not change greatly. Small changes among less frequent use categories were noted. For the licit substances of tobacco and alcohol, most users did not report very frequent use. The proportion of smoking declined most for 10 or more cigarettes per day, whereas the proportion of alcohol use declined substantially both for the lighter and heavier use categories.

As a check on the validity of self-reported frequency data, third trimester self-reported frequency was compared between drug-using women with and without a positive urine screen at labor and delivery (Table 3.8). Women with a positive screen, especially for cocaine or opiates, were more likely to report heavier use. However, the majority of women with positive screens did not report heavy use which raises concern
regarding the credibility of self-reported frequency. In addition, approximately 40% of women without a positive tox screen reported some level of use which points to the lack of sensitivity of urine screens given that women are unlikely to overstate their use.

Other Independent Variables

Social Factors

Social variables included maternal age (19-24, 25-34, 35+), race (Black, White/Other), education (<high school/GED, high school/GED, >high school/GED), contact with the father of the baby (lives with the father, contact with the father, no relationship), housing (subsidized/public, owns/rents), and places lived during pregnancy (1, 2+). Other variables used to differentiate this low-income sample were the receipt of public assistance (Welfare, Supplemental Security Income, Medicaid), employment, and the amount of monthly rent. In addition, the Family Resources Scale (FRS) provided assessment of the adequacy of material resources (8). The FRS is a psychometrically validated instrument composed of 30 items that measure the adequacy of resources for basic necessities and non-essential activities on a 5 point scale ranging from almost always to almost never. Through confirmatory factor analysis, three subscales have been identified in the sample reflecting money for essential resources (e.g. food, housing, heating), money for non-essential resources (e.g. personal items, vacations, family activities, savings), and time for self, family, and friends (1). All three subscales have Cronbach alpha coefficients of 0.80 or higher. The items in each subscale were summed and rescaled to reflect an average response.
Psychosocial Factors

Stress was measured with a validated 12 item scale adapted for use during pregnancy from the Hassles Scale (9). It measures the degree of stress experienced during pregnancy due to daily difficulties and circumstances (e.g. family problems, money worries, loss of a loved one, neighborhood crime) on a 4 point scale from no stress to severe stress. In this sample, the Cronbach alpha coefficient is 0.80. Categories for stress were constructed by calculating the average item response (none, some, moderate, severe). The scale carries strength as a measure of chronic stress, which is considered to be more consequential for health than temporary, acute stress (10).

Social support was examined both structurally (who gives the support) and functionally (the types of support she receives). Family support was measured with a 3-item scale assessing the support of family members in solving problems and looking out for one another (sample Cronbach $\alpha = 0.80$). Three other variables were examined as measures of functional support, defined as the number of household or social network members with whom she sometimes or often socialized, discussed problems, and got help from with housework, shopping, or child care if needed during pregnancy (0, 1, 2+). These three measures correspond to social, emotional, and instrumental support, respectively.

Depressive symptoms were measured by the widely-used CES-D instrument (11). This 20-item scale measures the weekly frequency of depressive symptoms on a four point scale. The Cronbach alpha coefficient in this sample was 0.89. Scores of 16 or higher, the common cutoff, defined significant depressive symptoms.
Mastery/Self-efficacy was measured with the Mastery Scale (12), a 7-item measure that assessed agreement with statements related to global perceptions of personal efficacy on a four-point scale ranging from “strongly disagree” to “strongly agree.” The alpha coefficient in this sample was 0.88. Categories were determined by the average item response.

Pregnancy locus-of-control was measured by a modified Pregnancy Belief Scale (13) and refers to the extent to which a woman believes that her pregnancy outcome is under internal control versus powerful others or fate. There are three subscales in the measure: internality, chance, and powerful others. Because the internal consistency of the modified scale in this sample was below an acceptable cutoff, two items with low item-to-total correlations were removed. The resulting measure had a Cronbach alpha coefficient of 0.72 and captures the dimensions of internality and chance (1). Categories were constructed to reflect the average item response on a four-point scale ranging from “strongly disagree” to “strongly agree.”

Physical violence was measured by the shortened version of the violence subscale in the Conflicts Tactic Scale (CTS) (14). The CTS is a standard measure of physical violence and was administered twice during the interview, once regarding violent acts by household members and again for anyone outside the household. Experience of any physical abuse during pregnancy was defined as a dichotomous variable (yes/no).

History of sexual abuse was defined as a positive report of any unwanted sexual experiences before age 18.

Appendix A contains the instruments for all scalar social and psychosocial variables.
Behavioral Factors

Health behaviors include smoking, alcohol consumption, early prenatal care, and unwanted pregnancy. Smoking and heavy alcohol use are well established risk factors for adverse pregnancy outcomes and frequently co-occur with illicit drug use (15, 16). To reduce the probability of residual confounding by smoking or alcohol consumption, these variables were defined ordinally by the average reported use during pregnancy. Smoking was categorized by the average number of cigarettes smoked per day (0, 1-9, 10+). Alcohol consumption was categorized by the average frequency of drinking alcoholic beverages during pregnancy (Never, 1 to 4 days a month, 1 to 2 days a week or more). Early prenatal care was defined as a first visit within the first trimester with four or more total visits. Unwanted pregnancy was measured by the woman’s report of not wanting to become pregnant when she did.

Biomedical Risk Factors

Abstracted medical record variables included conditions related to LBW such as hypertensive disorders (chronic hypertension, pregnancy-induced hypertension, preeclampsia, or eclampsia), sexually transmitted infections (gonorrhea, chlamydia, or syphilis), and bleeding disorders (abruptio placenta, placenta previa, or vaginal bleeding). Nutritional status was evaluated by prepregnancy body mass index and net weight gain during pregnancy, subtracting infant birth weight. Parity (0, 1, 2-3, 4+) was also examined.
Neighborhoods

The third aim of this dissertation examines neighborhood influences on birth outcomes. Census tracts were used to define the local neighborhood environment. Census tracts are administrative units containing an average of 4,000 people and were originally created on the basis of homogenous residential characteristics (17). Research from the Public Health Disparities Geocoding Project has established the predictive utility of census tract socioeconomic characteristics for a variety of health outcomes including low birth weight (18).

Of the 808 women in the analytic sample, 10% could not be geocoded to Baltimore city census tracts either because they lived outside of the city (n=33) or their addresses were unable to be matched (n=48). There were 126 of the 201 total Baltimore city census tracts represented in the sample with an average of 5.8 women per tract (range: 1-40). Women who were excluded from multilevel analysis were more likely to be white or other race, live with the father of the baby, and have more than a high school education (Table 3.9). Excluded women were also less likely to use cocaine or opiates but there were no differences according to other substance use, prenatal care utilization, or birth weight.

Census tract imputation for the 48 women with missing tracts was not performed out of concern for misclassification with only a small gain in statistical power. Techniques are being developed to more informatively impute tracts within a known zipcode (personal communication, Frank Curriero 2006); however zipcode data were not available as address files were destroyed after the initial geocoding. Regardless of
imputation, there is still an assumption of random missingness. If data are not missing at random, neither imputation nor exclusion will produce valid inference.

Neighborhood sociodemographic and housing data were obtained from the 1990 Census. Census tract violent crime counts for 1995 were furnished by the Baltimore City Police Department and divided by 1990 census population counts to produce neighborhood violent crime rates. Figure 3.3 displays the geographic distribution of the sample overlayed on census tract poverty rates. There is readily apparent variability in neighborhood poverty rates represented in the sample.

**Analytic Decisions and Methods**

Aim 2 (Chapter 5)

The objective of this chapter was to determine the impact of prenatal drug use on birth outcomes and the extent to which associated social, psychosocial, and biomedical factors account for the observed relation. Given that the number of drugs used was highly related to the combination of drugs used, only individual drug categories (marijuana, cocaine, opiates, other drugs) were examined in analyses to assess specific drug-related effects. Dose and timing effects based on self-reported data were also explored.

Regression models of LBW and continuous birth weight were constructed with sequential entry of social, psychosocial, behavioral, and biomedical factors. To preserve model parsimony, only variables independently related to the outcome (p<0.10) and those whose adjustment altered drug related effects by 10% or more were included (19). The extent to which associated factors explained drug-related effects was evaluated by
changes in statistical significance and the percentage reduction in the coefficients related to drug use. The distinction between mediation and confounding in regression based adjustment is made strictly on the basis of causal knowledge and temporal sequencing. Given that some of the biomedical factors may have resulted from drug use, care was taken in describing fully-adjusted coefficients as direct drug effects.

Aim 3 (Chapter 6)

The objective of this chapter was to examine the role of neighborhood context in influencing drug-related effects on birth outcomes, either as a confounder, modifier, or upstream determinant that shapes the likelihood of drug use. To determine whether the neighborhood environment might confound individual level drug use, the final birth weight model of chapter 5 was rerun with fixed census tract level effects (i.e. dummy variables) that control for both observed and unobserved neighborhood differences (Equation 1). Women who lived outside of the city and those whose addresses could not be geocoded were given separate indicator tracts that were also controlled as fixed effects. This approach reduces model degrees of freedom by the number of estimated tract level effects (N-1=125). As an alternative to the fixed effect approach, a within-neighborhood random intercept model also was performed wherein drug-related effects are centered about the neighborhood mean (Equation 2). The parameter in this model represents the average within-neighborhood effect of drug use. Both approaches, therefore, completely control for neighborhood differences (20).

Let i=individual, j=neighborhood

\[ Y_{ij} = \beta_0 + \delta_j + \beta X_{ij} + \varepsilon_{ij} \]
\[ \varepsilon_{ij} \sim N (0, \sigma^2) \]
Eq 2. \[ Y_{ij} = \beta_0 + \beta (X_{ij} - \bar{X}_j) + \mu_{0j} + \epsilon_{ij}\quad \mu_{0j} \sim N (0, \tau_{00})\quad \epsilon_{ij} \sim N (0, \sigma^2) \]

The drug related coefficients from these two models controlling for neighborhood factors were not significantly different from the individual level model coefficients (see Appendix B). Based on these results indicating no direct confounding by neighborhood level effects, chapter 6 focuses on the mediation and/or moderation of neighborhood effects on birth outcomes by psychosocial and behavioral factors. Drug use is one of the behavioral pathways through which neighborhoods may influence birth outcomes. Multilevel models with neighborhood-level random intercepts were performed to properly adjust the standard errors for non-independence of observations within neighborhoods and to estimate the variance components at both neighborhood and individual levels (Equation 3) (21). Chapter 6 contains greater detail about the specific neighborhood characteristics examined.

Let X=individual level variables, Z=neighborhood level variables

Eq 3. \[ Y_{ij} = \beta_0 + \beta X_{ij} + \beta Z_j + \mu_{0j} + \epsilon_{ij}\quad \mu_{0j} \sim N (0, \tau_{00})\quad \epsilon_{ij} \sim N (0, \sigma^2) \]

To investigate potential selection bias in the reduced neighborhood-level sample, individual level (Aim 2) model coefficients were compared between the full and reduced samples. Differences were observed for the coefficients related to cocaine and opiate use. Specifically, women excluded from the neighborhood analysis had significantly stronger cocaine related effects on birth weight and significantly weaker opiate related effects. Thus, in the reduced neighborhood sample compared to the full sample, the effect of opiate use was stronger than the effect of cocaine use. The frequency of self-reported use among excluded women was lower for both cocaine and heroin so differential usage patterns did not appear to explain the difference in noted effects. To
compensate for these altered effects, a single indicator variable of hard drug use capturing use of either cocaine or opiates was used in the neighborhood level analysis. The effect of hard drug use on birth weight did not vary between the full and neighborhood level samples.
References


Figure 3.1.

Study Flowchart

1201 Eligible Women
Exclusion Criteria
- private or transferred patient
- age 18 or under
- GA <20 wks or BW <500 g

93% Consented to Participate (n=1129)
Sampling Scheme
- All women with evidence of drug use or 1 or fewer prenatal visits
- 2 of 3 women with no drug use and 1 or more prenatal visits

824 Completed Interviews
Analytic Exclusion Criteria
- multiple birth (12)
- fetal death (4)

808 Available for Analysis
<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Medical Record</th>
<th>Tox Screen at L&amp;D&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Self-report</th>
<th>All Sources Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Drug Use</td>
<td>258 (91.8%)</td>
<td>172 (69.0%)</td>
<td>230 (81.9%)</td>
<td>281 (100%)</td>
</tr>
<tr>
<td>Type of Drug Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marijuana</td>
<td>78 (63.4%)</td>
<td>21 (19.2%)</td>
<td>97 (78.9%)</td>
<td>123 (100%)</td>
</tr>
<tr>
<td>Cocaine</td>
<td>174 (91.1%)</td>
<td>118 (69.6%)</td>
<td>143 (74.9%)</td>
<td>191 (100%)</td>
</tr>
<tr>
<td>Opiates</td>
<td>135 (88.2%)</td>
<td>88 (64.8%)</td>
<td>119 (77.8%)</td>
<td>153 (100%)</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>34 (64.2%)</td>
<td>7 (14.9%)</td>
<td>21 (39.6%)</td>
<td>53 (100%)</td>
</tr>
</tbody>
</table>

<sup>1</sup>Urine toxicological screens at labor and delivery were not performed on 91 women as a result of clinic staff oversight. The sensitivity estimate assumes that an equal proportion of drug use would have been detected in these 91 women as was detected among the 717 women actually screened.
Table 3.2. Prevalence of Other Substance Use By Type of Illicit Drug Use

<table>
<thead>
<tr>
<th>Type of Drug Use</th>
<th>Total</th>
<th>Marijuana</th>
<th>Cocaine</th>
<th>Opiates</th>
<th>Other</th>
<th>Cigarettes</th>
<th>Alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Drug</td>
<td>281(35)</td>
<td>43.8</td>
<td>68.0</td>
<td>54.5</td>
<td>18.9</td>
<td>73.7</td>
<td>36.3</td>
</tr>
<tr>
<td>Marijuana</td>
<td>123(15)</td>
<td>--</td>
<td>54.5</td>
<td>42.3</td>
<td>17.9</td>
<td>76.4</td>
<td>39.8</td>
</tr>
<tr>
<td>Cocaine</td>
<td>191(24)</td>
<td>35.1</td>
<td>--</td>
<td>61.8</td>
<td>19.4</td>
<td>79.6</td>
<td>41.9</td>
</tr>
<tr>
<td>Opiates</td>
<td>153(19)</td>
<td>34.0</td>
<td>77.1</td>
<td>--</td>
<td>28.1</td>
<td>81.1</td>
<td>36.0</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>53(7)</td>
<td>41.5</td>
<td>69.8</td>
<td>81.1</td>
<td>--</td>
<td>73.6</td>
<td>28.3</td>
</tr>
</tbody>
</table>
Table 3.3. Number of Drugs Used According to Type of Drug Use

<table>
<thead>
<tr>
<th>Type of Drug Use</th>
<th>Total N(%)</th>
<th># Drugs Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
<td>281(35)</td>
<td>43.8 34.2 22.1</td>
</tr>
<tr>
<td>Marijuana</td>
<td>123(15)</td>
<td>39.8 21.1 39.0</td>
</tr>
<tr>
<td>Cocaine</td>
<td>191(24)</td>
<td>25.1 43.5 31.4</td>
</tr>
<tr>
<td>Opiates</td>
<td>153(19)</td>
<td>13.1 47.1 39.9</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>53(7)</td>
<td>11.3 20.8 67.9</td>
</tr>
</tbody>
</table>
Table 3.4. Type of Drug Use According to the Number of Drugs Used

<table>
<thead>
<tr>
<th># Drugs Used</th>
<th>N (%)</th>
<th>Marijuana</th>
<th>Cocaine</th>
<th>Opiates</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>123(44)</td>
<td>39.8</td>
<td>39.0</td>
<td>16.3</td>
<td>4.9</td>
</tr>
<tr>
<td>2</td>
<td>96(34)</td>
<td>27.1</td>
<td>86.5</td>
<td>75.0</td>
<td>11.5</td>
</tr>
<tr>
<td>3+</td>
<td>62(22)</td>
<td>77.4</td>
<td>96.8</td>
<td>98.4</td>
<td>58.1</td>
</tr>
</tbody>
</table>
Table 3.5. Combinations of Drug Use

<table>
<thead>
<tr>
<th># drugs</th>
<th>Marijuana</th>
<th>Cocaine</th>
<th>Opiates</th>
<th>Other</th>
<th>N</th>
<th>% according to # of drugs used</th>
<th>% of Total Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>49</td>
<td>39.8%</td>
<td>17.4%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>48</td>
<td>39.0%</td>
<td>17.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>20</td>
<td>16.3%</td>
<td>7.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>4.9%</td>
<td>2.1%</td>
</tr>
<tr>
<td>2</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>21</td>
<td>21.9%</td>
<td>7.5%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>8</td>
<td>8.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>5.2%</td>
<td>1.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>51</td>
<td>53.1%</td>
<td>18.1%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>3</td>
<td>3.1%</td>
<td>1.1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>8.3%</td>
<td>2.8%</td>
</tr>
<tr>
<td>3</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>26</td>
<td>60.5%</td>
<td>9.3%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>1</td>
<td>2.3%</td>
<td>0.4%</td>
</tr>
<tr>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>2</td>
<td>4.7%</td>
<td>0.7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>14</td>
<td>32.6%</td>
<td>5.0%</td>
</tr>
<tr>
<td>4</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>19</td>
<td>100.0%</td>
<td>6.8%</td>
</tr>
</tbody>
</table>
Figure 3.2. Self-Reported Drug Use Before and During Pregnancy

- Marijuana
- Cocaine
- Heroin
- Tobacco
- Alcohol

Past 5 Years, Past 1 Year, 3 mos. Before Pregnancy, 1st Trimester, 2nd Trimester, 3rd Trimester
Table 3.6. Self-Reported Trimester Cessation and Cumulative Cessation Rates Among Past Year Users (%)

<table>
<thead>
<tr>
<th>Type of Drug</th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Cessation</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Cessation</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; Cessation</th>
<th>Trimester Cumulative Cessation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cessation</td>
<td>37.2</td>
<td>29.6</td>
<td>16.1</td>
<td>51.9</td>
</tr>
<tr>
<td>Cumulative Cessation</td>
<td>--</td>
<td>51.9</td>
<td>55.0</td>
<td></td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cessation</td>
<td>17.9</td>
<td>9.7</td>
<td>12.1</td>
<td>17.9</td>
</tr>
<tr>
<td>Cumulative Cessation</td>
<td>--</td>
<td>17.9</td>
<td>21.9</td>
<td></td>
</tr>
<tr>
<td>Opiates</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cessation</td>
<td>9.7</td>
<td>10.7</td>
<td>6.7</td>
<td>16.7</td>
</tr>
<tr>
<td>Cumulative Cessation</td>
<td>--</td>
<td>16.1</td>
<td>16.9</td>
<td></td>
</tr>
<tr>
<td>Tobacco</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cessation</td>
<td>11.5</td>
<td>10.5</td>
<td>7.1</td>
<td>16.8</td>
</tr>
<tr>
<td>Cumulative Cessation</td>
<td>--</td>
<td>16.8</td>
<td>20.5</td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cessation</td>
<td>46.5</td>
<td>37.7</td>
<td>27.9</td>
<td>59.3</td>
</tr>
<tr>
<td>Cumulative Cessation</td>
<td>--</td>
<td>59.3</td>
<td>66.3</td>
<td></td>
</tr>
</tbody>
</table>
Table 3.7. Frequency of Self-Reported Drug Use According to Pregnancy Trimester (%)

<table>
<thead>
<tr>
<th>Type of Drug</th>
<th>1&lt;sup&gt;st&lt;/sup&gt;</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt;</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>6.1</td>
<td>4.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Weekly</td>
<td>2.9</td>
<td>2.1</td>
<td>1.9</td>
</tr>
<tr>
<td>Daily</td>
<td>1.1</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>5.7</td>
<td>5.3</td>
<td>5.9</td>
</tr>
<tr>
<td>Weekly</td>
<td>6.6</td>
<td>7.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Daily</td>
<td>3.1</td>
<td>2.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Opiates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td>3.0</td>
<td>2.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Weekly</td>
<td>3.7</td>
<td>3.8</td>
<td>2.6</td>
</tr>
<tr>
<td>Daily</td>
<td>7.2</td>
<td>6.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Cigarettes (per day)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-9</td>
<td>16.5</td>
<td>17.6</td>
<td>16.7</td>
</tr>
<tr>
<td>10-15</td>
<td>10.8</td>
<td>9.7</td>
<td>8.5</td>
</tr>
<tr>
<td>16+</td>
<td>8.0</td>
<td>5.9</td>
<td>6.4</td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4 days/mo</td>
<td>11.3</td>
<td>9.2</td>
<td>7.9</td>
</tr>
<tr>
<td>1-2 days/wk+</td>
<td>6.8</td>
<td>4.6</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Table 3.8. Frequency of Self-reported Drug Use in 3rd Trimester According to Tox Screen at Labor & Delivery

<table>
<thead>
<tr>
<th>Frequency of Use</th>
<th>Marijuana</th>
<th>Cocaine</th>
<th>Opiates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>- Tox</td>
<td>+ Tox</td>
<td>- Tox</td>
</tr>
<tr>
<td>None Reported</td>
<td>(n=91)</td>
<td>(n=21)</td>
<td>(n=55)</td>
</tr>
<tr>
<td>Monthly</td>
<td>56.0</td>
<td>33.3</td>
<td>58.2</td>
</tr>
<tr>
<td>Weekly</td>
<td>27.5</td>
<td>42.8</td>
<td>18.2</td>
</tr>
<tr>
<td>Daily</td>
<td>11.0</td>
<td>14.3</td>
<td>20.0</td>
</tr>
</tbody>
</table>

p<0.1, ^p<0.001
Table 3.9. Characteristics According to Neighborhood Sample Inclusion

<table>
<thead>
<tr>
<th>Sociodemographic Characteristics</th>
<th>Included N=726</th>
<th>Excluded N=82</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>51.9</td>
<td>54.9</td>
</tr>
<tr>
<td>25-34</td>
<td>39.7</td>
<td>36.6</td>
</tr>
<tr>
<td>35+</td>
<td>8.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>95.5</td>
<td>76.8†</td>
</tr>
<tr>
<td>Relationship with Baby’s Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives with him</td>
<td>26.5</td>
<td>43.9†</td>
</tr>
<tr>
<td>Contact with him</td>
<td>60.5</td>
<td>42.7</td>
</tr>
<tr>
<td>No relationship</td>
<td>13.1</td>
<td>13.4</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; High School</td>
<td>46.8</td>
<td>25.6‡</td>
</tr>
<tr>
<td>High School or GED</td>
<td>42.4</td>
<td>47.6</td>
</tr>
<tr>
<td>&gt; High School</td>
<td>10.7</td>
<td>26.8</td>
</tr>
<tr>
<td>Employed during Pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enough Money for Necessities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; Half the time</td>
<td>7.4</td>
<td>4.9</td>
</tr>
<tr>
<td>Half the time</td>
<td>13.4</td>
<td>9.8</td>
</tr>
<tr>
<td>&gt; Half the time</td>
<td>55.1</td>
<td>68.3</td>
</tr>
<tr>
<td>Not Answered</td>
<td>24.1</td>
<td>17.1</td>
</tr>
<tr>
<td>Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own</td>
<td>17.8</td>
<td>20.7</td>
</tr>
<tr>
<td>Rent</td>
<td>47.8</td>
<td>53.7</td>
</tr>
<tr>
<td>Subsidized</td>
<td>15.0</td>
<td>12.2</td>
</tr>
<tr>
<td>Public Housing</td>
<td>19.4</td>
<td>13.4</td>
</tr>
<tr>
<td>Places lived during Pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drug Use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td>18.3</td>
<td>15.9</td>
</tr>
<tr>
<td>Tobacco</td>
<td>34.0</td>
<td>25.6</td>
</tr>
<tr>
<td>Marijuana</td>
<td>15.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Cocaine</td>
<td>24.7</td>
<td>14.6*</td>
</tr>
<tr>
<td>Opiates</td>
<td>20.3</td>
<td>7.3†</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>7.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Early Prenatal Care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birth Outcomes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Birth Weight</td>
<td>17.2</td>
<td>14.6</td>
</tr>
<tr>
<td>Birth Weight</td>
<td>3024</td>
<td>3020</td>
</tr>
</tbody>
</table>

*p<0.05, †p<0.01, ‡p<0.001
Spatial Distribution of Sample
According to Census Tract Poverty Rates, Baltimore City
CHAPTER FOUR

ILLICIT DRUG USE AND NEONATAL OUTCOMES: A CRITICAL REVIEW
Abstract

Although the neonatal consequences of tobacco and alcohol exposure are well established, the evidence related to prenatal illicit drug use is less consistent despite prevalent views to the contrary. The many social, psychosocial, behavioral, and biomedical risk factors for adverse birth outcomes associated with illicit drug use complicate evaluation of neonatal effects. Placing emphasis on recent research, this review summarizes the epidemiologic literature on the neonatal impact of marijuana, opiate, and cocaine use. Of these drugs, cocaine use is most consistently associated with fetal growth parameters and dose-response effects have been noted. However, studies to date have largely failed to control for surrounding social and psychosocial factors. Additional recommendations for future research are presented.
Introduction

Recent national estimates obtained from the 2002-2003 National Survey on Drug Use and Health indicate that 4.3% of pregnant women aged 15-44 reported illicit drug use within the past month (1). Although this is a conservative self-report estimate that reflects point prevalence rather than period prevalence of use at any time during pregnancy, it suggests that nearly 200,000 infants born each year have been exposed to illicit substances prenatally. And studies of high-risk, urban populations, relying on single or multiple detection methods, report much higher prevalence estimates of illicit substance use ranging from 15-30% (2-6). The purpose of this article is to review the evidence from epidemiologic studies of the effect of illicit drug use on newborn outcomes. While the effects of tobacco and alcohol on fetal growth restriction and fetal alcohol syndrome are well established, the impact of illicit drugs is less certain despite prevalent perceptions of devastating consequences (7, 8).

A major difficulty in evaluating the effect of illicit drugs is the range of sociodemographic, psychosocial, behavioral and biological risk factors associated with both illicit drug use and adverse pregnancy outcomes. Such concomitant risks include poverty, lack of prenatal care, unwanted pregnancy, sexually transmitted infections, poor nutrition, physical abuse, stress, depression, and lack of social support (2, 9, 10). Moreover, pregnant drug users often use multiple substances, including tobacco, alcohol, and other illicit drugs (2, 4, 6).

Given the numerous lifestyle factors and social circumstances associated with both drug use and pregnancy outcomes, it is challenging to determine the extent to which adverse newborn outcomes are due to direct effects of the drug versus the surrounding
social milieu. Early studies did not control for basic confounding by tobacco use or relied exclusively on single methods of ascertainment (11). The use of multiple sources of drug use detection has been shown to improve identification and decreases the likelihood of misclassification (3, 12, 13). However, self-reported data are still the only cost-effective way to assess dose and timing effects throughout pregnancy in a population-based sample interviewed at delivery (14), while positive urine screens may provide a proxy for more intense use (13, 15). In addition, many studies have not adequately disentangled the effects of single drugs from overlapping polydrug use. Determining the direct versus confounded or indirect effects of drug use is important to identify the factors that should be addressed in treatment and prevention strategies to improve birth outcomes both among drug users and more generally.

This review of the neonatal consequences of marijuana, opiate, and cocaine exposure provides an update to prior reviews (7, 8) by incorporating more recent studies published within the last five years and also in providing directions for future research. Included studies were published in the English language and identified from PubMed searches using keywords and Mesh terms related to illicit drug use and infant/newborn health or pregnancy complications. The reference lists of resulting studies were also examined to identify additional literature. Evidence is reviewed with attention to study design, method of drug use assessment, and dose or timing effects. Preference was given to studies that employed multiple methods of detection and controlled for other drug use and at least one social or psychosocial factor. This review focuses on newborn outcomes related to fetal growth and gestational age at delivery (i.e. birth weight, low birth weight (LBW), gestational age, preterm birth (PTB), small-for-gestational age (SGA) or intra-
uterine growth restriction (IUGR), and anthropometric measurements), that are predictive of morbidity, mortality, cognitive delay, and adult-onset diseases (16-20). Other potential neurobehavioral and developmental effects stemming from direct drug effects on neurotransmitters and the central nervous system are also summarized.

Marijuana

Studies that have examined the impact of prenatal marijuana use on birth outcomes have generally reported small and inconsistent effects. For example, a large, multicenter, prospective study found that most of a crude association between marijuana use, as assessed by self-report or serum assay at 23-26 weeks, and LBW was confounded by cigarette smoking (21). Among other prospective and retrospective studies that have employed multiple methods of ascertainment (13, 21-24), only one reported a significant effect on birth outcomes. In a prospective study with exposure categorized as either a positive urine assay (with or without self-report) or self-report only, Zuckerman et al (1989), reported a 79 gram decrement in gestational age-adjusted birth weight and a 0.52 cm decrement in birth length only among those with a positive urine assay. This study controlled for other drug use, pre-pregnancy weight, weight gain during pregnancy, and prenatal care. Most recently, however, the retrospective multi-site Infant Development, Environment, and Lifestyle (IDEAL) study found that marijuana use (self-report or positive meconium assay) was unrelated to the examined fetal growth parameters of gestational age-adjusted birth weight and SGA (24).

Many other studies have attempted to assess dose and/or timing effects of marijuana exposure based upon self-reported use (21, 22, 25-32). Of these, two reported significant findings. Day et al (1991) reported a significant negative association between
first trimester use on birth length (26). The other study reported an association between first trimester use and LBW and gestational age only among women with no prenatal care (29).

In addition to null or negative effects, several studies have reported unexpected, positive effects of marijuana on gestational age-adjusted birth weight. A retrospective hospital-based study in Washington, DC found that reported use of any marijuana during pregnancy was associated with a significant 139 gram increase in birth weight (33). In a prospective study of self-reported dose effects, Day et al (1991) observed a 142 gram increase for heavy marijuana use (≥1 joint/day) in the third trimester. Another prospective study of over 12,000 women in Great Britain found that occasional use as reported at 18-20 weeks gestation was associated with a significant increase in gestational age-adjusted birth weight (59 grams) (31). Although marijuana can be an appetite stimulant, maternal weight gain was controlled in the former two studies.

Additional null findings were reported from the retrospective, multisite Maternal Lifestyle Study (MLS). Reported marijuana use was not significantly related to LBW, PTB, or IUGR (34). There also was no observed effect on gestational age-adjusted birth weight, birth length, or head circumference, with marijuana use measured either in total (35) or in dose-related categories (25).

A 1997 meta-analysis of 10 studies concluded that there was inadequate evidence that marijuana reduces birth weight at the amount typically consumed by pregnant women (36). Frequent use (>4 times/week), however, was associated with a 131 gram decrease in birth weight (95% CI: 52-209g). Yet neither of the two studies on which this estimate was based had adjusted for any other illicit drug use, social, or psychosocial
factors. The mechanism by which marijuana may affect neonatal outcomes is largely unknown; however, an effect on growth via reduced fetal oxygenation has been proposed (7). While the bulk of research evidence suggests little to no effect of marijuana use on birth outcomes, the literature would benefit from more studies that employ multiple detection methods, enroll women at delivery to ensure a fully representative sample of drug users, and control for multiple social and psychosocial risk factors in addition to other illicit drug use.

**Opiates**

Most studies of prenatal opiate, heroin, or methadone use show increased LBW, PTB, and reduced fetal growth parameters, although few have controlled for associated risk factors. A meta-analysis estimated a 483 gram reduction in birth weight and a relative risk for LBW of 3.81 associated with any opiate use during pregnancy (37). The effects of using methadone, as opposed to heroin, were smaller but the studies were not randomized and did not control for the intensity of use or other factors associated with seeking treatment. None of the studies in this meta-analysis had adjusted for smoking let alone other risk factors.

Only a handful of studies have examined the impact of opiate use independent of other drug use. Studies relying on self-reported data offer conflicting results. No relation between opiate use (heroin or methadone) and various fetal growth parameters (birth weight, length, and head circumference adjusted for gestational age) was observed in a prospective clinical study controlling for the use of cocaine, marijuana, alcohol, and tobacco (13). Two other small studies also found no difference in head circumference or
birth length among opiate-exposed and non-exposed infants after accounting for differences in smoking, prenatal care, and maternal education (38, 39). Conversely, a retrospective cohort study reported a 483 gram decrement in birth weight adjusted for gestational age and other drug use (33). However, this finding was based on only 11 opiate users who used multiple substances.

Other studies have relied on toxicology results. Gillogley et al (1990) compared 19 women with a positive intrapartum toxicology result for opiates only (heroin or methadone) to those without any history of substance abuse (n=293). Although most of the women were receiving methadone maintenance in prenatal care, there was a non-significant birth weight decrement of 130 grams and no statistical or clinically relevant difference in LBW, PTB, or gestational age. Another small prospective clinical study reported a 1.2 cm average decrease in infant head circumference among mothers who used opiates at least once a month (n=16), controlling for other drugs, prepregnancy weight, and number of prenatal care visits (22).

Perhaps the best available data are from the Maternal Lifestyle Study (MLS), a large, multisite cohort study funded by a consortium of federal agencies. Using the MLS data, Bada et al (2002) reported a 73 gram reduction in birth weight associated with maternal opiate use (self report or positive meconium) among infants born at 33 or more weeks’ gestation independent of prenatal care utilization, medical risk factors, and other drug use. A similar effect observed at less than 33 weeks’ gestation was not statistically significant. In another study of the dataset, opiate use was not significantly related to LBW, PTB, or IUGR (34).
Given the paucity of studies that have controlled for other drug use, it is not surprising that none have adjusted for any social or psychosocial factors with the possible exception of Medicaid enrollment. Aside from an anorexic effect on maternal nutrition, a mechanism of action for opiate use on fetal growth or timing of delivery has not been described. Although the available evidence on the relation between opiate use and birth outcomes may be limited, transitory withdrawal symptoms are commonly observed among infants exposed to opiates late in gestation (40).

**Cocaine**

Of all illicit substances, cocaine has been studied most extensively due to a rapid rise in use during the 1980s and public concern over the purported “crack baby” phenomenon. Though still highly controversial, the neonatal impact of cocaine use, particularly on fetal growth, is more consistently observed than for other illicit substances. Cocaine is hypothesized to reduce fetal growth via maternal vasoconstriction and reduced uteroplacental transfer (41). It may also have a direct effect on fetal metabolism and interfere with fat deposition (42). In addition, the effect of cocaine on maternal hypertension and tachycardia has been proposed to influence gestational age via preterm labor and premature rupture of membranes (43).

Several epidemiologic studies have noted effects of cocaine use on neonatal outcomes, primarily birth weight, length, and head circumference, even after adjustment for tobacco, alcohol, or other drug use, nutritional indicators, and various sociodemographic factors (13, 15, 25, 27-30, 35, 44-47). For example, a study of 8,600 mother-infant dyads enrolled in the Maternal Lifestyle Study found that cocaine use (self
report or positive meconium) was negatively associated with gestational-age adjusted birth weight (-151 g), head circumference (-0.71 cm), and length (-0.43 cm), but only among infants born at 33 or more weeks’ gestation (35). These results were adjusted for other drug use (tobacco, alcohol, marijuana, opiates), adequate prenatal care, and medical risk factors and suggest that the effect of cocaine may be evident only at later gestational ages when the fetus undergoes rapid growth. Another analysis of the MLS data noted stronger cocaine effects on LBW at term (OR: 3.59) and for IUGR (OR: 2.24) than for PTB (OR: 1.25) (all p<0.05) (34). Similarly, a large retrospective cohort study at an inner city hospital reported differences in LBW, fetal growth restriction, and PTB between cocaine exposed (positive urine screen) and non-exposed infants (44). After controlling for confounders, however, only LBW (OR: 1.7) and fetal growth restriction (OR:1.6) were significantly related to cocaine.

Several studies also have shown dose-response effects of cocaine exposure on fetal growth. A retrospective cohort study in a New York City hospital estimated a 27 gram decrement in birth weight with each log unit increase in cocaine concentration in maternal hair at delivery, adjusted for gestation, smoking, and alcohol consumption (15). Furthermore, this effect was observed only at higher exposure levels with a threshold compatible with the average cocaine concentration in the hair of women with a positive urine screen. Other studies based on cocaine concentration in maternal hair or infant meconium have also reported dose effects on growth parameters (46, 48, 49), although dose analysis of these biomarkers may be unreliable due to differences in metabolism and other exposures (14). Two studies of self-reported use have not confirmed dose effects (25, 50). Regardless, many concomitant risk factors occur in direct proportion with the
intensity of cocaine use and most effects are more than halved after adjustment for these risk factors. For example, Zuckerman et al (1989) found that 75% of a 409 gram weight decrement of infants exposed to cocaine (positive urine assay) was attributed to factors other than the drug itself, emphasizing the potential importance of other uncontrolled or imprecisely measured factors.

Still other studies report no relation between cocaine use and birth outcome either before (21, 50) or after controlling for associated confounders (22, 23, 33, 51-53). For example, a multicenter cohort study found that cocaine use (self-report or positive serum assay) was not associated with LBW or PTB (21). Mean birth weight and fetal growth, however, were not assessed and the prospective enrollment of women who obtained prenatal care may have excluded heavy users. Another smaller study reported that crude growth decrements in cocaine-exposed newborns (maternal self-report or positive urine assay at delivery) were attenuated to insignificance after controlling for the higher blood lead and urine cotinine levels of cocaine-using mothers (52). This study demonstrated the importance of measuring confounders with precision since the effect estimates were more greatly reduced by adjusting for continuous cotinine levels than a dichotomous indicator of self-reported smoking.

The two most recent meta-analyses characterize the controversy over the neonatal effects of cocaine exposure. Hulse et al (1997) examined the relation between cocaine use and birth weight based on 11 studies that controlled for tobacco use and presented data on birth weight in a usable form. Given the significant heterogeneity of the studies, random effect models were used for pooled estimates. For any cocaine use, the relative risk of LBW was 1.77 (95% CI: 1.15-2.71) and for more frequent cocaine use, the
relative risk was 4.42 (95% CI: 2.24-8.71). The mean reduction in birth weight was 112 grams (95% CI: 62-161). Despite their findings, the authors acknowledge the possibility of confounding by other drug use, socioeconomic status and other lifestyle factors that were not consistently controlled for among the studies.

In contrast, a 2001 meta-analysis of 33 studies utilized a different approach to control for confounding by comparing cocaine-exposed infants with those exposed to multiple drugs other than cocaine (54). Strong associations between cocaine exposure and various newborn outcomes, including LBW, birth weight, PTB, gestational age, head circumference, and birth length, were seen when comparing cocaine-exposed infants to drug-free controls. However, there were no significant differences observed when comparing cocaine-exposed infants (cocaine only or polydrug) to polydrug-exposed infants without cocaine exposure. A sensitivity analysis excluding retrospective studies and those that assessed drug exposure by self-report or record review did not produce different results, but there were very few studies that presented data in a usable form to compare cocaine-exposure (cocaine only or polydrug) to polydrug-exposure excluding cocaine. It is also possible that cocaine may not add further insult among polydrug users, who are likely to use other drugs with greater intensity, including those with well-established neonatal effects (i.e. tobacco and alcohol).

Despite a biologically plausible mechanism, observed effects may be largely the result of uncontrolled lifestyle factors or residual confounding. For example, few studies have adjusted for income or economic indicators besides Medicaid, which may be important to differentiate even low-income or high-risk samples. Only one identified study adjusted for any psychosocial factor (28). Singer et al (2002) found that both
psychological distress and the average reported dose of cocaine were independently related to birth weight and head circumference. However, all of the cocaine users in the sample were users of multiple substances and there was no indication how much, if any, of the crude cocaine effect could be attributed to greater psychological distress (28).

It is important to recognize that while some studies have observed larger cocaine than tobacco effect sizes for LBW and PTB, the population attributable risk is much higher for tobacco than cocaine given the much higher prevalence of smoking (21, 34, 55). Approximately 1 in 5 pregnant women in the general population report cigarette smoking (1).

In addition to fetal growth, cocaine use has been associated with subtle newborn neurobehavioral effects on state regulation (56-59) and the obstetric complications of abruptio placenta and premature rupture of membranes (54, 60). Neurobehavioral effects are thought to be a direct result of drug exposure rather than a withdrawal syndrome as is the case for opiates. Both depressed and excitable profiles have been observed which may be related to the dose of exposure (58).

**Cessation of Exposure**

Along with the strength, consistency, and biologic plausibility of an association, a reduction in risk secondary to exposure cessation or reduction is another causal criterion that may be used to evaluate the relation between illicit drug use and birth outcomes. Shankaran et al (2004) examined fetal growth parameters according to the self-reported pattern of drug use during pregnancy (consistently high, moderate, low, increasing, and decreasing) but did not find consistent effects. However, observational studies such as
this one and others that show improvements in birth outcomes for substance-using
women who enter treatment and/or prenatal care cannot control for the selection factors
and differences in background characteristics that may be responsible for observed
effects.

While randomized controlled trials of drug use during pregnancy cannot be
ethically conducted, randomized trials of drug treatment offer an alternative. A meta-
analysis of randomized, controlled trials for smoking cessation during pregnancy reported
small but statistically significant increases in birth weight and reductions in both LBW
and PTB (61). Only two randomized, controlled studies of illicit drug treatment
programs could be identified that evaluated birth outcomes (62, 63). In both small
studies, improvements in birth outcomes were noted without changes in drug use or
abstinence, which may suggest a critical role for psychosocial and ancillary services for
these high risk women.

**Later Effects of Prenatal Drug Use**

There is little evidence of significant long-term effects of prenatal exposure to
illicit substances, although some subtle developmental effects have been noted mainly for
marijuana and cocaine exposure. Early claims of profound and irreparable consequences
of prenatal cocaine exposure from direct central nervous system disruption of the
developing brain have been largely assuaged by appropriately controlled studies that
show subtle if any long term developmental consequences. A systematic review
concluded that after controlling for confounders, including exposure to other drugs and
the quality of the home environment, there is no consistent effect of prenatal cocaine
exposure on physical growth or developmental and behavioral test scores among children 6 years of age or younger (64). Two recently published large longitudinal studies generally confirm this conclusion at 3 to 4 years of age, although one noted subtle effects on specific cognitive subscales (65, 66).

However, studies assessing later developmental effects generally control for infant birth size, which may be a greater mediator than confounder. And in the absence of data on older children and adolescents, it may be premature to conclude that there are minimal to no neurotoxic effects of cocaine exposure in utero. Even subtle effects can produce sizeable population level impact on resource needs for educational intervention services (67). Nevertheless, the magnitude of observed outcomes of illicit substance use, to date, do not compare to the more established health and developmental risks of prenatal alcohol and tobacco exposure (7). Heavy alcohol consumption can lead to fetal alcohol syndrome, characterized by intrauterine and postnatal growth restriction, cranial dysmorphology, and cognitive deficits, with specific teratogenic effects resulting from first trimester exposure (7). Prenatal smoking is consistently and strongly related to growth restriction and later behavioral problems via nicotine disruption of central nervous system development (55, 68).

The greatest impact of perinatal illicit substance use on children may be the increased postnatal risks of neglect and maltreatment, foster care placement, and other disruptions in the home environment (11, 59, 69). These factors have much stronger effects on cognitive and behavioral outcomes than fetal drug exposure (64). Demonstrating the importance of the home environment and parenting quality, the IQ of cocaine-exposed children placed in non-relative foster or adoptive care was no different
than non-exposed children and significantly higher than exposed infants in biological maternal or relative care (66). Another recent study showed that the mortality of drug-exposed infants is only elevated in the postneonatal period, also supporting the preeminent negative role of drug use on the postnatal environment (70). In addition, estimates for the costs of social services and additional hospital stay among drug-exposed “boarder babies” awaiting home and social evaluation or foster care placement are substantial (71, 72).

Conclusions and Directions for Future Research

Overall, research regarding the neonatal impact of illicit substance use is inconclusive, though possibly more consistent for cocaine use and restricted fetal growth. The few prospective studies that have been conducted may be missing those most at risk for both drug use and poor birth outcomes by selecting only women receiving prenatal care. Several recent retrospective studies have had suboptimal response rates (23% - 70%) and do not include psychosocial or detailed socioeconomic data (24, 28, 30, 35). As a recent NIDA conference on drug use, placental biology, and fetal development concluded (73),

“little information is available as to whether the detrimental effects seen in drug-exposed offspring are the direct result of perturbations in the development of placenta and its functions or caused by “host” factors such as poor prenatal care, stress, infection, and poor maternal nutrition, which are common comorbid factors in drug abusing women.”

This conference emphasized the need for greater understanding of how drugs of abuse and related exposures influence placental biology. In addition, further epidemiologic research that employs multiple detection methods and includes a full range of confounders could help to clarify these relations and more precisely quantify the
contribution of various associated social, psychosocial, behavioral, and biomedical factors versus direct drug effects. Understanding the relative role of factors that account for drug-related effects would help to direct interventions for improving outcomes among women who use drugs during pregnancy. Chronic stress, in particular, is consistently related to LBW and PTB (74) with hypothesized pathways via neuroendocrine, immune, and vascular mechanisms that may influence both the timing of delivery and uteroplacental transfer (75, 76). Stress and other psychological symptoms can also lead to substance use as a coping mechanism (77), yet no studies investigating the neonatal consequences of prenatal exposure to various illicit drugs have measured and controlled for chronic stress.

Another category of factors that have not been considered in even the best-designed studies is the physical and social environment in which women live. Drug use is often geographically clustered (78, 79) and residential characteristics, including socioeconomic disadvantage, violent crime, and pollution levels, have been observed to influence birth weight, LBW, and PTB (80-84). The extent to which adverse neighborhood exposures might confound or modify the effect of illicit drugs on birth outcomes has not been explored and represents an avenue for future research. Synergistic interactions have been reported between air pollution and neighborhood disadvantage on PTB (83) and between prenatal environmental tobacco smoke exposure and material hardship on cognitive delays (85). It is possible that neighborhood stressors may exacerbate the impact of prenatal drug exposure akin to “double jeopardy”. Various statistical methods can control for both observed and unobserved neighborhood exposures by conditioning or matching at the neighborhood level, whereas multilevel
models with neighborhood level covariates can be used to test interactions and to control for observed neighborhood characteristics (86, 87).

In addition to the general lack of control for multiple confounders, especially social and psychosocial risks, many studies have relied on multiple regression adjustment to estimate the independent effect of various drugs even though most women do not use substances in isolation. This can be problematic when there is poor overlap between exposed and unexposed subjects across the distribution of covariates (e.g. few or no drug users who do not use other drugs), since regression estimation will impute values where few or none exist (also known as regression smoothing) (88). Propensity score matching is an alternative statistical technique that may be usefully applied to better balance the data and control for multiple confounders, including polydrug use. In essence, propensity score matching simulates a randomized, controlled trial from observational data by matching exposed and unexposed subjects with equivalent combinations of background characteristics and hence equal observed propensity to use drugs (89). Since prenatal illicit drug exposure cannot be ethically randomized, propensity score models should be explored as an alternative technique to promote causal inference. This method, however, carries complications in evaluating drug interactions and the inability to assess the relative importance of various confounders.

While consideration of the neighborhood context and alternate statistical techniques may help to improve the estimation of illicit drug effects on newborn outcomes, the myriad other health and social consequences of drug abuse and addiction for women and their families make prevention and treatment efforts imperative, regardless of the neonatal impact. Knowledge of the relative role of drug use and
surrounding factors, however, would help to frame an agenda of priorities to prevent adverse newborn outcomes. A more holistic approach that addresses the constellation of social and psychosocial risk factors, for which drug use is a common symptom, may be necessary to improve outcomes.
References


CHAPTER FIVE

ILLICIT DRUG USE AND ADVERSE BIRTH OUTCOMES:
IS IT DRUGS OR CONTEXT?
Abstract

Objective: To determine the degree to which adverse birth outcomes associated with drug use are due to the drugs versus surrounding factors.

Methods: Data are from a clinical sample of low-income women who delivered at Johns Hopkins Hospital between 1995 and 1996 (n=808). Use of marijuana, cocaine, and opiates was determined by self-report, the medical record, and urine toxicology screens at delivery. Information on various social, psychosocial, behavioral, and biomedical risk factors were gathered from a postpartum interview or the medical record. Multivariable regression models of birth outcomes (mean birth weight and low birth weight, LBW <2500g) were used to assess the effect of drug use independent of associated factors.

Results: In unadjusted results, cocaine and opiate use were related to mean birth weight (-329 and -239 grams, p<0.01) and LBW (ORs: 1.93 and 2.06, p<0.05). Only the effect of cocaine on mean birth weight remained significant after adjusting for all associated factors (-143 grams, p=0.04). Neither drug was significantly related to LBW in fully adjusted models (ORs: 1.16 and 1.69). About half of the unadjusted effect of cocaine use on mean birth weight was explained by surrounding psychosocial and behavioral factors, particularly stress and smoking. Most of the unadjusted effect of opiate use was explained by smoking and lack of early prenatal care.

Conclusions: Given that associated psychosocial and behavioral factors explained most of the effect of illicit drugs on birth outcomes, prevention efforts that aim to improve newborn health must also address the surrounding context in which drug use frequently occurs.
Introduction

Maternal drug use is a significant public health concern given the potential consequences for the health and well-being of both the mother and developing fetus. Recent national estimates indicate that 4.3% of pregnant women report using illicit substances in the past month (1). Although this figure is likely underestimated given the reliance on self-reported data and point rather than period prevalence of any use during pregnancy, it suggests that at least 200,000 infants born annually have been prenatally exposed to drugs. Moreover, the burden of maternal drug use may not be equally distributed; prevalence estimates in low-income and/or urban populations have ranged as high as 10-30% (2-6). Marijuana is generally the most commonly used drug during pregnancy, followed by cocaine and opiates.

While illicit drug use is widely perceived to cause adverse birth outcomes, such as low birth weight, preterm birth, and growth restriction, the actual empirical evidence is less established than for the more frequently used licit substances of tobacco or alcohol (7). Of marijuana, cocaine, and opiates, cocaine is most consistently associated with birth outcomes, particularly those that capture dimensions of fetal growth such as birth weight, head circumference, low birth weight, and small for gestational age (6, 8-15), although not all studies have noted effects (16-19). Marijuana is weakly and unreliably related to birth weight, with some studies even reporting increases in birth weight (6, 8, 9, 16, 18, 20-23). Opiate use is also inconsistently related to birth outcomes; both large and small decrements in birth weight have been noted (6, 8, 9, 18, 24). Accordingly, recent analyses of a large, multisite cohort study found that use of cocaine, and to a lesser extent, opiates was related to gestational age-adjusted birth weight, and only cocaine use
was related to low birth weight (8, 9). These analyses controlled for the use of tobacco and alcohol, adequacy of prenatal care, and various medical conditions.

In addition to inadequate prenatal care utilization and the frequent concomitant use of tobacco and alcohol, illicit drug use is also associated with multiple social, psychosocial, behavioral, and biomedical risk factors including poverty, stress, depression, lack of social support, physical abuse, sexually transmitted infections, and poor nutrition (4, 25, 26). To date, no studies examining specific drug effects have accounted for the full spectrum of associated risk factors for birth outcomes, particularly psychosocial risk factors, or estimated the proportion of risk attributable to a presumed biological mechanism versus these related factors. Knowledge of the determinants underlying the differentially worse birth outcomes associated with drug use may help to direct treatment-based interventions and prioritize the factors that should be addressed to improve birth outcomes more generally. It may not be sufficient to focus on drug cessation without addressing the disadvantaged context that often surrounds drug use. This study addresses this knowledge gap by evaluating the impact of drug use on birth outcomes using a biopsychosocial model that incorporates multiple related social, psychosocial, behavioral, and biomedical factors.

Methods

Study Sample

Data for this analysis come from a hospital-based retrospective cohort study designed to examine the influence of drug use on patterns and barriers to prenatal care (27). The study sample consists of low-income women (not private or transferred
patients), aged 19 or older, who delivered a live birth or fetal death at the Johns Hopkins Hospital (JHH) between February 16, 1995 and May 31, 1996. Eligible women were approached in the postpartum unit by trained survey staff and, once consenting to participate, were briefly screened to determine their selection probability. All women with evidence of drug use (medical record, self-report, or toxicological screen) or no prenatal care, and two out of three remaining women were selected to participate. Women were assured of confidentiality with a NIDA certificate and compensated $15 for their time in completing the 1 hour interview.

Of 1201 eligible women, 1114 (93%) consented to participate. Upon completion of the screening questionnaire, 1 out of 3 women who had received prenatal care and had no evidence of drug use were not selected as per the sampling scheme (n=290), resulting in 824 women with completed interviews. The analytic sample is restricted to 808 women who delivered singleton, live births.

Data Sources

Data were primarily collected from the medical record and the postpartum interview. Medical records were abstracted to determine infant birth characteristics, prenatal care utilization, drug use (from toxicology screens or report by a healthcare provider), and the presence of medical risk factors. The postpartum interview gathered information on social and psychosocial characteristics using standardized instruments, as well as behavioral factors, including a detailed drug use history.
Measures and Variables

Drug Use

Prenatal drug use of marijuana, cocaine, and opiates was determined by positive evidence on any of three measures: a universal urine toxicological screen at admission to labor and delivery, self-report (screener questionnaire or postpartum interview), or other report in the medical record (prenatal toxicology screen or report by a health care provider). Any use of these three types of drugs (marijuana, cocaine, opiates) during pregnancy was examined with separate dichotomous indicator variables. The self-reported frequency of drug use (monthly v. weekly or daily) was also examined for the 75% of drug users who reported use in the postpartum interview. Use of any other type of drug, as determined by self-report, the medical record, or a toxicological screen for barbiturates, was controlled for in adjusted analyses.

Birth Outcomes

Birth weight, as abstracted from the medical record, served as the primary outcome measure. It was analyzed both continuously as mean birth weight in grams and as a binary variable of low birth weight (LBW, <2500 g). Growth restriction and preterm birth, the proximate determinants of low birth weight, were not examined directly out of concern for the validity of gestational age estimation in a sample overrepresented for drug use and lack of prenatal care. Therefore, observed associations can be viewed as the total effect on birth weight, irrespective of the mechanism. Reduced birth weight, particularly LBW, is related to infant morbidity and mortality (28), as well as later developmental deficits (29).
Other Independent Variables

Several social, psychosocial, behavioral, and biomedical factors that have been related to both drug use and birth outcomes were evaluated as potential control variables. A biospsychosocial framework that places social and psychosocial factors as distal determinants influencing birth outcomes via proximate behavioral and biomedical factors was used to guide the analysis (30).

Social factors: Social variables included maternal age, race, education, relationship with the father of the baby, employment during pregnancy, money for necessities, and type of housing. Money for necessities (e.g. food, housing, heating) was determined by a 7-item subscale of the Family Resources Scale (sample Cronbach’s α = 0.87) (31).

Psychosocial factors: Psychosocial variables included stress, family support, depression, pregnancy locus of control, physical abuse, and unwanted pregnancy. Stress was measured with a validated 11-item Hassles Scale (32), that assesses chronic stress during pregnancy due to daily difficulties and circumstances (e.g. family problems, money worries, loss of a loved one, general overload). One item reflecting stress due to problems with alcohol or drugs was removed from the summed scale to prevent the adjustment of a potentially mediating factor (sample Cronbach’s α = 0.80). Family support was measured with a 3-item scale assessing the support of family members in solving problems and looking out for one another (sample Cronbach’s α = 0.80). The Center for Epidemiologic Studies Depression Scale was used to measure depressive symptoms (sample Cronbach’s α = 0.88) (33). Pregnancy locus-of-control was measured
by 5 related items in the Pregnancy Belief Scale (34) and refers to the extent to which a
woman believes that her pregnancy outcome is under internal control versus chance or
fate (sample Cronbach’s $\alpha = 0.72$). The shortened version of the violence subscale in the
Conflicts Tactic Scale (CTS) (35) was used to measure physical abuse and included the
experience of any physical abuse during pregnancy by household or non-household
members. Unwanted pregnancy was defined as not wanting to have a baby at the time of
learning pregnancy status.

Behavioral factors: Other behavioral factors examined were smoking, alcohol
consumption, and the receipt of early prenatal care. Prenatal smoking and alcohol
collection were ordinally categorized by the average number of cigarettes smoked per
day (0, 1-9, or 10+) and the frequency of drinking (never, monthly, or weekly). Early
prenatal care was defined as a first visit within the first trimester with four or more total
visits.

Biomedical Factors: Biomedical risk factors included hypertensive disorders (chronic
hypertension, pregnancy-induced hypertension, preeclampsia, or eclampsia), sexually
transmitted infections (gonorrhea, chlamydia, or syphilis), other medical risk factors
(thromboembolic disease, vaginal bleeding, asthma requiring medication, cancer, renal
disease, Hepatitis, or HIV/AIDS), and parity. Nutritional status was examined by
prepregnancy weight and net weight gain during pregnancy (subtracting infant birth
weight).
**Analytic Methods**

Bivariate analyses were performed to examine associations between drug use and birth weight variables and between drug use and other independent variables using chi-square tests for categorical variables and t-tests or ANOVA for continuous variables (birth weight). Multivariable linear (birth weight) and logistic (LBW) regression models were then used to determine the proportion of unadjusted drug use effects on birth weight (LBW, continuous) that could be explained by the sequential addition of social, psychosocial, behavioral, and biomedical factors. Variables were retained in the model if they were independently related to the birth outcome (p<0.10) or if their removal altered any of the drug use coefficients by 10% or more (36). Correlation matrices were used to check for collinearity and potential interactions between the drugs and other model variables were explored. The Cronbach’s α coefficient, a measure of internal consistency and reliability, exceeded 0.70 for all scale variables. Items were summed and rescaled to reflect an average response. In general, survey data were highly complete. For one variable, money for necessities, missing data exceeded 5% and a dummy variable using a separate category was created. Otherwise the few missing observations were placed in the reference group.

As some biomedical variables (i.e. hypertensive disorders, nutritional status) may be the consequences of illicit drug use rather than true confounders, the final model adjusting for biomedical factors may be viewed as estimating direct effects of drug use.
Results

Sample Description

Slightly more than one third of the women used drugs during pregnancy (35%, \( n=281 \)). As per the sampling design, however, this figure is inflated as a prevalence estimate. The actual estimated prevalence was 25% (281/1114). Cocaine was the most commonly used drug (24%), followed by opiates (19%), marijuana (15%), and other drugs (7%). Tables 1 and 2 show the distribution of social, psychosocial, behavioral, and biomedical factors for the total sample. Consistent with the population of inner city Baltimore, the majority of the sample was Black and only 12% had received education beyond high school.

Social, Psychosocial, Behavioral and Biomedical Correlates of Drug Use

Tables 1 and 2 also show the percentage of drug use according to the selected covariates. All of the social factors were associated with at least one type of drug use during pregnancy (Table 5.1). Social factors associated with multiple types of drug use included older age, lower levels of education, being unemployed, and not having enough money for necessities. Psychosocial factors associated with one or more types of drug use included greater stress and depressive symptoms, less family support, and a lower internal locus-of-control regarding pregnancy outcomes.

Women who smoked or drank alcohol with greater intensity were significantly more likely to use marijuana, cocaine, and opiates during pregnancy (Table 5.2). Having an unwanted pregnancy and not receiving early prenatal care were also associated with both cocaine and opiate use. Of the biomedical risk factors examined, lower pre-
pregnancy weight and net weight gain and higher parity were associated with more than one type of drug use. Medical risk factors were not more common among drug users.

Observed associations were generally stronger for the use of cocaine and opiates than marijuana or other drugs.

Drug Use and Birth Outcomes

In bivariate comparisons, all categories of drug use were significantly related to both LBW and mean birth weight (Table 5.3). The strength of the association was greatest for cocaine and opiate use. In multiple regression models, adjusting for other types of drug use, only cocaine and opiate use were significantly related to mean birth weight (Table 5.4) and LBW (Table 5.5).

Cocaine

After adjustment for all social, psychosocial, behavioral, and biomedical factors cocaine use remained significantly related to mean birth weight (-143 grams, p<0.05). However, more than half of the unadjusted effect was explained by other factors, particularly stress and cigarette smoking. In contrast to mean birth weight, the effect of cocaine use on LBW was not significant after adjustment for social factors and nearly all of the cocaine-related excess odds was explained by the additional control for psychosocial and behavioral characteristics.

Opiates

Opiate use was not significantly related to mean birth weight after adjustment for behavioral factors and the effect was further reduced after controlling for biomedical factors, particularly prepregnancy weight and net weight gain. Similar to mean birth
weight, opiate use was not significantly related to LBW after adjustment for the behavioral factors of smoking and lack of early prenatal care.

There were no significant interactions between drug use and other model variables, indicating additive rather than synergistic effects. Evaluation of self-reported frequency generally showed dose-response trends but no effects were statistically significant (data not shown). Alternatively, examination of positive labor and delivery screens versus other sources as a proxy for use intensity did show a significant effect for cocaine on birth weight. Compared to women with no indication of cocaine use, those with a positive labor and delivery screen for cocaine had significantly smaller infants (-175.8 g, p=0.03) whereas those with another indication of use (self-report or medical record only) did not have significantly smaller infants (-81.9 g, p=0.38).

Discussion

This study provides confirmation of the multiple risks related to drug use, including inadequate material resources, stress, depression, delayed or no prenatal care, poor nutritional status, as well as concurrent use of tobacco and alcohol, and is the first to our knowledge to control for multiple social, psychosocial, behavioral, and biomedical factors when evaluating specific drug use effects on birth outcomes. In bivariate associations, marijuana, cocaine, and opiate use, were all strongly related to mean birth weight and LBW. These effects were attenuated but still significant for cocaine and opiates after controlling for overlapping drug use. After adjustment for associated risk factors for reduced birth weight and LBW, however, only the use of cocaine was significantly related to mean birth weight. Cocaine use was not more likely to result in
LBW—an outcome of greater clinical significance. Altogether, these results suggest that illicit drug use is a stronger risk marker than a risk factor for adverse birth outcomes.

The observed independent effect of cocaine use on birth weight (-143 g) is similar in magnitude to that found in a large, multisite cohort study that adjusted for gestational age but no social or psychosocial factors (-151 g) (8). Of the illicit drugs examined, cocaine also has the most biologically plausible effect on birth weight via vasoconstriction and reduced utero-placental transfer (37). The greater birth weight decrement observed among infants of women with a positive labor and delivery urine screen is consistent with a dose-response effect and suggests that only heavier use may be consequential.

Approximately 60% of birth weight decrements related to the three drug types was explained by factors associated with drug use. Between 30% and 80% of the increased odds of LBW associated with the type of drug use was explained by surrounding factors. Social, psychosocial, and behavioral factors all accounted for considerable proportions of cocaine-related effects on birth weight. In particular, stress and smoking individually accounted for more than 10% of unadjusted cocaine effects on both LBW and birth weight. For opiate use, the behavioral factors of smoking and early prenatal care and the biomedical nutritional status indicators accounted for a substantial proportion of the estimated effects on both LBW and birth weight.

Thus, where birth outcomes are concerned, emphasis on drug use per se may be misplaced. For example, the birth weight effects of moderate to severe stress (-244 g, p<0.01) and smoking 10 or more cigarettes per day (-161 g, p<0.05) exceeded that of cocaine and accounted for a significant portion of unadjusted cocaine-related effects.
Chronic stress is consistently related to birth weight and gestational age with hypothesized mechanisms via behavioral and biological pathways (38, 39). In relation to drug use, stress may promote and reinforce substance use as a coping mechanism (40). Cigarette smoking is also strongly related to fetal growth restriction and is common among drug users (7).

Although nutritional status may be a consequence of the anorexic effects of opiates, the use of opiates was not significantly related to either birth weight outcome before adjustment of potentially indirect biomedical factors. The absence of early prenatal care may also be a consequence of the depressive effect of opiate use (27). However, the effect of prenatal care on birth outcomes is more likely to reflect unmeasured positive health related behaviors and attitudes than a causal relationship (41, 42). Regardless of whether poor nutrition or lack of early prenatal care lie on the causal pathway, these risk factors exist in the absence of opiate use and deserve attention irrespective of drug use.

In contrast to the findings of some studies, physical abuse and medical risk factors were not more common among drug users than non-users and did not account for drug-related effects on birth weight. The experience of physical abuse was relatively high in this low-income sample and might reflect less severe forms of abuse that are common in some families. The report of stress because of abuse, an item in the hassles scale, was indeed twice as high among drug users (20% v. 10%) (data not shown). Another study of this sample found that this single item related to abuse accounted for most of the effect of stress on birth weight as measured by the entire scale (43). The significantly lower prevalence of sexually transmitted infections among opiate users is likely to be the result
of surveillance bias due to inadequate health care utilization. As many biomedical risk factors were less common among drug users, their control introduced a form of negative confounding and generally increased estimates of drug-related effects.

In addition to the measurement and control of multiple social and psychosocial confounders, a major strength of this study was the capacity to assess independent drug effects. Unlike some previous studies that have relied on statistical control among polydrug users, there were sufficient numbers of women in our study who used only cocaine (n=48) and only opiates (n=20) to estimate independent effects. The combination of sources for drug use ascertainment, including self-report, the medical record, and urine toxicology screens, is another major strength that reduces misclassification and increases confidence in the estimates of drug-related effects.

This study also has several limitations that deserve mention. First, the effect of amphetamine use—a drug of increasing popularity—could not be examined since only one woman reported its use and toxicological screens were not routinely performed in the mid 90s. However, the pharmacologic effects of amphetamine use are identical to cocaine and other epidemiologic studies suggest similar effects on birth weight (23, 44). Second, differences in gestational age or preterm birth were not evaluated out of concern for the reliability of gestational age estimation in a sample overrepresented for drug use and lack of prenatal care. The reported date of last menstrual period is less reliable for women with social risk factors and ultrasound-based estimation is most accurate when performed in the first trimester (45). The existing literature is more suggestive of illicit drug effects on birth weight or fetal growth than the length of gestation (7). Third, the potential for recall bias and/or error exists in any retrospective study. However, there is
little empirical evidence of differential reporting of exposures according to pregnancy outcome (46). If anything, random measurement error and/or underreporting of sensitive exposures related to drug use would have introduced residual confounding that would yield a conservative estimate of the explanatory power of covariates. Moreover, the clinic-based prospective alternative to a retrospective study would have excluded the third of drug users who did not receive prenatal care—a very high risk group.

Conclusions

Although illicit drug use is often strongly related to poor birth outcomes in crude associations, it is a powerful marker for multiple social, psychosocial, behavioral, and biomedical risk factors. In this study, psychosocial and behavioral factors, including stress, smoking, and late or no prenatal care, explained most of the birth weight decrements associated with illicit drug use. These factors may therefore warrant special focus in drug treatment programs for women of reproductive age. Given the preeminent role of factors other than drug use, however, broader prevention efforts that aim to improve newborn health must address the surrounding context in which drug use more commonly occurs.
References


Table 5.1. Drug Use (%) According to Social and Psychosocial Factors

<table>
<thead>
<tr>
<th>Social Factors</th>
<th>N(%)</th>
<th>Drug Use During Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Marijuana</td>
</tr>
<tr>
<td>Maternal Age</td>
<td></td>
<td>123(15)</td>
</tr>
<tr>
<td>19-24</td>
<td>422(52)</td>
<td>11.6⁺</td>
</tr>
<tr>
<td>25-34</td>
<td>318(39)</td>
<td>19.8</td>
</tr>
<tr>
<td>35+</td>
<td>68(9)</td>
<td>16.2</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>756(94)</td>
<td>14.6*</td>
</tr>
<tr>
<td>White/Other</td>
<td>52(6)</td>
<td>25.0</td>
</tr>
<tr>
<td>Lives with him</td>
<td>228(28)</td>
<td>14.0</td>
</tr>
<tr>
<td>Contact with him</td>
<td>476(59)</td>
<td>14.3</td>
</tr>
<tr>
<td>No relationship</td>
<td>104(13)</td>
<td>22.1</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; High School</td>
<td>361(44)</td>
<td>18.3*</td>
</tr>
<tr>
<td>High School or GED</td>
<td>347(44)</td>
<td>13.8</td>
</tr>
<tr>
<td>&gt; High School</td>
<td>100(12)</td>
<td>9.0</td>
</tr>
<tr>
<td>Employed during Pregnancy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>328(41)</td>
<td>11.0⁺</td>
</tr>
<tr>
<td>No</td>
<td>480(59)</td>
<td>18.1</td>
</tr>
<tr>
<td>Enough Money for Necessities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; Half the time</td>
<td>58(7)</td>
<td>32.8⁺</td>
</tr>
<tr>
<td>Half the time</td>
<td>105(13)</td>
<td>21.9</td>
</tr>
<tr>
<td>&gt; Half the time</td>
<td>456(57)</td>
<td>12.3</td>
</tr>
<tr>
<td>Not Answered</td>
<td>189(23)</td>
<td>13.2</td>
</tr>
<tr>
<td>Housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own</td>
<td>146(18)</td>
<td>13.0</td>
</tr>
<tr>
<td>Rent</td>
<td>391(48)</td>
<td>15.4</td>
</tr>
<tr>
<td>Subsidized</td>
<td>119(15)</td>
<td>10.9</td>
</tr>
<tr>
<td>Public Housing</td>
<td>152(19)</td>
<td>20.4</td>
</tr>
<tr>
<td>Psychosocial Factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little to none</td>
<td>307(38)</td>
<td>8.1⁺</td>
</tr>
<tr>
<td>Some</td>
<td>389(48)</td>
<td>17.7</td>
</tr>
<tr>
<td>Moderate to Severe</td>
<td>112(14)</td>
<td>25.9</td>
</tr>
<tr>
<td>Family Support</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almost always</td>
<td>121(15)</td>
<td>12.4</td>
</tr>
<tr>
<td>Sometimes</td>
<td>538(67)</td>
<td>14.7</td>
</tr>
<tr>
<td>Hardly ever</td>
<td>149(18)</td>
<td>19.5</td>
</tr>
<tr>
<td>Drug Use During Pregnancy</td>
<td>Total N(%)</td>
<td>Marijuana 123(15)</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------</td>
<td>-------------------</td>
</tr>
<tr>
<td><strong>Depression (CESD Score)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;16</td>
<td>338(42)</td>
<td>9.8(\dagger)</td>
</tr>
<tr>
<td>16-19</td>
<td>107(13)</td>
<td>18.7</td>
</tr>
<tr>
<td>20-29</td>
<td>198(25)</td>
<td>17.2</td>
</tr>
<tr>
<td>30+</td>
<td>165(20)</td>
<td>21.8</td>
</tr>
<tr>
<td><strong>Pregnancy Locus of Control</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little to None</td>
<td>246(30)</td>
<td>17.5</td>
</tr>
<tr>
<td>Some</td>
<td>329(41)</td>
<td>14.6</td>
</tr>
<tr>
<td>Moderate to Strong</td>
<td>233(29)</td>
<td>13.7</td>
</tr>
<tr>
<td><strong>Physical Abuse</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>111(14)</td>
<td>20.7</td>
</tr>
<tr>
<td>No</td>
<td>697(86)</td>
<td>14.4</td>
</tr>
<tr>
<td><strong>History of Sexual Abuse</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>167(21)</td>
<td>25.2(\ddagger)</td>
</tr>
<tr>
<td>No</td>
<td>641(79)</td>
<td>12.6</td>
</tr>
</tbody>
</table>

* p<0.05, † p<0.01, ‡ p<0.001
Table 5.2. Drug Use (%) According to Behavioral and Biomedical Factors

<table>
<thead>
<tr>
<th>Behavioral Factors</th>
<th>Total N(%)</th>
<th>Drug Use During Pregnancy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Marijuana 123(15)</td>
<td>Cocaine 191(24)</td>
</tr>
<tr>
<td><strong>Behavioral Factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cigarettes/day</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>540(67)</td>
<td>5.7&lt;sup&gt;i&lt;/sup&gt;</td>
<td>7.0&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>1-9</td>
<td>142(18)</td>
<td>33.8</td>
<td>49.3</td>
</tr>
<tr>
<td>10+</td>
<td>126(15)</td>
<td>34.9</td>
<td>65.9</td>
</tr>
<tr>
<td><em>Alcohol</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never</td>
<td>662(82)</td>
<td>11.2&lt;sup&gt;i&lt;/sup&gt;</td>
<td>16.8&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>1-4 days/month</td>
<td>91(11)</td>
<td>26.4</td>
<td>47.3</td>
</tr>
<tr>
<td>1-2 days/week+</td>
<td>55(7)</td>
<td>45.5</td>
<td>67.3</td>
</tr>
<tr>
<td><em>Early Prenatal Care</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>302(37)</td>
<td>8.6&lt;sup&gt;i&lt;/sup&gt;</td>
<td>8.6&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>No</td>
<td>506(63)</td>
<td>19.2</td>
<td>32.6</td>
</tr>
<tr>
<td><em>Unwanted Pregnancy</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>178(22)</td>
<td>17.4</td>
<td>32.0&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>No</td>
<td>630(78)</td>
<td>14.6</td>
<td>21.3</td>
</tr>
<tr>
<td><strong>Biomedical Factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Hypertensive Disorders</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>85(11)</td>
<td>5.9&lt;sup&gt;*&lt;/sup&gt;</td>
<td>20.0</td>
</tr>
<tr>
<td>No</td>
<td>723(89)</td>
<td>16.3</td>
<td>24.1</td>
</tr>
<tr>
<td><em>STI</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>109(13)</td>
<td>12.8</td>
<td>22.0</td>
</tr>
<tr>
<td>No</td>
<td>699(87)</td>
<td>15.6</td>
<td>23.9</td>
</tr>
<tr>
<td><em>Other Medical Risk Factor</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>158(20)</td>
<td>14.6</td>
<td>23.4</td>
</tr>
<tr>
<td>No</td>
<td>650(80)</td>
<td>15.4</td>
<td>23.7</td>
</tr>
<tr>
<td><em>Pre-pregnancy weight</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;120</td>
<td>186(23)</td>
<td>19.4&lt;sup&gt;*&lt;/sup&gt;</td>
<td>34.4&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>120-159</td>
<td>382(47)</td>
<td>15.5</td>
<td>23.6</td>
</tr>
<tr>
<td>160-199</td>
<td>152(19)</td>
<td>13.2</td>
<td>17.1</td>
</tr>
<tr>
<td>200+</td>
<td>88(11)</td>
<td>9.1</td>
<td>12.5</td>
</tr>
<tr>
<td><em>Net Weight Gain</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td>251(31)</td>
<td>16.7</td>
<td>32.7&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>10-29</td>
<td>413(51)</td>
<td>15.3</td>
<td>21.8</td>
</tr>
<tr>
<td>30-39</td>
<td>80(10)</td>
<td>11.3</td>
<td>18.8</td>
</tr>
<tr>
<td>40+</td>
<td>64(8)</td>
<td>14.1</td>
<td>6.3</td>
</tr>
<tr>
<td><em>Parity</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>208(26)</td>
<td>8.2&lt;sup&gt;i&lt;/sup&gt;</td>
<td>6.7&lt;sup&gt;i&lt;/sup&gt;</td>
</tr>
<tr>
<td>1</td>
<td>225(28)</td>
<td>16.4</td>
<td>16.0</td>
</tr>
<tr>
<td>2-3</td>
<td>283(35)</td>
<td>18.4</td>
<td>36.0</td>
</tr>
<tr>
<td>4+</td>
<td>92(11)</td>
<td>18.5</td>
<td>42.4</td>
</tr>
</tbody>
</table>

p<0.05, † p<0.01, ‡ p<0.001
Table 5.3. Bivariate Associations between Drug Use and Birth Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Birth Weight</th>
<th>LBW</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N(%)</td>
<td>Mean (SE)</td>
<td>Difference (95% CI)</td>
</tr>
<tr>
<td>Marijuana</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>123(15)</td>
<td>2812 (57)</td>
<td>-287‡</td>
</tr>
<tr>
<td>No</td>
<td>685(85)</td>
<td>3099 (33)</td>
<td>(-128 , -446)</td>
</tr>
<tr>
<td>Cocaine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>191(24)</td>
<td>2661 (49)</td>
<td>-516‡</td>
</tr>
<tr>
<td>No</td>
<td>617(76)</td>
<td>3176 (34)</td>
<td>(-385 , -647)</td>
</tr>
<tr>
<td>Opiates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>153(19)</td>
<td>2649 (52)</td>
<td>-501‡</td>
</tr>
<tr>
<td>No</td>
<td>655(81)</td>
<td>3149 (33)</td>
<td>(-358 , -644)</td>
</tr>
</tbody>
</table>

*p<0.05, †p<0.01, ‡p<0.001
Table 5.4. Linear Regression Results of Birth Weight and Drug Use

<table>
<thead>
<tr>
<th></th>
<th>Marijuana Coefficient (95% CI)</th>
<th>% Change</th>
<th>Cocaine Coefficient (95% CI)</th>
<th>% Change</th>
<th>Opiates Coefficient (95% CI)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted(^1)</td>
<td>-69.5 (-205.8, 66.7)</td>
<td>--</td>
<td>-329.3 (-469.2, -189.5) (^\dagger)</td>
<td>--</td>
<td>-239.3 (-396.5, -82.1) (^\dagger)</td>
<td>--</td>
</tr>
<tr>
<td>Adjusted For</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Factors</td>
<td>-48.3 (-183.4, 86.9)</td>
<td>-31%</td>
<td>-293.0 (-439.8, -146.4) (^\dagger)</td>
<td>-11%</td>
<td>-235.5 (-392.7, -78.3) (^\dagger)</td>
<td>-2%</td>
</tr>
<tr>
<td>Social and Psychosocial Factors</td>
<td>-42.4 (-176.0, 91.5)</td>
<td>-39%</td>
<td>-237.8 (-384.5, -91.1) (^\dagger)</td>
<td>-28%</td>
<td>-214.8 (-370.6, -58.9) (^\dagger)</td>
<td>-10%</td>
</tr>
<tr>
<td>Social, Psychosocial, and Behavioral Factors</td>
<td>6.1 (-131.0, 143.2)</td>
<td>-108%</td>
<td>-172.7 (-322.6, -22.7) (^*)</td>
<td>-48%</td>
<td>-129.9 (-289.3, 29.4)</td>
<td>-46%</td>
</tr>
<tr>
<td>Social, Psychosocial, Behavioral, and Biomedical Factors</td>
<td>-27.3 (-157.2, 102.7)</td>
<td>-61%</td>
<td>-143.3 (-285.9, -0.8) (^*)</td>
<td>-56%</td>
<td>-85.4 (-237.5, 66.7)</td>
<td>-64%</td>
</tr>
</tbody>
</table>

\(^1\) Unadjusted for non-drug use variables (adjusted for other drug use)
Social factors include maternal age, money for necessities, and housing
Psychosocial factors include stress and pregnancy locus of control
Behavioral factors include cigarette smoking and early prenatal care
Biomedical factors include hypertensive disorders, other medical risk factors, pre-pregnancy weight, and net weight gain

\(p<0.05, ^\dagger p<0.01, ^* p<0.001\)
Table 5.5. Logistic Regression Results of LBW and Drug Use

<table>
<thead>
<tr>
<th></th>
<th>Marijuana OR (95% CI)</th>
<th>% Change</th>
<th>Cocaine OR (95% CI)</th>
<th>% Change</th>
<th>Opiates OR (95% CI)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted1</td>
<td>1.24 (0.76, 2.05)</td>
<td>--</td>
<td>1.93 (1.15, 3.21)</td>
<td>*</td>
<td>2.06 (1.19, 3.58)</td>
<td>†</td>
</tr>
<tr>
<td>Adjusted For</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Factors</td>
<td>1.17 (0.70, 1.96)</td>
<td>-29%</td>
<td>1.65 (0.95, 2.89)</td>
<td>-30%</td>
<td>2.25 (1.26, 3.99)</td>
<td>†</td>
</tr>
<tr>
<td>Social and Psychosocial Factors</td>
<td>1.20 (0.82, 2.54)</td>
<td>-17%</td>
<td>1.44 (0.82, 2.54)</td>
<td>-53%</td>
<td>2.10 (1.17, 3.76)</td>
<td>*</td>
</tr>
<tr>
<td>Social, Psychosocial, and Behavioral Factors</td>
<td>1.05 (0.61, 1.79)</td>
<td>-79%</td>
<td>1.16 (0.65, 2.08)</td>
<td>-83%</td>
<td>1.57 (0.86, 2.87)</td>
<td>-46%</td>
</tr>
<tr>
<td>Social, Psychosocial, Behavioral, and Biomedical Factors</td>
<td>1.17 (0.66, 2.06)</td>
<td>-29%</td>
<td>1.16 (0.63, 2.16)</td>
<td>-83%</td>
<td>1.69 (0.90, 3.17)</td>
<td>-35%</td>
</tr>
</tbody>
</table>

* p<0.05, † p<0.01, ‡ p<0.001
1 Unadjusted for non-drug use variables (adjusted for other drug use)
Social factors include maternal age, money for necessities, and housing
Psychosocial factors include stress and pregnancy locus of control
Behavioral factors include cigarette smoking and early prenatal care
Biomedical factors include hypertensive disorders, other medical risk factors, and pre-pregnancy weight
CHAPTER SIX

NEIGHBORHOOD EFFECTS ON BIRTH WEIGHT:
AN EXPLORATION OF PSYCHOSOCIAL AND BEHAVIORAL PATHWAYS
Abstract

Neighborhood characteristics have been proposed to influence birth outcomes through psychosocial and behavioral pathways, yet empirical evidence is lacking. Using data from an urban, low-income sample, this study examined the impact of the neighborhood environment on birth weight and evaluated mediation by psychosocial and behavioral factors. The sample included 726 women who delivered a live birth at Johns Hopkins Hospital between 1995 and 1996. Census tract data were used to create a principal component index of neighborhood risk based on racial and economic stratification (% Black, % poverty), social disorder (violent crime rate), and physical deterioration (% boarded-up housing) (α=0.82). Information on sociodemographic, psychosocial, and behavioral factors was gathered from a postpartum interview and medical records. Random intercept multilevel models were used to estimate neighborhood effects and assess potential mediation. Controlling for sociodemographic characteristics, a standard deviation increase in neighborhood risk conferred a 76 gram birth weight decrement (p=0.01). This represents an approximate 300 gram difference between the best and worst neighborhoods (4SD*76g). Although stress (daily hassles), locus of control, and social support were related to birth weight, their adjustment reduced the neighborhood coefficient by only 12%. In contrast, the neighborhood effect was reduced by an additional 30% and was no longer significant after adjustment for the behavioral factors of smoking, drug use, and delayed prenatal care. These findings suggest that neighborhood factors may influence birth weight by shaping maternal behavioral risks. Thus, neighborhood level interventions should be considered to address multiple maternal and infant health risks. Future studies should examine more direct measures of
neighborhood stress, such as perceived neighborhood disorder, and evaluate alternative mechanisms by which neighborhood factors influence behavior (e.g., social norms and access to goods and services).
Introduction

Fueled by the appealing efficiency of population-based prevention, there is a growing body of literature linking the residential environment in which women live to birth outcomes, particularly contextual indicators of socioeconomic disadvantage and residential segregation (1). Neighborhood effects on birth weight, low and very low birth weight, and their subcomponents of preterm birth and growth restriction, have been observed independent of various individual level characteristics. The notion of “independent” effects, however, may be fallacious as neighborhood influences on individual health must ultimately operate through some mechanism on the individual. A frequent exhortation of contextual critiques is to move beyond “black box” epidemiology toward the examination of theory-based exposures and pathways through which neighborhoods influence health (2-6).

While many researchers have proposed psychosocial and behavioral pathways for neighborhood effects on birth outcomes, empirical exploration is lacking. Observed independent effects may be due to confounding by omitted sociodemographic variables that influence the selection of neighborhoods or true effects whose mediators have not been identified or properly evaluated. Largely due to the data constraints of vital records, few multilevel studies of birth outcomes have controlled for the individual level characteristics that parallel aggregated census variables, making it difficult to distinguish contextual versus compositional effects. Moreover, no studies have evaluated psychosocial pathways via stress or self-efficacy, while others have controlled for the behavioral factors that may mediate rather than confound the effects of neighborhood context. Likewise, the bulk of perinatal research conducted at the individual level
identifies psychosocial, behavioral, and biological risk factors divorced from the contextual/environmental factors that may shape and sustain them.

Using a biopsychosocial framework, the present study integrates individual and contextual approaches by exploring potential individual level pathways through which neighborhood disadvantage may influence birth weight. Specifically, psychosocial, behavioral, and biological mediation is evaluated, while controlling for individual level sociodemographic characteristics that may confound neighborhood effects. The elucidation of neighborhood pathways may promote causal theory and holds promise to inform strategies for intervention at multiple levels.

**Background**

The neighborhood variables most frequently linked to birth outcomes are census-based indicators of socioeconomic deprivation and racial composition or segregation that proxy structural attributes. Socioeconomic indicators, including income, education, employment, occupation, and housing, measured at the level of census block group, tract, or tract clusters have been associated with birth weight (7-10), low birth weight (11-14), PTB (15-17), gestational age, and fetal growth (18). Studies in Europe and Canada have shown similar associations among equivalent administrative units (19-22). These studies frequently control for a single individual level socioeconomic indicator, generally education, although a few studies have demonstrated effects independent of individual level income (9, 15, 17). Racial density or segregation is also commonly associated with various birth outcomes. Black-white segregation indices and the % Black are often related to adverse outcomes including LBW and infant mortality at the census tract (10,
23) and MSA levels (24, 25) Polednak, LaViest), although some positive effects have been noted (26, 27).

In addition to main effects, indicators of disadvantage have been found to modify the effect of maternal age, such that older age carries added risk in more disadvantaged environments (12, 14). Several other studies have observed effects of neighborhood disadvantage on adverse birth outcomes among Black but not White women (8, 9, 13, 15, 17).

The actual features and processes that characterize racially and socioeconomically stratified neighborhoods and that may influence an array of health endpoints, including birth outcomes, have been largely conceptualized along dimensions of the physical, social, and service environments that impact social norms, processes, and access to resources (1, 28). Relatively few studies of birth outcomes have examined these neighborhood attributes that are not purely aggregated individual-level census variables.

Aspects of the physical and social environment that have been related to various birth outcomes include the stressors of vacant or boarded up housing (17, 18) and violent crime (10, 29-31), air pollution (32), and the positive dimension of neighborhood social cohesion (8, 10).

The service environment encompasses the quantity and quality of outlets for food and physical activity as well as health care. Several studies have not reported associations between area availability of prenatal or primary care and birth outcomes (33, 34), although others have found positive influences of primary care at larger levels of aggregation (35, 36). A more recent study also found no association between various census-tract outlet densities (tobacco and alcohol outlets, supermarkets, or fast food
restaurants) and fetal growth or gestational age (18). It is possible that health behaviors may be influenced irrespective of the availability of services via social norms or psychosocial factors, and/or that the meaningful area unit for services was not measured.

**Proposed Pathways**

The proposed individual level pathways through which neighborhood context may influence birth outcomes include psychosocial, behavioral, and biological factors. A conceptual model, found in figure 6.1, depicts the potential direct and indirect neighborhood pathways that may influence the proximate biological production of adverse birth outcomes. There is both theoretical and empirical evidence linking neighborhood context to a variety of psychosocial, behavioral, and biological predictors of perinatal health.

Figure 6.1. Conceptual Model of Neighborhood Effects on Birth Outcomes

*Psychosocial Factors*

Residents of disadvantaged neighborhoods are exposed to more stressful life events, daily hassles, and chronic stressors (37, 38), including ambient hazards or
social/physical disorder (e.g. graffiti, noise, crime, abandoned houses) (39, 40), and have
greater risk of depressive symptoms (39, 41-43). In addition to promoting stress, living
in a disadvantaged neighborhood may also diminish social and psychological assets, such
as social support, self-efficacy, and internal locus of control. Perceptions of crime and
disorder have been related to social isolation and feelings of powerlessness (40).

At the individual level, psychosocial factors may have direct biological effects on
birth outcomes via neuroendocrine, immune, and vascular mechanisms that influence the
timing of delivery directly and secondarily through susceptibility to infection and
hypertensive disorders (44). Both stress and social support have been connected to
neuroendocrine parameters that regulate parturition and uteroplacental transfer (45).
Stress, in particular, is most consistently related to LBW and preterm delivery, with
between 1.5 to 2-fold increased risks observed in both prospective and retrospective
studies (46). Chronic stress, as opposed to acute stress, is considered to be most
detrimental given its cumulative toll on multiple physiologic systems, known as allostatic
load (47). In a study of pregnant women, an indicator of neighborhood stress (homeless
rate) was found to predict rates of bacterial vaginosis—a marker for infection that has
been related to preterm birth, independent of sociodemographic characteristics, sexual
behavior, and perceived stress (48).

**Health Behaviors**

Indicators of neighborhood disadvantage have also been related to several health
behaviors linked to adverse birth outcomes, including substance use (49), delayed entry
to prenatal care (50), and poor dietary intake and/or physical activity (51). The stress,
hopelessness, and fatalism that can result from stratification and residence in
disadvantaged neighborhoods may foster the adoption and/or maintenance of adverse
health behaviors as self-medicating coping mechanisms (52). Psychological distress has
been found to partially mediate the influence of neighborhood disorder and disadvantage
on both drug use and frequency of drug use (42, 53). Residence in disadvantaged
neighborhoods may also constrain choices and opportunities. For example, prenatal care
may be a less prominent priority in daily conditions of neighborhood stress and
disadvantage. There is also some evidence that fear of crime and lack of perceived
neighborhood safety may reduce physical activity (54, 55).

In addition to psychosocial pathways, neighborhood effects on health behaviors
may be explained by shared norms or social contagion. The proportion of area residents
who smoke, for example, is strongly associated with the average quantity smoked, above
and beyond individual socioeconomic status, which tends to support the role of normative
transmission (56). Neighborhoods may also influence behaviors based on access to
resources (i.e. drug availability, density of fast-food outlets, parks and recreation
facilities, prenatal clinics). For example, there are fewer supermarkets in disadvantaged
areas and the presence of more neighborhood supermarkets is associated with greater
consumption of fruits and vegetables, independent of individual income and education
(57, 58).

**Study Purpose and Objectives**

The purpose of this study was to evaluate the effect of neighborhood environment
on birth outcomes and to explore proposed pathways suggested in the literature.
Accordingly the objectives were 1) to determine the impact of neighborhood context independent of individual sociodemographic confounders and 2) to assess mediation via psychosocial, behavioral, and biological factors. Secondarily, the indirect effects of individual psychosocial characteristics via behavioral and biological factors and of health behaviors via biological factors were also explored.

Methods

Study Design and Sample

The sample for this analysis comes from a hospital-based study designed to examine the patterns and barriers to prenatal care in a low-income, urban setting. Recruitment occurred in the postpartum unit and eligibility was restricted to women who had received prenatal care at the Johns Hopkins Hospital or a satellite clinic and those who had not received care at all. All women with evidence of drug use (medical record, self-report, or toxicological screen) or no prenatal care, and two out of three remaining women were selected to participate. Informed consent was obtained prior to participation and women were compensated with $15 for their time in completing the 1 hour postpartum interview. Highly trained survey staff helped to achieve a 93% participation rate among eligible women.

The study sample included 824 women, aged 19 or older, who delivered a live birth or fetal death weighing at least 500 grams between February 1995 and June 1996. The 808 women who delivered singleton, live births were selected for analysis. An additional 10% of the sample who lived outside the city (n=33) and those whose
addresses were unable to be geocoded (n=48) were excluded from analysis, resulting in a final analytic sample of 726 women (88% of the total sample).

Data were primarily collected from the postpartum interview, which gathered information on social and psychosocial characteristics using standardized instruments, as well as behavioral factors, including a detailed drug use history. Medical records also were abstracted to determine infant birth characteristics, prenatal care utilization, drug use (from toxicology screens or report by a healthcare provider), and the presence of medical risk factors.

Birth Outcomes

Birth weight was selected as the primary dependent variable, modeled as a continuous rather than binary outcome (LBW, <2500 grams), to preserve statistical power and precision. Continuous birth weight may also be more sensitive in capturing potentially subtle effects of the neighborhood environment on fetal growth or the timing of delivery (in shifting the distribution). Reductions in birth weight and its proximate determinants, fetal growth restriction and preterm birth, are linked to morbidity and mortality in childhood (59, 60), cognitive delays (61, 62), and adult-onset diseases (63). Fetal growth restriction and preterm birth were not examined directly out of concern for the validity of gestational age estimation in a sample overrepresented for drug use and lack of prenatal care.
Neighborhood Variables

Neighborhoods were defined according to the census tract, a commonly used administrative unit in neighborhood research that captures the immediate local environment. Census tracts contain an average of 4,000 residents and were created as relatively small geographic statistical units with homogeneous sociodemographic composition (64). Other research has demonstrated the predictive utility of census tract economic indicators with respect to birth outcomes (65).

Contextual sociodemographic and housing data are from the 1990 U.S. Census. Tract level crime statistics from 1995 were obtained from the Baltimore City Police Department. Because of the colinearity of neighborhood variables, a single index was created through principal component analysis that captured theoretically meaningful and distinct constructs of neighborhood structural indicators and processes. The structural-process risk (SPR) index includes two structural indicators of racial and economic stratification (% Black, % poverty) and two process indicators of social disorder (violent crime rate per 1,000) and physical deterioration (% boarded-up housing). The Cronbach $\alpha$ coefficient for the index was 0.82, indicating appropriate reliability. Table 6.1 shows the descriptive statistics and principal component score loadings for the four neighborhood variables. There were 126 census tracts represented among the sample with an average of 5.8 subjects per tract and a range of 1 to 40. One extreme outlier for violent crime with significant leverage was recoded to the average crime rate given the poverty level of the tract. The index was standardized with a mean of zero and a standard deviation of 1 with values ranging from -1.95 to 1.97. Table 6.2 describes the distribution of the four neighborhood variables according to tertile of neighborhood risk.
Individual Level Variables

Sociodemographic Factors

A range of sociodemographic factors were examined to control for compositional influences (separate compositional from contextual effects). These included maternal age, race, relationship with the father of the baby, employment during pregnancy, education, money for necessities, public assistance (welfare, Supplemental Security Income, or Medicaid), and home ownership. Money for necessities (e.g. food, housing, heating) was measured by a 7-item subscale of the Family Resources Scale (sample Cronbach α = 0.87) (66).

Psychosocial Factors

Three psychosocial variables related to birth outcomes and that may be influenced by the neighborhood environment were examined: stress, locus-of-control, and social support. Stress was measured with a validated 12-item Hassles Scale (67), that assesses chronic stress during pregnancy due to daily difficulties and circumstances (e.g. money worries, general overload, stress due to crime in the neighborhood) (sample Cronbach α = 0.80). Locus-of-control specific to pregnancy was measured by 5 related items in the Pregnancy Belief Scale (68) and refers to the extent to which a woman believes that her pregnancy outcome is under internal control versus chance or fate (sample Cronbach α = 0.72). Internality is a construct akin to self-efficacy. A measure of social support was defined as having two or more social network members to discuss problems with either sometimes or often. This measure captures the dimension of emotional support most often related to birth outcomes.
**Behavioral Factors**

Health behaviors included substance use and prenatal care utilization. Self-reported *smoking* and *alcohol consumption* during pregnancy were ordinally categorized by the average number of cigarettes smoked per day (0, 1-9, or 10+) and the frequency of drinking (never, monthly, or weekly). *Hard drug use* of cocaine or opiates was determined by self-report, documentation in the medical record, or a urine screen at delivery. *Early prenatal care* was defined as a first visit within the first trimester with four or more total visits.

**Biomedical Factors**

Several biomedical factors were examined that may be responsive to neighborhood stressors and resources. An indicator variable of *hypertensive disorders*, including chronic hypertension, pregnancy-induced hypertension, preeclampsia, or eclampsia, captured cardiovascular risk. Another global indicator of *infection* included gonorrhea, syphilis, Hepatitis, HIV/AIDS, chorioamnionitis, and pyelonephritis. The medical record was used to determine the presence of these biological risk factors. Nutritional status was measured by *prepregnancy weight* and *net weight gain* during pregnancy (subtracting infant birth weight). These variables were constructed from a combination of information obtained in the medical record and postpartum interview.

**Statistical Analyses**

The objectives of the analysis were to 1) determine the influence of neighborhood risk on birth weight independent of individual sociodemographic confounders, and 2) to
evaluate the psychosocial, behavioral, and biomedical pathways through which neighborhood risk may impact birth weight. First, individual level characteristics were examined according to neighborhood risk tertiles to determine preliminary associations requisite for confounding and mediation. Statistical significance was evaluated with chi-square tests for categorical variables and ANOVA for continuous variables. Scalar variables (money for necessities, stress, locus-of-control) were summed and categorized according to the average item response to preserve the meaning of original categories.

To examine the effect of the neighborhood risk index on birth weight, random intercept multilevel linear regression models were performed using SAS Proc MIXED (69). Multilevel models with neighborhood random intercepts account for the variation between neighborhoods and appropriately adjust the standard errors for the clustering of observations within neighborhoods. Models were constructed sequentially following the conceptual framework. A baseline model estimated the total neighborhood effect controlling for known sociodemographic confounders. Hypothesized psychosocial, behavioral, and biomedical mediators were then sequentially added to examine pathways by the resulting change in neighborhood effects. Based on empirical fit (exploratory observation of a linear association in non-parametric lowess graphs), the risk index was modeled continuously to maximize power and avoid arbitrary percentile cutoffs. Residential mobility during pregnancy was controlled for in all models.

**Results**

Consistent with the population of low-income, inner city Baltimore, sample women were predominantly Black, receiving public assistance, and had less than a high
school education. Oversampling for drug use and lack of prenatal care likely exaggerated the disadvantaged nature of the sample, yet there was sufficient variability in residential context to examine neighborhood influences (Tables 1 and 2). Table 6.3 details the sample distribution of other psychosocial, behavioral, and biomedical factors.

The sociodemographic characteristics of race, cohabitation, education, money for necessities, public assistance, and home ownership were associated with neighborhood risk. Women who were less educated and with fewer economic resources were more likely to live in disadvantaged neighborhoods. Among the proposed mediators, neighborhood risk was associated with stress, locus-of-control, emotional support, substance use, prenatal care, infection, and net pregnancy weight gain. Women who lived in more disadvantaged (riskier) neighborhoods had greater stress levels, reported less internal locus-of-control and emotional support, and were more likely to smoke, drink alcohol, use hard drugs, and to have late or no prenatal care, an infection or inadequate weight gain during pregnancy. The strongest associations with neighborhood risk were observed for smoking, hard drug use, and net weight gain.

Neighborhood Effects on Birth Weight (Table 6.4)

In multilevel models controlling for individual level sociodemographic confounders, neighborhood risk was associated with birth weight. A 1 SD increase in neighborhood risk was associated with a 76g decrement in birth weight (95% CI: -137, -16; p=0.01). This corresponds to an approximate 300g difference between the best and worst neighborhoods (4SD*76g=304g), the magnitude of which was similar to material
hardship at the individual level. The index of neighborhood risk explained nearly 80% of the variation between neighborhoods (not shown).

Mediation

Adjustment for the proposed psychosocial mediators of stress, locus-of-control, and emotional support, modestly reduced the effect of neighborhood risk (12% reduction). Stress and locus-of-control were strongly related to birth weight and appeared to explain more of the individual level effects of sociodemographic characteristics, including maternal age, education, and money for necessities.

After controlling for potential behavioral mediators of substance use and early prenatal care, the neighborhood risk coefficient was reduced by an additional 30% and was no longer significant. Smoking in particular was strongly related to birth weight and alone accounted for two-thirds of the reduction. These behavioral factors appeared to mediate between 20-40% of the effects of psychosocial factors and further reduced effects related to maternal age, education, and money for necessities.

Additional model entry of biomedical mediators explained an extra 10% of the neighborhood risk coefficient. This attenuation was attributable to both medical conditions and the indicators of nutritional status. Closer examination revealed that mediation by medical conditions was explained entirely by the more severe conditions of preeclampsia and chorioamnionitis, which were more common in higher risk neighborhoods. Controlling for biomedical factors further attenuated the individual level effects of sociodemographic variables and behavioral factors, but not the psychosocial factors of stress and locus of control, which remained significant.
Additional models with proposed psychosocial and behavioral mediators modeled as dependent variables confirmed that neighborhood risk was significantly related only to behavioral risk factors (smoking, drug use, lack of early prenatal care) after controlling for sociodemographic characteristics.

Discussion

The results of this study provide further confirmation that neighborhood structures and processes may influence birth outcomes independent of sociodemographic composition. In this already low-income sample with added control for education, adequacy of resources for necessities, public assistance, and home-ownership, women residing in the most disadvantaged neighborhoods delivered infants approximately 300 grams lighter on average than women who lived in the least disadvantaged neighborhoods. The magnitude of this contextual effect was similar to that of individual level risk factors, and may have a large population impact given the high prevalence of residence in risky neighborhoods. The linear nature of the observed association is consistent with other studies, suggesting a gradient rather than threshold effect of neighborhood risk. And while it is appropriate to control for the sociodemographic characteristics that influence the selection of neighborhoods, the contextual effect noted may be conservatively estimated since individual/adult socioeconomic status can also be determined by neighborhood resources and opportunity structures.

In this study, stress, locus-of-control, and emotional network support were associated with neighborhood risk but only modestly explained the neighborhood effect. Instead, direct effects on health behaviors, particularly smoking and hard drug use,
accounted for the largest fraction (~1/3) of the neighborhood risk effect. Further control for biomedical factors explained an additional 10% of the neighborhood effect. No prior multilevel studies of birth outcomes have incorporated individual level psychosocial factors or quantified the extent of mediation by these and other behavioral and biomedical factors.

The relative lack of psychosocial mediation may be explained by inadequate or imprecisely measured constructs or a true lack of strong neighborhood level mediation. The measure of stress used in the study was a validated instrument assessing daily hassles that should theoretically be related to neighborhood context. However, the scale more clearly mediated individual level socioeconomic status and only one item specifically captured a neighborhood level feature (stress because of crime in the neighborhood). More specific examination of the violent crime – stress theory revealed a significant correlation between violent crime and the single item reflecting stress because of crime in the neighborhood. However, stress due to neighborhood crime did not mediate the relation between violent crime and birth weight as this single item was unrelated to birth weight after controlling for sociodemographic factors. A study examining psychosocial stressors in North Carolina similarly found no association between perceived neighborhood safety and PTB (70). Another multilevel study in California also did not find that perceived neighborhood safety explained the effect of neighborhood economic indicators on birth weight (9).

Future studies should assess more specific measures of perceived neighborhood problems and stressors that may lend credibility to objective measures of social and physical disorder and mediate indicators of disadvantage (for examples see Steptoe &
A growing body of literature has linked perceptions of neighborhood disorder (e.g. litter, loitering, graffiti, vacant properties, civil incivilities) to mental health (39, 41, 71), substance use (72, 73), and general health status (74-76). Systematic social observation may be preferred over individual subjective ratings to prevent the same-source bias that can induce a correlation irrespective of the actual quality of the neighborhood (77). A recent study, however, did not find that systematically observed signs of physical disorder (graffiti, beer cans, cigarette butts, broken glass, abandoned cars) were related to LBW (78).

It is also possible that instead of having direct psychosocial effects, neighborhood risk may exacerbate personal vulnerabilities. For example, in a sample of African-American women, Cutrona et al found that neighborhood disadvantage/disorder magnified the effect of negative life events on incident depression (43). Another study also found that the positive dimension of neighborhood stability buffered the impact of stress on self-reported physical health (38). In the present study, however, interactions between the neighborhood risk index and individual level variables were tested and none were found to be significant although the sample may not have been adequately powered to examine cross-level interactions.

Health behaviors, primarily smoking and illicit drug use, by far accounted for the largest portion of the neighborhood effect on birth weight. This is consistent with many studies linking both objective and perceived indicators of neighborhood disadvantage and disorder to smoking (56, 79, 80) and drug use (42, 53), including use during pregnancy (49). Aside from psychosocial pathways, which were not observed in this study, neighborhoods may influence substance use through substance availability (81, 82),
social contagion and norms and/or the absence of social control against adverse health behaviors (56, 79), and potentially through access to treatment. Further research is needed to determine the relative role of these factors and in what phase of use (i.e. initiation, progression, cessation) to determine strategies for intervention (83).

Direct mediation through biomedical risk factors was not hypothesized given the control for psychosocial and behavioral determinants. The modest reduction in the neighborhood effect observed when controlling for biomedical factors may be explained by residual mediation via imprecisely measured or omitted variables. For example, the behavioral determinants (diet and exercise) of weight and weight gain were not measured and could not be controlled. The absence of a bivariate association between hypertensive disorders and neighborhood risk may be explained by surveillance bias given that the majority of the sample received late or little prenatal care and this varied by neighborhood risk.

A distinct limitation of this study was the inability to disentangle the effects of specific neighborhood structures and processes given their considerable colinearity. Selecting one of the theoretically and statistically related indicators versus creating a composite index has been described as the choice between dishonest specificity and honest ambiguity (84). The latter “honest” approach of creating an index was preferred to account for a greater share of the total variation. The four variable index, capturing both structures and processes, explained close to 80% of the neighborhood level variation in the random intercept. Due to the lack of available data, the index did not incorporate any positive attributes of community social cohesion or collective efficacy, such as the density of churches or community organizations. A prior population-based study in
Baltimore, however, did not report an association between the number of community
groups and LBW at the census tract level (12).

Because sample women were predominantly Black and low-income, these results
may not extend to more advantaged, non-Black populations. In particular, neighborhood
effects may be smaller for White, non low-income women as other studies of birth
outcomes have noted stronger effects of neighborhood disadvantage for Black than White
women (8, 9, 17). Studies of other health outcomes have also shown that the effect of
neighborhood disadvantage is more consequential for low-income individuals (53, 85).
This phenomenon of “double jeopardy”, wherein persons most likely to reside in
disadvantaged neighborhoods are also most likely to be affected by them, may be due to
lack of buffering resources and/or more time spent in the neighborhood among low-
income, Black populations with fewer options for mobility.

The cross sectional nature of the study represents the chief limitation constraining
causal inference. Observed neighborhood effects may be the result of endogeneity and
unidentified factors that influence the sorting of people into neighborhoods (86). It is
difficult to imagine, however, that net of sociodemographic characteristics, people would
select into and out of neighborhoods on the basis of psychosocial, behavioral, or
biomedical factors. Moreover, residential mobility during pregnancy was controlled for
in all models. It was assumed that women likely move into and out of similar
neighborhoods and neighborhood effects were not appreciably different according to
mobility, lending support to this hypothesis. Nevertheless, the presence of drug use in
neighborhoods may have led to or hastened deterioration of the physical and social
environment as a result of out-migration. Longitudinal, experimental, or intervention studies are necessary to rule out possible selection biases.

Conclusions

Overall findings in this urban, low-income sample suggest that neighborhood structures and processes may have an impact on infant birth weight, an outcome with potential consequence throughout the lifecourse, by shaping maternal behavioral risks. As interventions to alter neighborhood quality could impact multiple health endpoints for thousands of individuals at a time, continued research to quantify and qualify neighborhood influences may yield substantial health gains. Although daily hassles, internality, and network support were not prominent pathways through which neighborhoods affected birth weight, future research might evaluate the role of perceived neighborhood disorder and better delineate the mechanisms by which neighborhoods produce adverse health behaviors. Longitudinal designs assessing changes over time in both neighborhood features and birth outcomes, and natural experiments of community change, would go farthest in promoting causal inference.


78. Wei E, Hipwell A, Pardini D, Beyers JM, Loeber R. Block observations of neighbourhood physical disorder are associated with neighbourhood crime, firearm injuries and deaths, and teen births. *J Epidemiol Community Health* 2005;59:904-8.


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Table 6.1. Neighborhood Characteristics (N=126)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD)</th>
<th>Min</th>
<th>Max</th>
<th>PC Score Loadings</th>
</tr>
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<tbody>
<tr>
<td>% Black</td>
<td>69.2 (35.0)</td>
<td>0.9</td>
<td>99.7</td>
<td>0.26</td>
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<tr>
<td>% Poverty</td>
<td>26.1 (17.3)</td>
<td>2.5</td>
<td>79.2</td>
<td>0.32</td>
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<tr>
<td>Violent Crime Rate</td>
<td>35.3 (21.4)</td>
<td>4.3</td>
<td>113.5</td>
<td>0.33</td>
</tr>
<tr>
<td>% Boarded-Up Housing</td>
<td>1.9 (2.7)</td>
<td>0</td>
<td>13.8</td>
<td>0.32*</td>
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</table>

Score loading for the natural log of boarded-up housing
Table 6.2. Distribution of Neighborhood Variables According to Neighborhood Risk Tertile

<table>
<thead>
<tr>
<th>Neighborhood Risk Index</th>
<th>% Black Mean (SD)</th>
<th>% Poverty Mean (SD)</th>
<th>Violent Crime Rate Mean (SD)</th>
<th>% Boarded Up Housing Mean (SD)</th>
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</thead>
<tbody>
<tr>
<td>Lower Tertile</td>
<td>36.5 (32.2)</td>
<td>10.6 (5.4)</td>
<td>16.6 (7.9)</td>
<td>0.2 (0.3)</td>
</tr>
<tr>
<td>Middle Tertile</td>
<td>76.6 (28.8)</td>
<td>23.1 (11.2)</td>
<td>31.8 (11.6)</td>
<td>1.0 (1.1)</td>
</tr>
<tr>
<td>Upper Tertile</td>
<td>92.8 (13.1)</td>
<td>44.3 (12.6)</td>
<td>56.9 (18.4)</td>
<td>4.7 (3.1)</td>
</tr>
</tbody>
</table>
Table 6.3. Individual Characteristics According to Neighborhood Risk Tertile

<table>
<thead>
<tr>
<th>Sociodemographic Control Variables</th>
<th>Total N(%)</th>
<th>Neighborhood Risk Tertile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>First 109(15)</td>
</tr>
<tr>
<td><strong>Maternal Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>377(52)</td>
<td>51.4</td>
</tr>
<tr>
<td>25-34</td>
<td>288(40)</td>
<td>38.5</td>
</tr>
<tr>
<td>35+</td>
<td>61(8)</td>
<td>10.1</td>
</tr>
<tr>
<td><strong>Race†</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>693(95)</td>
<td>87.2</td>
</tr>
<tr>
<td><strong>Married or Living with Father of Baby‡</strong></td>
<td>192(26)</td>
<td>40.4</td>
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<tr>
<td><strong>Education‡</strong></td>
<td></td>
<td></td>
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<tr>
<td>&lt; High School</td>
<td>340(47)</td>
<td>33.9</td>
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<tr>
<td>High School or GED</td>
<td>308(42)</td>
<td>38.5</td>
</tr>
<tr>
<td>&gt; High School</td>
<td>78(11)</td>
<td>27.5</td>
</tr>
<tr>
<td><strong>Enough Money for Necessities</strong>*</td>
<td></td>
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p<0.1, *p<0.05, †p<0.01, ‡p<0.001
### Table 6.4. Sequential Multilevel Model Coefficients for Birth Weight (grams)

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<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
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<tr>
<td><em>Education</em></td>
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<tr>
<td>&lt; High School</td>
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<tr>
<td>Almost always</td>
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<tr>
<td><em>Public Assistance</em></td>
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<tr>
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<tr>
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*p<0.1, †p<0.01, ‡p<0.001
CHAPTER SEVEN

CONCLUSIONS
Conclusions

In contrast to common perceptions, the overarching findings of this dissertation show that illicit drug use is not a strong predictor of adverse birth outcomes relative to other concomitant risk factors, suggesting that a more holistic approach to perinatal substance use is warranted. The critical review of the literature in Chapter 4 (Aim 1) revealed that the most consistent epidemiologic finding concerning illicit drug use and birth outcomes is an effect of cocaine use on fetal growth restriction—a finding that is supported by biologic plausibility via vasoconstrictive mechanisms. However, no studies have accounted for the full spectrum of social, psychosocial, behavioral, and biomedical risks associated with drug use, particularly the social and psychosocial risks of material hardship, stress, and physical abuse. The empirical analysis of Chapter 5 (Aim2), accounting for this broad array of surrounding factors, showed a 143 gram birth weight decrement associated with cocaine use. Yet, control for these other risk factors, particularly moderate to severe stress (-244 grams), lack of early prenatal care (-109 grams), and heavy smoking (-162 grams), accounted for more than half of the unadjusted effect of cocaine use. Moreover, there were no effects of any type of drug use on LBW, an outcome of greater developmental import.

It is tempting for policymakers and clinicians to focus on easily identifiable behaviors, often cast in an individualized, moralistic sense, as the cause of urban problems. However, this is a myopic, “blame the victim” view that places drug use as a scapegoat for underlying structural issues. Where newborn health is concerned, this analysis clearly shows that prenatal drug use is not a major determinant of adverse outcomes. Cocaine use was found to be one of many factors related to birth weight.
Moreover, it was not related to LBW suggesting only mild birth weight effects via fetal
growth. Thus, elimination of drug use without addressing contextual circumstances for
which drug use is a common symptom, would do little to reduce LBW.

Factors that were found to be independently related to an increased odds of LBW in this low-income, urban sample included older maternal age, residence in public
housing, stress, external locus of control, lack of early prenatal care, hypertensive
disorders, other medical risks, and low prepregnancy weight (Appendix D). Of these factors, the population attributable risk (1, 2) was highest for lack of early prenatal care
given that it occurred for 63% of the sample and was associated with a 2-fold increased
odds of LBW. Assuming causality, 38% of LBW births would have been prevented if all
women had received early prenatal care.1 This statistic should be interpreted with
cautions, however, since women with no prenatal care utilization were oversampled by
design and the causal impact of prenatal care has been debated (3, 4). Nonetheless,
comprehensive prenatal care with linkages to ancillary social and psychosocial services is
likely to be of greatest benefit to low-income women (5).

External locus-of-control had the second largest population attributable risk at
23%, followed by medical risk factors (20%), moderate to severe stress (13%), low
prepregnancy weight (13%), hypertensive disorders (12%), residence in public housing
(12%), and older maternal age (8%). Thus, psychosocial factors had an influence greater
than or equal to biomedical risks. Pregnancy locus-of-control is a construct akin to
mastery and self-efficacy but specific to the context of pregnancy. The measure in this

1 Population attributable risks were calculated based on adjusted relative risks using the method of
Kleinbaum and Schesselman (1). The formula incorporates the proportion of cases exposed to the risk
factor and the relative risk: PD_e*(RR-1)/RR. Relative risks were approximated from odds ratios using a
standard formula (2).
study primarily captured the dimension of internal versus external control. Elevated odds of delivering a LBW infant were noted for women with some (OR: 2.44) or little to no internal locus-of-control (OR: 2.41), compared to women with moderate to strong levels of internal control. Other studies have similarly observed effects of locus-of-control on birth weight (6) and preterm delivery (7). Although women who deliver a LBW infant may be more likely to retrospectively report that they had little control over the outcome of their pregnancy, there is little evidence of recall bias in other studies (8, 9). Moreover, there were no significant differences in NICU admission by locus-of-control, which tends to disprove bias given that infant hospital admission is a more readily perceived adverse outcome. Locus of control may influence health behaviors and psychological resources for stress coping. Moderate to severe stress, in turn, was associated with a more than 2 fold increased odds of LBW, consistent with other research and biologic plausibility (10). Residence in public housing was an important contextual effect that may serve as a marker for environmental stress. It was associated with a 2 fold increase in the odds of LBW and has been related to birth weight in a previous study (6).

In summary, a variety of social, psychosocial, behavioral, and biomedical factors, exclusive of drug use, were predictive of LBW and explained a sizeable proportion of LBW cases. While there have been other studies that have not found drug use, including cocaine, to be associated with LBW, they have been hindered by methodological issues (11-13). For example, two studies recruited women prospectively from prenatal clinics, thereby excluding high risk women who do not receive prenatal care and potentially underestimating associations (12, 13). Visscher et al (2003) relied exclusively on self-reported drug use which may also underestimate drug use and its effects. Major strengths
of this study were the multimethod assessment of drug use and enrollment of women at
delivery to ensure a representative sample of drug users. The restriction of the sample to
low-income women and control for multiple social, psychosocial, behavioral, and
biomedical factors also limited the likelihood of confounding by surrounding factors.
Even studies that report significant cocaine effects on LBW show much smaller
population attributable risks than for smoking (14, 15) but these findings are often lost
among media and policymakers.

Although these results suggest that drug use is not a major contributor to adverse
birth outcomes, the many other adverse health and social consequences of maternal drug
use for both women and their children make treatment and prevention efforts imperative.
In particular, the developmental consequences of an inadequate caregiving environment
are likely to be far more significant than any potential biological effects from prenatal
exposure (16). There is mixed evidence as to whether the association between maternal
drug use and the acute outcomes of child abuse or foster care placement is the result of
the drug use versus surveillance bias or confounding by sociodemographic risks (17-19).
However, drug use and involvement clearly impacts the general availability and adequacy
of caregiving.

The effectiveness of treatment models for substance-dependent women appears to
be contingent on the comprehensiveness of services in addressing social and mental
health, life skills, vocational training, and parenting practices (20, 21). The provision of
ancillary services, including child care and transportation, has been identified as a key
factor in promoting retention—a major determinant of treatment success (21). The
results of Aim 2 revealed that psychosocial stress, smoking, and prenatal care accounted
for the majority of illicit drug effects. Therefore, these factors may warrant special emphasis in treatment programs to improve birth weight for current and subsequent pregnancies. Unfortunately, the need for treatment far exceeds availability; only an estimated one in three women receive treatment (22). Moreover, state trends toward punitive policies may deter women from seeking prenatal care and the limited treatment that is available (23).

Though prenatal and postpartum drug treatment services are imperative to help women break their addiction and improve their life circumstances, treatment is an ameliorative rather than fundamental approach that does not influence the incidence of maternal drug use and abuse. The upstream structural determinants that promote drug abuse must be addressed to affect primary prevention.

As argued by Link and Phelan (1995), it is critical to alter the fundamental social structural determinants of health given that mediating risk factors are fungible, varying over time (24). Older risk factors related to poverty and substandard housing, such as sanitation and immunization, have been replaced by substance use, diet, and exercise. Thus the traditional individual risk factor approach is ineffective because the proximate risk factors will change and evolve if the fundamental root causes are still intact. Individually based approaches also will fail if they ignore the contextual factors that place individuals “at risk of risks” (24). Community stressors, for example, have been identified by addicted women as a barrier to obtaining treatment (25). Neighborhood disadvantage and disorder are also linked to the availability of drugs and the initial opportunity to use (26, 27), as well as the escalation of drug use behaviors (28).
The fundamental importance of the neighborhood environment may be evidenced by its connection to a variety of health behaviors and outcomes, including mortality, chronic disease, mental health, substance use, dietary patterns, physical activity, and violence (29, 30). Neighborhood effects have been noted across the age spectrum, from birth outcomes to elderly cognitive functioning, controlling for individual level sociodemographic characteristics. The features of the neighborhood context that may be relevant for health include social cohesiveness and norms, the quality of the physical environment, and access to goods and services (31, 32).

The neighborhood literature has been criticized out of concern for endogeneity from the selection of neighborhoods (33). There is, however, prospective evidence of effects on mortality controlling for baseline health status (34, 35) and experimental evidence related to mental health (36). The observed effects have been small in magnitude; yet, the multitude of potential health outcomes affected for entire groups of people could yield large dividends for population health. As Link and Phelan note, “an intervention that has even a modest impact on many diseases may be far more important than one that has a relatively strong impact on just one.” A related argument furthered by Rose recognizes that a large number of people at small risk may give rise to more cases of disease than a small number at high risk (37). Birth weight is an outcome of critical importance given its connection to morbidity, mortality, and later lifecourse effects on adult onset diseases, educational attainment, and earnings potential (38-42). As such, early life health may play an important role in reproducing social inequality (43).

In an effort to contextualize risk factors for adverse birth outcomes, the multilevel analysis of Aim 3 (Chapter 6) examined the contribution of the neighborhood
environment to birth weight and evaluated psychosocial and behavioral risk factor pathways. Controlling for individual sociodemographic characteristics, a standard deviation increase in neighborhood risk conferred a 76 gram decrement in birth weight, constituting a near 300 gram (2/3 lb) difference between the best and worst neighborhoods. Moreover, the sample was concentrated in risky neighborhoods so it appears that women were duly burdened by personal as well as neighborhood disadvantage. The neighborhood effect was no longer significant after controlling for behavioral risk factors, suggesting that neighborhoods may influence birth weight by shaping maternal health behaviors. Consistent with the results of Aim 2, smoking was a stronger predictor of birth weight than hard drug use, which was only marginally related to birth weight in the final model.

This study represents the first multilevel analysis to integrate individual and contextual exposures in examining how neighborhoods may influence birth outcomes. Identifying specific neighborhood features and mechanisms will be necessary to inform interventions and requires further research. Neighborhoods may influence health behaviors through psychosocial stress processes, social norms or cohesion, or access to goods or services (i.e. clinics, substances). Although behavioral factors appeared to explain the neighborhood effect independent of psychosocial pathways, the psychosocial instruments did not include items directly related to the neighborhood with the exception of stress because of crime in the neighborhood. Perceptions of neighborhood disorder (i.e. litter, grafitti, loitering, vacant or deteriorating properties) may be more relevant in testing the stress pathway. Although it is difficult to imagine that women would select their neighborhood of residence based on smoking status or prenatal care utilization,
selection or sorting related to hard drug use cannot be overruled in a cross-sectional study.

To be circumspect, neighborhoods are only one part of the contextual landscape and may be a reflection or consequence of other more fundamental structural histories emanating from economic changes. According to William Julius Wilson’s examination of urban decline, deindustrialization and out-migration of middle class residents has resulted in concentrated disadvantage (44). The transition to non-unionized service sector jobs brought about a decline in the living wage concomitant with a rise in the cost of living (45). And the growing residential segregation, economic divestment, and lack of opportunity disintegrated the social fabric of neighborhoods, allowing disorder to fester with emergent drug economies.

Therefore, external neighborhood interventions may not be sustainable without a comprehensive approach that addresses the factors that led to neighborhood deterioration. Efforts should be pursued jointly with community groups, city governments, and businesses in affecting structural determinants such as the living wage, housing quality, education, and criminal justice policies. In this study, some degree of material hardship affected almost half the sample and was significantly related to lower birth weight. In contrast, the receipt of public assistance was associated with improvements in birth weight, consistent with evidence regarding material transfers in cash and food stuffs (46). These findings reinforce the oft-made assertion that economic policy is health policy. As Lynch et al (2001) conclude:
“It is strategic investments in neo-material conditions via equitable distribution of public and private resources that are likely to have the most impact on reducing health inequalities and improving public health in the 21st century.”(47)

Overall, this contextual examination of drug use and neonatal health showed that drug use was not a strong risk factor for adverse birth outcomes. Other factors, including housing, psychosocial stress, locus of control, smoking, and prenatal care, were stronger determinants of birth weight that may warrant intervention both in drug treatment and the general urban population. However, the individual risk factor approach is woefully inefficient in ignoring the fundamental contextual factors that shape multiple health risks for numerous individuals. Results from this low-income sample suggest that neighborhood disadvantage may influence infant health by promoting maternal risk behaviors related to substance use and delayed prenatal care. Individual level material hardship was also strongly related to birth weight and appeared to be mediated by psychosocial and behavioral risks. Future contextual research should 1) better identify specific neighborhood attributes that carry relevance for multiple health behaviors and outcomes, 2) take advantage of natural experiments of neighborhood change, community trials, or longitudinal designs to promote causal inference, and 3) consider the fundamental social structural processes that historically produced and continue to perpetuate personal and neighborhood disadvantage in urban areas.
References


APPENDICES
APPENDIX A: Instruments for Scalar Social and Psychosocial Variables

Family Resources Scale
Money for Necessities Subscale

Responses range from 1-5
1=Almost always
2=More than half the time
3=About half the time
4=Less than half the time
5=Almost never

<table>
<thead>
<tr>
<th>#</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How often did you have enough money to buy food for 2 meals a day while you were pregnant?</td>
</tr>
<tr>
<td>2</td>
<td>How often did you have enough money to pay the rent or mortgage for your apartment or house?</td>
</tr>
<tr>
<td>3</td>
<td>How often did you have enough money to pay for other necessities such as heat for your home or to pay your electric bill?</td>
</tr>
<tr>
<td>4</td>
<td>How often did you have enough money to buy enough clothes for your family?</td>
</tr>
<tr>
<td>5</td>
<td>How often did you have enough heat for your house or apartment?</td>
</tr>
<tr>
<td>6</td>
<td>How often did you have enough money to pay your monthly bills?</td>
</tr>
<tr>
<td>7</td>
<td>How often did you have enough furniture for your home or apartment?</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.87
**Hassles Scale**
Responses range from 1-4
1=No stress
2=Some stress
3=Moderate stress
4=Severe stress

<table>
<thead>
<tr>
<th>#</th>
<th>To what extent (was/were) [OPTION] a hassle for you during your pregnancy?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Worries about food, shelter, health care, and transportation</td>
</tr>
<tr>
<td>2</td>
<td>Money worries like paying bills</td>
</tr>
<tr>
<td>3</td>
<td>Problems related to family</td>
</tr>
<tr>
<td>4</td>
<td>Having to move, either recently or in the future</td>
</tr>
<tr>
<td>5</td>
<td>A recent loss of a loved one</td>
</tr>
<tr>
<td>6</td>
<td>The pregnancy itself</td>
</tr>
<tr>
<td>7</td>
<td>Sexual, emotional or physical abuse</td>
</tr>
<tr>
<td>8</td>
<td>Problems with alcohol or drugs</td>
</tr>
<tr>
<td>9</td>
<td>Work problems</td>
</tr>
<tr>
<td>10</td>
<td>Problems with your friends</td>
</tr>
<tr>
<td>11</td>
<td>Feeling generally “overloaded”</td>
</tr>
<tr>
<td>12</td>
<td>Crime in your neighborhood</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.80
**Family Support**

Responses range from 1-4
1=Almost always
2=Sometimes
3=Hardly ever
4=Never

<table>
<thead>
<tr>
<th>#</th>
<th>In general, how would you describe your family when a problem arises?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Each person is on his or her own to solve the problem?</td>
</tr>
<tr>
<td>2</td>
<td>We try to help each other come up with a way to deal with the problem?</td>
</tr>
<tr>
<td>3</td>
<td>In general, on a day to day basis, would you say that the members of your family look out for each other?</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.80
Depressive Symptoms (CES-D)
Responses range from 1-4
1 = Rarely or none of the time (less than 1 day a week)
2 = Some or a little of the time (1-2 days a week)
3 = Occasionally or a moderate amount of time (3-4 days a week)
4 = Most or all of the time (5-7 days a week)

<table>
<thead>
<tr>
<th>#</th>
<th>Please tell me the phrase on this card that best describes how often you felt or behaved this way during your pregnancy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I was bothered by things that usually don’t bother me</td>
</tr>
<tr>
<td>2</td>
<td>I did not feel like eating; my appetite was poor</td>
</tr>
<tr>
<td>3</td>
<td>I felt that I could not shake off the blues even with help from my family or friends</td>
</tr>
<tr>
<td>4</td>
<td>I felt that I was just as good as other people</td>
</tr>
<tr>
<td>5</td>
<td>I had trouble keeping my mind on what I was doing</td>
</tr>
<tr>
<td>6</td>
<td>I felt depressed</td>
</tr>
<tr>
<td>7</td>
<td>I felt that everything I did was an effort</td>
</tr>
<tr>
<td>8</td>
<td>I felt hopeful about the future</td>
</tr>
<tr>
<td>9</td>
<td>I thought my life had been a failure</td>
</tr>
<tr>
<td>10</td>
<td>I felt fearful</td>
</tr>
<tr>
<td>11</td>
<td>My sleep was restless</td>
</tr>
<tr>
<td>12</td>
<td>I was happy</td>
</tr>
<tr>
<td>13</td>
<td>I talked less than usual</td>
</tr>
<tr>
<td>14</td>
<td>I felt lonely</td>
</tr>
<tr>
<td>15</td>
<td>People were unfriendly</td>
</tr>
<tr>
<td>16</td>
<td>I enjoyed life</td>
</tr>
<tr>
<td>17</td>
<td>I had crying spells</td>
</tr>
<tr>
<td>18</td>
<td>I felt sad</td>
</tr>
<tr>
<td>19</td>
<td>I felt that people disliked me</td>
</tr>
<tr>
<td>20</td>
<td>I could not get “going”</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.89
Self-Efficacy (Mastery Scale)
Responses range from 1-4
1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

<table>
<thead>
<tr>
<th>#</th>
<th>Please tell me how strongly you agree or disagree with the following statements about yourself</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There is really no way I can solve some of the problems I have</td>
</tr>
<tr>
<td>2</td>
<td>Sometimes I feel that I’m being pushed around in life</td>
</tr>
<tr>
<td>3</td>
<td>I have little control over the things that happen to me</td>
</tr>
<tr>
<td>4</td>
<td>I can do just about anything I really set my mind to</td>
</tr>
<tr>
<td>5</td>
<td>I often feel helpless in dealing with the problems of life</td>
</tr>
<tr>
<td>6</td>
<td>What happens to me in the future most depends on me</td>
</tr>
<tr>
<td>7</td>
<td>There is little I can do to change many of the important things in my life</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.88
Pregnancy Locus of Control
Responses range from 1-4
1=Strongly agree
2=Agree
3=Disagree
4=Strongly disagree

<table>
<thead>
<tr>
<th>#</th>
<th>How much do you agree or disagree that (READ STATEMENTS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>There was nothing I could do to make sure my child was born healthy</td>
</tr>
<tr>
<td>2</td>
<td>It was my job as a mother to make sure my child was born healthy</td>
</tr>
<tr>
<td>3</td>
<td>Bad luck could have kept my child from being born healthy</td>
</tr>
<tr>
<td>4</td>
<td>I could make very few choices about my child’s health at birth</td>
</tr>
<tr>
<td>5</td>
<td>I could do many things to make sure my child was born healthy</td>
</tr>
</tbody>
</table>

Cronbach alpha = 0.72
**Physical Violence**
Responses range from 1-4
1=Never
2=Rarely
3=Sometimes
4=Frequently

<table>
<thead>
<tr>
<th>#</th>
<th>During your pregnancy, how often did anyone 12 years of age or older (READ OPTIONS)?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Throw something at you?</td>
</tr>
<tr>
<td>2</td>
<td>Push, grab, or shove you?</td>
</tr>
<tr>
<td>3</td>
<td>Slap you?</td>
</tr>
<tr>
<td>4</td>
<td>Kick, bite, or hit you?</td>
</tr>
<tr>
<td>5</td>
<td>Hit or try to hit you with an object?</td>
</tr>
<tr>
<td>6</td>
<td>Beat you up?</td>
</tr>
<tr>
<td>7</td>
<td>Burn or scald you?</td>
</tr>
<tr>
<td>8</td>
<td>Threaten you with a gun or knife?</td>
</tr>
</tbody>
</table>
### APPENDIX B

Individual-Level Model Drug Use Coefficients Controlling for Neighborhood Differences

<table>
<thead>
<tr>
<th></th>
<th>OLS</th>
<th>Tract Fixed Effects Model</th>
<th>Random Intercept Within Neighborhood Model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>SE</td>
<td>$\beta$</td>
</tr>
<tr>
<td>Marijuana</td>
<td>-27.3</td>
<td>66.3</td>
<td>-48.3</td>
</tr>
<tr>
<td>Cocaine</td>
<td>-143.3</td>
<td>72.7</td>
<td>-135.3</td>
</tr>
<tr>
<td>Opiates</td>
<td>-85.4</td>
<td>77.6</td>
<td>-86.3</td>
</tr>
</tbody>
</table>
APPENDIX C

Coefficients from Sequential Linear Regression Models of Birth Weight (Aim 2)

<table>
<thead>
<tr>
<th>Drug Use</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td>-69.5</td>
<td>-48.3</td>
<td>-42.4</td>
<td>6.1</td>
<td>-27.3</td>
</tr>
<tr>
<td>Cocaine</td>
<td>-329.3(\dagger)</td>
<td>-293.1(\dagger)</td>
<td>-237.8(\dagger)</td>
<td>-172.7(*)</td>
<td>-143.3(*)</td>
</tr>
<tr>
<td>Opiates</td>
<td>-239.3(\dagger)</td>
<td>-235.5(\dagger)</td>
<td>-214.8(\dagger)</td>
<td>-129.9</td>
<td>-85.4</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>39.0</td>
<td>57.2</td>
<td>37.3</td>
<td>43.4</td>
<td>30.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Social Factors</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19-24</td>
<td>-43.2</td>
<td>-48.7</td>
<td>-68.0</td>
<td>-47.7</td>
<td></td>
</tr>
<tr>
<td>25-34</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>35+</td>
<td>-208.8(*)</td>
<td>-185.4(*)</td>
<td>-136.8</td>
<td>-88.4</td>
<td></td>
</tr>
<tr>
<td>Enough Money for Necessities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; Half the time</td>
<td>-261.1(\dagger)</td>
<td>-154.0</td>
<td>-115.4</td>
<td>-40.7</td>
<td></td>
</tr>
<tr>
<td>Half the time</td>
<td>-155.9(*)</td>
<td>-69.9</td>
<td>-60.3</td>
<td>-28.4</td>
<td></td>
</tr>
<tr>
<td>&gt; Half the time</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Not Answered</td>
<td>-114.3(*)</td>
<td>-93.7</td>
<td>-92.8</td>
<td>-82.1</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Own</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Rent</td>
<td>-112.3</td>
<td>-110.3(\dagger)</td>
<td>-111.8(\dagger)</td>
<td>-101.7(\dagger)</td>
<td></td>
</tr>
<tr>
<td>Subsidized</td>
<td>-103.8(\dagger)</td>
<td>-89.1</td>
<td>-71.5</td>
<td>-35.6</td>
<td></td>
</tr>
<tr>
<td>Public Housing</td>
<td>-208.3(\dagger)</td>
<td>-174.0(*)</td>
<td>-163.0(*)</td>
<td>-173.3(*)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Psychosocial Factors</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little to none</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>Some</td>
<td>-99.6(\dagger)</td>
<td>-83.3</td>
<td>-97.9(*)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate to Severe</td>
<td>-261.1(\dagger)</td>
<td>-226.9(\dagger)</td>
<td>-244.4(\dagger)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pregnancy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Locus of Control</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Little to None</td>
<td>-190.8(\dagger)</td>
<td>-173.3(\dagger)</td>
<td>-157.0(\dagger)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some</td>
<td>-108.1(\dagger)</td>
<td>-96.8(\dagger)</td>
<td>-79.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate to Strong</td>
<td>Ref</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Behavioral Factors</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarettes/day</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-9</td>
<td>-100.0</td>
<td>-85.3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+</td>
<td>-230.9(\dagger)</td>
<td>-161.6(\dagger)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 3</td>
<td>Model 4</td>
<td>Model 5</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Early Prenatal Care</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Ref</td>
<td>Ref</td>
<td></td>
<td>-155.4†</td>
<td>-108.9*</td>
</tr>
<tr>
<td>No</td>
<td>-155.4†</td>
<td></td>
<td>-108.9*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biomedical Factors</strong></td>
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<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Hypertensive Disorders</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>-309.0‡</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-224.7‡</td>
</tr>
<tr>
<td><strong>Other Medical Risk Factor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pre-pregnancy weight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;120</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-195.1‡</td>
</tr>
<tr>
<td>120-159</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>160-199</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>205.2‡</td>
</tr>
<tr>
<td>200+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>280.5‡</td>
</tr>
<tr>
<td><strong>Net Weight Gain</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;10</td>
<td></td>
<td></td>
<td></td>
<td>-127.5*</td>
<td></td>
</tr>
<tr>
<td>10-29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ref</td>
</tr>
<tr>
<td>30-39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>79.3</td>
</tr>
<tr>
<td>40+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>228.9‡</td>
</tr>
<tr>
<td><strong>R²</strong></td>
<td>0.09</td>
<td>0.12</td>
<td>0.14</td>
<td>0.16</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*p<0.1, *p<0.05, †p<0.01, ‡p<0.001
### APPENDIX D

Odds Ratios from Sequential Logistic Regression Models of LBW (Aim 2)

<table>
<thead>
<tr>
<th>Drug Use</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marijuana</td>
<td>1.24</td>
<td>1.17</td>
<td>1.20</td>
<td>1.05</td>
<td>1.17</td>
</tr>
<tr>
<td>Cocaine</td>
<td>1.93*</td>
<td>1.65†</td>
<td>1.44</td>
<td>1.16</td>
<td>1.16</td>
</tr>
<tr>
<td>Opiates</td>
<td>2.06†</td>
<td>2.25†</td>
<td>2.10†</td>
<td>1.57</td>
<td>1.69</td>
</tr>
<tr>
<td>Other Drugs</td>
<td>0.97</td>
<td>0.91</td>
<td>0.93</td>
<td>0.95</td>
<td>0.85</td>
</tr>
</tbody>
</table>

**Social Factors**

**Maternal Age**
- 19-24: 1.38, 1.44, 1.55†, 1.51
- 25-34: Ref, Ref, Ref, Ref
- 35+: 3.22†, 3.16†, 2.71†, 2.44*

**Enough Money for Necessities**
- < Half the time: 3.35†, 2.51†, 2.19*, 1.74
- Half the time: 2.06*, 1.59, 1.54, 1.36
- > Half the time: Ref, Ref, Ref, Ref
- Not Answered: 1.63†, 1.56†, 1.61†, 1.63

**Housing**
- Own: Ref, Ref, Ref, Ref
- Rent: 1.64, 1.64, 1.66, 1.74†
- Subsidized: 1.91†, 1.86†, 1.66, 1.50
- Public Housing: 2.11†, 1.95†, 1.80†, 2.11*

**Psychosocial Factors**

**Stress**
- Little to none: Ref, Ref, Ref
- Some: 1.44, 1.32, 1.41
- Moderate to Severe: 2.09*, 1.84†, 2.24*

**Pregnancy Locus of Control**
- Little to None: 2.54†, 2.48†, 2.41†
- Some: 2.51†, 2.45†, 2.44†
- Moderate to Strong: Ref, Ref, Ref

**Behavioral Factors**

**Cigarettes/day**
- 0: Ref, Ref
- 1-9: 1.44, 1.34
- 10+: 1.94*, 1.69
<table>
<thead>
<tr>
<th></th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Early Prenatal Care</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>Ref</td>
<td>Ref</td>
</tr>
<tr>
<td>No</td>
<td>2.17†</td>
<td>2.04†</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Biomedical Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hypertensive Disorders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td>3.59‡</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other Medical Risk Factor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.94‡</td>
</tr>
<tr>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pre-pregnancy weight</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;120</td>
<td></td>
<td></td>
<td></td>
<td>1.70*</td>
<td></td>
</tr>
<tr>
<td>120-159</td>
<td></td>
<td></td>
<td></td>
<td>Ref</td>
<td></td>
</tr>
<tr>
<td>160-199</td>
<td></td>
<td></td>
<td></td>
<td>0.34†</td>
<td></td>
</tr>
<tr>
<td>200+</td>
<td></td>
<td></td>
<td></td>
<td>0.45‡</td>
<td></td>
</tr>
<tr>
<td><strong>Hosmer-Lemeshow Goodness of Fit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P&gt;χ²</td>
<td>0.75</td>
<td>0.89</td>
<td>0.72</td>
<td>0.90</td>
<td>0.47</td>
</tr>
</tbody>
</table>

p<0.1, *p<0.05, †p<0.01, ‡p<0.001
**Birth Weight Coefficient Changes with Single Variable Entry (Aim 2)**

<table>
<thead>
<tr>
<th></th>
<th>Marijuana Coefficient (95% CI)</th>
<th>% Change</th>
<th>Cocaine Coefficient (95% CI)</th>
<th>% Change</th>
<th>Opiates Coefficient (95% CI)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td>-69.5 (-205.8, 66.7)</td>
<td>--</td>
<td>-329.3 (-469.2, -189.5)</td>
<td>--</td>
<td>-239.3 (-396.5, -82.1)</td>
<td>--</td>
</tr>
<tr>
<td><strong>Model 2</strong></td>
<td>-48.3 (-183.4, 86.9)</td>
<td>-31%</td>
<td>-293.0 (-439.8, -146.4)</td>
<td>-11%</td>
<td>-235.5 (-392.7, -78.3)</td>
<td>-2%</td>
</tr>
<tr>
<td>Maternal Age</td>
<td>-73.7</td>
<td>-28%</td>
<td>-318.0</td>
<td>-8%</td>
<td>-262.8</td>
<td>-7%</td>
</tr>
<tr>
<td>Money</td>
<td>-50.0</td>
<td></td>
<td>-302.8</td>
<td></td>
<td>-222.6</td>
<td>-5%</td>
</tr>
<tr>
<td>Housing</td>
<td>-62.5</td>
<td></td>
<td>-333.3</td>
<td></td>
<td>-228.4</td>
<td></td>
</tr>
<tr>
<td><strong>Model 3</strong></td>
<td>-42.4 (-176.0, 91.5)</td>
<td>-39%</td>
<td>-237.8 (-384.5, -91.1)</td>
<td>-28%</td>
<td>-214.8 (-370.6, -58.9)</td>
<td>-10%</td>
</tr>
<tr>
<td>Stress</td>
<td>-31.0</td>
<td>-55%</td>
<td>-254.0</td>
<td>-23%</td>
<td>-236.5</td>
<td></td>
</tr>
<tr>
<td>Locus of control</td>
<td>-59.8</td>
<td></td>
<td>-271.9</td>
<td>-17%</td>
<td>-212.3</td>
<td>-11%</td>
</tr>
<tr>
<td><strong>Model 4</strong></td>
<td>6.1 (-131.0, 143.2)</td>
<td>-108%</td>
<td>-172.7 (-322.6, -22.7)</td>
<td>-48%</td>
<td>-129.9 (-289.3, 29.4)</td>
<td>-46%</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.23</td>
<td>-100%+</td>
<td>-191.7</td>
<td>-42%</td>
<td>-162.4</td>
<td>-32%</td>
</tr>
<tr>
<td>EPNC</td>
<td>-32.7</td>
<td></td>
<td>-213.3</td>
<td>-35%</td>
<td>-178.4</td>
<td>-25%</td>
</tr>
<tr>
<td><strong>Model 5</strong></td>
<td>-27.3 (-157.2, 102.7)</td>
<td>-61%</td>
<td>-143.3 (-285.9, -0.8)</td>
<td>-56%</td>
<td>-85.4 (-237.5, 66.7)</td>
<td>-64%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>-11.5</td>
<td></td>
<td>-175.5</td>
<td></td>
<td>-136.8</td>
<td></td>
</tr>
<tr>
<td>Other risks</td>
<td>-3.7</td>
<td></td>
<td>-189.4</td>
<td></td>
<td>-134.5</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>8.2</td>
<td>-112%</td>
<td>-148.3</td>
<td>-55%</td>
<td>-107.3</td>
<td>-55%</td>
</tr>
<tr>
<td>Weight Gain</td>
<td>-0.7</td>
<td></td>
<td>-154.9</td>
<td>-53%</td>
<td>-108.1</td>
<td>-55%</td>
</tr>
</tbody>
</table>

*p<0.1, †p<0.05, ‡p<0.01, ††p<0.001

Bold coefficients indicate an adjustment that accounted for 10%+ change from previous model
APPENDIX F    LBW Odds Ratio Changes with Single Variable Entry (Aim 2)

<table>
<thead>
<tr>
<th></th>
<th>Marijuana Coefficient (95% CI)</th>
<th>% Change</th>
<th>Cocaine Coefficient (95% CI)</th>
<th>% Change</th>
<th>Opiates Coefficient (95% CI)</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1</td>
<td>1.24 (0.76, 2.05)</td>
<td>--</td>
<td>1.93 (1.15, 3.21)</td>
<td>*</td>
<td>2.06 (1.19, 3.58)</td>
<td>†</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.17 (0.70, 1.96)</td>
<td>-29%</td>
<td>1.65 (0.95, 2.89)</td>
<td>-30%</td>
<td>2.25 (1.26, 3.99)</td>
<td>+18%</td>
</tr>
<tr>
<td>Maternal Age</td>
<td>1.29</td>
<td></td>
<td>1.79*</td>
<td>-15%</td>
<td>2.43†</td>
<td>-4%</td>
</tr>
<tr>
<td>Money</td>
<td>1.14</td>
<td>-42%</td>
<td>1.70*</td>
<td>-25%</td>
<td>1.95†</td>
<td>-10%</td>
</tr>
<tr>
<td>Housing</td>
<td>1.24</td>
<td></td>
<td>1.97†</td>
<td>-25%</td>
<td>2.02†</td>
<td>-4%</td>
</tr>
<tr>
<td>Model 3</td>
<td>1.20 (0.82, 2.54)</td>
<td>-17%</td>
<td>1.44 (0.82, 2.54)</td>
<td>-53%</td>
<td>2.10 (1.17, 3.76)</td>
<td>+4%</td>
</tr>
<tr>
<td>Stress</td>
<td>1.13</td>
<td>-46%</td>
<td>1.50</td>
<td>-46%</td>
<td>2.27†</td>
<td></td>
</tr>
<tr>
<td>Locus of control</td>
<td>1.25</td>
<td></td>
<td>1.56</td>
<td>-40%</td>
<td>2.07†</td>
<td></td>
</tr>
<tr>
<td>Model 4</td>
<td>1.05 (0.61, 1.79)</td>
<td>-79%</td>
<td>1.16 (0.65, 2.08)</td>
<td>-83%</td>
<td>1.57 (0.86, 2.87)</td>
<td>-46%</td>
</tr>
<tr>
<td>Smoking</td>
<td>1.05</td>
<td>-79%</td>
<td>1.26</td>
<td>-72%</td>
<td>1.81</td>
<td>-24%</td>
</tr>
<tr>
<td>EPNC</td>
<td>1.17</td>
<td>-29%</td>
<td>1.30</td>
<td>-68%</td>
<td>1.80</td>
<td>-25%</td>
</tr>
<tr>
<td>Model 5</td>
<td>1.17 (0.66, 2.06)</td>
<td>-29%</td>
<td>1.16 (0.63, 2.16)</td>
<td>-83%</td>
<td>1.69 (0.90, 3.17)</td>
<td>-35%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.14</td>
<td></td>
<td>1.16</td>
<td></td>
<td>1.64</td>
<td></td>
</tr>
<tr>
<td>Other risks</td>
<td>1.07</td>
<td></td>
<td>1.26</td>
<td></td>
<td>1.65</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>1.03</td>
<td>-87%</td>
<td>1.11</td>
<td>-88%</td>
<td>1.50</td>
<td>-53%</td>
</tr>
</tbody>
</table>

* p<0.1, † p<0.05, ‡ p<0.01, § p<0.001

Bold odds ratios indicate an adjustment that accounted for 10%+ change from previous model.
BIBLIOGRAPHY


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EDUCATION

Doctor of Philosophy, Department of Population, Family and Reproductive Health
Concentration in Perinatal Epidemiology
Johns Hopkins Bloomberg School of Public Health, Baltimore, MD 21205
September 2002 – May 2007
THESIS: “Illicit Drug Use and Birth Outcomes: A Contextual Examination in Baltimore, Maryland”

Honors and Awards
- Paul A. and C. Esther Harper Award for outstanding doctoral achievement, 2007
- NICHD Summer Institute in Reproductive & Perinatal Epidemiology Selected Participant, 8/2006
- Donald Cornely Scholarship Award, 2005/2006
- HRSA/MCHB Maternal and Child Health Epidemiology Training Grant, 2004/2005
- Chenoweth-Pate Endowed Fellowship Award, 2004/2005
- NICHD Population Traineeship, 2002 - 2004

Bachelor of Science with Highest Honors in Health Policy and Administration
Concentration in Biobehavioral Health
The Pennsylvania State University, University Park, PA 16802
August 1998 – May 2002
THESIS: “Prevalence and Predictors of Immunization Among Vulnerable Children: A Comparison of Health Center and National Coverage Rates”

Honors and Awards
- Schreyer Honors College Scholarship, 1998 - 2002
- 1st Place, Honors Thesis Competition, College of Health & Human Development, 2002
- Rose Cologne Keystone Citizen Award, AT&T Center for Service Leadership, 2001
- Evan Pugh Scholar Award for Academic Excellence, 2001
- Schreyer Ambassador Award for International Study in Mexico, Summer 2000
- Francis Hoffman Award for Excellence in Professional Writing, 1999

MANUSCRIPTS & PUBLICATIONS


PRESENTATIONS

Schempf, A. “Illicit Drug Use and Adverse Birth Outcomes: Is it Drugs or Context?”
Department of Population, Family & Reproductive Health Seminar
Johns Hopkins Bloomberg School of Public Health
Baltimore, MD: March 28, 2007

Schempf, A., Kroelinger, C., & Guyer, B. “Rising Infant Mortality in Delaware: Racial Differences in Secular Trends.”
Twelfth Annual CDC Maternal and Child Health Epidemiology Conference
Atlanta, GA: December 7, 2006

The Society for Pediatric and Perinatal Epidemiologic Research Annual Meeting
Toronto, Canada: June 27, 2005 (Poster)
Eleventh Annual CDC Maternal and Child Health Epidemiology Conference
Miami, FL: December 9, 2005

Tenth Annual CDC Maternal and Child Health Epidemiology Conference
Atlanta, GA: December 8, 2004 (Poster)
The Society for Pediatric and Perinatal Epidemiologic Research Annual Meeting
Toronto, Canada: June 27, 2005 (Poster)
Schempf, A.H., Minkovitz, C.S., Strobino, D.M., & Guyer, B. “Satisfaction with Care: Does it Improve Immunization of Young Children?”

Ninth Annual CDC Maternal and Child Health Epidemiology Conference
Tempe, AZ: December 10, 2003

Association of Teachers of MCH Student Research Symposium
Washington, DC: February 29, 2004


Society of Behavioral Medicine 23rd Annual Meeting and Scientific Sessions
Washington, DC: April 5, 2002

The 36th CDC National Immunization Conference
Denver, CO: April 30, 2002

GRANTS

R03 DA020632-01
Illicit Drug Use and Associated Social Factors: Effects on Birth Outcomes
National Institute on Drug Abuse, NIH/DHHS 4/06-8/07

The Determinants of Childhood Immunization at Community Health Centers
Bureau of Primary Health Care, HRSA/DHHS 8/02-2/03

Comparison of Health Center and National Childhood Immunization Coverage
Bureau of Primary Health Care, HRSA/DHHS 9/01-3/02

PROFESSIONAL EXPERIENCE

Department of Population and Family Health Sciences
Johns Hopkins Bloomberg School of Public Health

Collaborated with the Delaware Department of Health to investigate racial differences in infant mortality trends as part of an MCHB training grant. Assisted on the final report of the statewide Infant Mortality Task Force. Produced a manuscript for publication.

Research Intern Summer 2004
Office of Analysis and Epidemiology
National Center for Health Statistics

Analyzed multiple years of natality data to examine racial/ethnic differences in the maternal age and parity related risks of preterm birth. Completed a manuscript for publication and presented the analysis at a staff meeting. Attended federal interagency collaborations related to the National Children’s Study and the Forum on Child and Family Statistics.

Teaching Assistant Spring 2004
Department of Population and Family Health Sciences
Johns Hopkins Bloomberg School of Public Health

Research Assistant  
Department of Population and Family Health Sciences  
Johns Hopkins Bloomberg School of Public Health  
Summer 2003  
Conducted prospective analysis of the relation between parental satisfaction with pediatric care and childhood immunization using data from the National Evaluation of the Healthy Steps for Young Children Program. Produced a manuscript for publication.

Teaching Assistant  
Department of Biobehavioral Health  
The Pennsylvania State University  
Fall 2001  

Research Intern  
Office of Data, Evaluation, Analysis, and Research  
Bureau of Primary Health Care, Health Resources and Services Administration  
Summer 2001  
Conducted an evaluation of childhood immunization coverage at Community Health Centers. Prepared a manuscript for publication. Presented findings to Bureau staff. Attended internal and professional meetings and conferences. Edited government documents/presentations.

Administrative Intern  
Complementary Medicine Program  
University of Maryland Medical Center  
Summer 1999  

SERVICE  
Article Reviewer, Demography  
Maternal and Child Health Journal  
Paediatric and Perinatal Epidemiology  
Volunteer, Mt. Washington Pediatric Hospital  12/2005 - present  
Instructor, Community Adolescent Sexuality Education Program  Spring 2006  
Student Representative, Departmental Admissions Committee  2005 - 2007  
Student Representative, School-Wide Honors and Awards Committee  2005/2006

COMPUTER SKILLS  
SAS, Stata, ArcGIS, Microsoft Word, Excel, Power Point