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MULTIDIMENSIONAL FUNCTIONING IN
CHILDREN WITH PRENATAL METHAMPHETAMINE EXPOSURE

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF EDUCATIONAL PSYCHOLOGY

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Abstract

Methamphetamine is one of the most neurotoxic and addictive drugs of abuse. While prenatal exposure to all illicit drugs is considered detrimental, it might be argued that because of the polydrug nature of methamphetamine and the harmful effects that physical exposure to the substance can produce, it is perhaps even more damaging, or damaging in a different manner, than other drugs when used by pregnant women. Few studies have focused on the effects of prenatal exposure to methamphetamine alone or methamphetamine when combined with or compared to other substances. Additionally, no study has focused solely on the differences in the cognitive, language, motor, emotional functioning, behavioral functioning, and head circumference of young children prenatally exposed to methamphetamine only, young children prenatally exposed to methamphetamine plus other substances, and young children prenatally exposed to other substances not including methamphetamine. The present study attempted to address these issues by utilizing archival data from a specialty clinic in a large Southwestern city to which children, aged 1-month to 7-years, were referred specifically because of their prenatal exposure to substances. 1,556 records of children met inclusion criteria, although many of the records did not include data from all assessment measures. The

subjects received a standardized battery of tests to determine their cognitive, language, motor, emotional and behavioral functioning, and physical development. Although no significant differences were found between exposure groups on scores of cognitive development, emotional development, and behavioral development, a nonsignificant difference ($p < .069$) was found for language development. Additionally, significant differences were found between exposure groups on scores of motor development and head circumference measurements. This suggests that prenatal exposure to methamphetamine is as harmful as prenatal exposure to other substances; however, it does not appear to cause increased cognitive, language, emotional, or behavioral damage, nor does it appear to compound the effects of other drugs. However, findings of significant differences in the motor development and head circumference categories seem to indicate that these areas may be at risk of increased damage through prenatal exposure to methamphetamine. The current study was limited by lack of a control group, an inability to control for environmental exposure to drugs and alcohol, and retrospective, maternal and second-party report.

Chapter 1

Introduction

The use of methamphetamine has become a significant problem in the United States over the past two decades. According to the 2007 National Survey on Drug Use and Health (NSDUH), approximately 13 million Americans 12 years or older reported using methamphetamine at least once during their lifetimes. This represents 5.3% of the population aged 12 or older. While national surveys have shown recent declines in methamphetamine abuse among U.S. youth, evidence from emergency departments and treatment programs attest to the growing impact of methamphetamine abuse in the country (NSDUH).

The Drug Abuse Warning Network (DAWN), which collects information on drug-related episodes from hospital emergency departments (EDs) throughout the nation, has reported a greater than 50% increase in the number of ED visits related to methamphetamine abuse between 1995 and 2002, reaching approximately 73,000 ED visits, or 4% of all drug-related visits in 2004. In that same year, 45% of the primary admissions to substance use treatment for methamphetamine use were for women, compared to approximately 26% of the primary admissions to substance use treatment for alcohol

abuse and for marijuana use (NSDUH, 2007). Unfortunately, pregnant women are included in this trend.

Research has shown that the highest rate of methamphetamine use occurs in the 18-25 age groups (Nordahl, Salo, & Leamon, 2003; NIDA, 2006). Additionally, in a study on methamphetamine use, 5.2% of 1,632 women reported using the drug while pregnant (Arria et al., 2006). Furthermore, the prevalence of methamphetamine use in pregnant women appears to be comparable to the national prevalence of methamphetamine use in women who are not pregnant (Meredith, Jaffe, Ang-Lee, & Saxon, 2005).

Cause and effect has not been clearly delineated regarding ingestion of certain drugs during pregnancy and human birth defects. However, all illicit drugs that are taken during pregnancy reach the fetus once they cross the placenta. Therefore, the effects of drugs on the fetus may be caused directly through the drug's transfer through the placenta or may be secondary to changes in the fetal environment (Plessinger, 1998).

Methamphetamine has vasoconstrictive effects that result in decreased uteroplacental blood flow, fetal hypozia, and anorexic effects on the mother, possibly resulting in intrauterine growth retardation (Plessinger, 1998). Adding to the confusion, although using certain

drugs while pregnant increases risks of adverse outcomes, birth defects are not an “all-or-none phenomena” (Plessinger, p. 120). However, birth malformations have been reported in the infants of mothers who have abused amphetamine or methamphetamine during pregnancy (Plessinger).

Adverse outcomes including prematurity (Eriksson, Larsson, Winbladh, et al., 1978), stillbirth (Eriksson, Larsson, Winbladh, et al., 1978; Stewart & Meeker, 1997), low birth weight (Little, Snell, & Gilstrap, 1988; Oro & Dixon, 1987), growth reduction (Eriksson, Larsson, & Zetterstrom, 1981; Little, Snell, & Gilstrap; Oro & Dixon), reduced head circumference (Eriksson, Larsson, & Zetterstrom, 1981; Little, Snell, & Gilstrap; Oro & Dixon), cleft lip (Little, Snell, & Gilstrap; Milkovich & van den Berg, 1977; Nelson & Forfar, 1971; Saxen, 1975; Thomas, 1995), cardiac defects (Little, Snell, & Gilstrap; Nelson & Forfar; Nora, McNamara, & Clarke-Fraser, 1968; Nora, Vargo, Nora, et al., 1970), biliary atresia (Golbus, 1980; Levin, 1984), hyperbilirubinemia requiring exchange transfusion (Eriksson, Larsson, Winbladh, et al., 1978), cerebral hemorrhage (Dixon & Bejar, 1989), low body fat (Little, Snell, & Gilstrap), undescended testes (Little, Snell, & Gilstrap), systolic murmur (Little, Snell, & Gilstrap), and mongolian spots (Little, Snell, & Gilstrap) have been associated with maternal use of the substance.

Additionally, according to one study, it was found that three infants born with oral clefts were known to be exposed to amphetamines on the 43rd and 50th days of gestation. These days are reported to be crucial in oral facial development (Plessinger, 1998). Furthermore, research has found that the physical effects of prenatal methamphetamine use may include such complications as premature labor and delivery, cardiac and brain abnormalities, separation of the placenta, and altered behavioral patterns in infants such as irritability and abnormal reflexes (NIDA, 2006).

Although cleft lip and cleft palate have not been reported in infants prenatally exposed to cocaine, these birth defects have been found in five incidences of prenatal amphetamine exposure (Plessinger, 1998). Many cardiovascular effects, such as bradycardia and tachycardia, resolve in newborns that have been prenatally exposed to amphetamine or methamphetamine. However, some visual cognitive effects and behavior changes appear to be permanent (Plessinger). Furthermore, visual recognition memory, which has been correlated with subsequent IQ, was found to be lower in infants with prenatal stimulant exposure (Hansen, Struthers, & Gospe, 1993).

Finally, because many pregnant women also use different combinations of other psychoactive drugs, there is also the risk of

combined impact on the physical, cognitive, and emotional development of the fetus (Wouldes et al., 2004).

Current Study

Problem Statement

Of women who use illicit drugs in the United States, approximately half are in the childbearing age group (NIDA, 1996). It has also been noted that female addicts frequently exhibit a marked desire to have a baby (Weir, 1972). In 2004, 8% of treatment admissions were for the abuse of stimulants, and 99% of all stimulant admissions were for methamphetamine or amphetamine abuse. According to the Alcohol Drug and Pregnancy Team (ADAPT) at National Women's Hospital in New Zealand, widespread methamphetamine use is also climbing among pregnant women in that country. In 2001, the total number of referrals due to methamphetamine use was 10%; a number that escalated to 59% just two years later (Wouldes, LaGasse, Sheridan, & Lester, 2004).

In 1993, the largest study specifically focusing on the prevalence of alcohol, tobacco, and other substance use during pregnancy was conducted. Because the methamphetamine problem did not emerge until the mid to late 1990s, less than 1% of pregnant women in the study had used methamphetamine during pregnancy (Arria et al., 2006).

Unfortunately, while the National Survey on Drug Use and Health could report on past month illicit drug use by 4.3% of pregnant women between the ages of 15 and 44 years, the estimates were conservative because they only reflect past month substance use during pregnancy, not substance use at any point during pregnancy. These estimates of past month substance use reflected use among women who were pregnant at the time of the survey, not among all pregnant women in 2002 or 2003 (NSDUH, 2005). Furthermore, the Pregnancy Risk Assessment Monitoring System (PRAMS), which is funded by the Centers for Disease Control (CDC), provides estimates of alcohol and tobacco use only during the last 30 days of pregnancy and does not inquire about the illicit use of substances (Arria et al., 2006).

While we know that prenatal exposure to all illicit drugs is detrimental, it might be argued that because of the polydrug nature of methamphetamine and the harmful effects that physical exposure to the substance can produce, it is perhaps even more damaging, or damaging in a different manner, than other drugs when used by pregnant women. Few studies conducted up to this time focused on the effects of prenatal exposure to methamphetamine alone or methamphetamine when combined with or compared to other substances. Moreover, they had small samples and other limitations or confounding factors. The largest

prenatal methamphetamine exposure study to date, the Infant Development, Environment, and Lifestyle study (IDEAL; Arria et al., 2006) is longitudinal and just in the early phases of examining data on the participants. Prior to the current study, no study focused solely on the differences in the cognitive, language, motor, emotional functioning, behavioral functioning, and head circumference of young children prenatally exposed to methamphetamine only, young children prenatally exposed to methamphetamine plus other substances, and young children prenatally exposed to other substances not including methamphetamine.

The present study attempted to address these issues by utilizing a large database of scores on children who were referred to a specialty clinic specifically because of their prenatal exposure to substances. The children presented at various ages, from 1 month to 7 years of age, and received a standardized battery of tests to determine their cognitive, language, motor, emotional and behavioral functioning, and physical development. Information was also gathered regarding demographics and the specific drug(s) to which they were prenatally exposed.

The hope was that by comparing children with prenatal methamphetamine exposure with children who have been prenatally exposed to methamphetamine plus other substances, and prenatally

exposed to other substances not including methamphetamine we might discover information that could prove helpful for those who provide early intervention services. For example, when children presented for assessment at the facility in this study, those with fetal alcohol exposure were given the opportunity to participate in a specialized behavioral treatment program and receive monetary compensation for their participation, as this treatment is part of an FAS research grant. These opportunities were directly related to research finding behavioral difficulties in children with prenatal alcohol exposure.

We did not know whether or not children with prenatal methamphetamine exposure experience the same types of difficulties or delays that children with prenatal exposure to alcohol and/or other substances experience. Knowledge of specific prenatal exposure could help professionals to be especially observant in particular areas (such as cognition, language, motor, emotional functioning, or behavioral functioning) and perhaps conduct additional evaluations in the suspected problem area. Additionally, once the children at the facility in this study reach school age, they become reliant upon the public school system for developmental and behavioral services. Caregivers, as well as the school system, could benefit if a specific domain is listed as being a potential problem area in the future. For example, when there are 30

young children in a class, acting out because of language difficulties can look much like acting out because of behavior difficulties. Children may be labeled as “troublemakers,” when the fact is they may be suffering from delayed problems due to prenatal drug exposure. Understanding the early and future difficulties that may be faced by children whose mothers engaged in prenatal substance abuse, particularly methamphetamine, could help to fill in the gaps that currently exist in the literature, as well as prove helpful for those who provide early intervention services.

Research Questions

The research questions addressed in this study included the following: (1) Are there differences in the cognitive scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine? (2) Are there differences in the language scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine? (3) Are there differences in the motor scores of

children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine? (4) Are there differences in the emotional functioning scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine? (5) Are there differences in the behavioral functioning scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine? (6) Are there differences in the head circumference measurements of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

Objective

The objective of this study was to ascertain whether or not differences emerged between the cognitive, language, motor, emotional, and behavioral scores, and head circumferences of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine.

Chapter 2

Literature Review

History of Methamphetamine

Methamphetamine is a stimulant that affects the central nervous system (CNS). Legally available only through a prescription that cannot be refilled, methamphetamine is highly addictive and has a high potential for abuse. Medical uses of methamphetamine are limited, with prescribed doses much lower than the amounts that are typically abused (National Institute on Drug Abuse, NIDA, InfoFacts, 2008).

First synthesized in the early 1900's, amphetamines, including methamphetamine, were identified for medical use and manufactured in the 1930s as a bronchial dilator. Later they would be prescribed for other conditions such as narcolepsy, attention deficit disorder, obesity, and fatigue. As drug abuse became an increasing problem in the 1950s and 1960s, methamphetamine labs emerged in California's Bay Area with motorcycle gangs such as the Hells Angels taking control of the illicit market (Meredith et al., 2005).

In 1970, amphetamine and methamphetamine were made Schedule II substances, which meant they had a high potential for abuse and were available only through prescriptions that could not be refilled (Hanson, 2002). Bay Area biker groups initially used the "P2P method"

of methamphetamine synthesis (principal chemicals included phenyl-2-propanone, aluminum, methylamine, and mercuric acid). However, development of strict federal controls of P2P in 1988 made this method much less profitable. Consequently, the P2P method was replaced by a cheaper, simpler, and more efficient process known as the ephedrine/pseudoephedrine reduction method, or “Nazi method,” which results in a much purer yield of the D-isomer of methamphetamine (Meredith, et al., 2005).

Elemental lithium, isolated from rechargeable camera batteries, can also be used as a catalyst in the ammonia/alkali method of reducing ephedrine into methamphetamine. This chemical reduction results in the production of “crank,” a name that was derived from bikers using the crank cases of their motorcycles to transport the substance. This method, in which precursor compounds can be easily diverted from legitimate use, gave birth to the advent of “superlabs,” which have the capacity to produce ten or more pounds of methamphetamine in one production cycle (Meredith et al., 2005). As a result, while methamphetamine’s popularity faded somewhat in the 1970s, due to restrictions on prescriptions and the chemicals needed for its manufacture, the 1980s witnessed the reappearance of methamphetamine, beginning in Hawaii and the West (Hunt, Kuck, &

Truitt, 2006). Throughout the 1990s, use of methamphetamine continued to grow steadily in the West and Northwest and by 2000 had reappeared in many Midwestern and Southern areas. It had also emerged, to a lesser degree, in the Mid Atlantic and Northeast (Hunt & Truitt, 2006).

Street methamphetamine is referred to by many names, such as "speed," "meth," and "chalk." Methamphetamine hydrochloride, clear chunky crystals that resemble ice and can be inhaled by smoking, is referred to as "ice," "crystal," and "glass." The smoke from ice is odorless and leaves a residue that can be resmoked. Producing effects that may continue for 12 or more hours, ice is a large, usually clear crystal of high purity that is most often smoked in a glass pipe (Hanson, 2002; NIDA, 2006).

Prevalence of Use

Second only to marijuana, methamphetamine is the most widely used illegal drug, with an estimated 35 million regular users worldwide (Rawson, Anglin, & Ling, 2002). In fact, according to the Centers for Disease Control and Prevention (CDC; 2005), methamphetamine is considered the fastest-growing illicit drug in the United States.

Effects of Methamphetamine on Users

A synthetic psychostimulant, methamphetamine is a bitter-tasting crystalline powder that is white, odorless, and easily dissolvable in water or alcohol. Methamphetamine is taken orally, intranasally (snorting), by smoking, or by needle injection (NIDA InfoFacts, 2008). The effects of methamphetamine are produced in 3 to 20 minutes and, depending on method of use, remain present in the brain longer than other stimulants (from 6 to 24 hours). Immediately after smoking or injecting, the user experiences an intense sensation called a “rush” or “flash” that lasts only a few seconds. Oral or intranasal use produces euphoria, but not a rush. Like similar stimulants, methamphetamine is most often used in a “binge and crash” pattern. As tolerance occurs within minutes, the intense pleasurable effects begin to disappear even before the concentration of the drug in the blood falls significantly. This results in users trying to maintain the high by binging on the drug (Hanson, 2002; NIDA, 2006).

Methamphetamine releases high levels of the neurotransmitter dopamine, which stimulates brain cells and enhances mood and body movement. It also damages brain cells that contain dopamine and serotonin (NIDA InfoFacts, 2008). The effects of methamphetamine include increased activity, decreased appetite, euphoria, and elevated blood pressure – actions in the CNS that result from taking even small

amounts of the drug. Other effects can include irritability, insomnia, confusion, anxiety, convulsions, tremors, paranoia, and aggressiveness. Users may become addicted quickly and use methamphetamine with increasing frequency and in increasing doses. Methamphetamine can also cause irreversible damage to blood vessels in the brain, producing strokes, as well as increased heart rate, respiratory problems, cardiovascular collapse, and death (NIDA, 2006; NIDA InfoFacts, 2008).

In adults, high doses of methamphetamine not only cause adverse physiological effects, but also psychological and behavioral effects including violence, hostility, hallucinations, and paranoid psychosis that may resemble schizophrenia (Shearer, Sherman, Wodak, & vanBeek, 2002; Wouldes et al., 2004).

In a review on the neuropsychological effects of chronic methamphetamine use on neurotransmitters and cognition, Nordahl, Salo, & Leamon (2003) found that “neuroanatomical, neurochemical, and imaging data support the conclusion that methamphetamine abuse causes damage to multiple transmitter systems that are distributed throughout the brain. Whether the ensuing damage is permanent or reversible over time has not yet been determined” (p. 320).

Finally, in a 2000 study, Ernst, Chang, Leonido-Lee, and Speck found that methamphetamine abuse causes harmful physical changes in

the brain that can last for many months, perhaps longer, after the drug use has stopped. In the study, Drs. Chang and Ernst measured levels of brain chemicals that indicate whether brain cells are healthy, diseased, or damaged. They found abnormal brain chemistry in the methamphetamine users in all three brain regions that were studied. Additionally, in one of the regions, the amount of damage was also related to the history of drug use. Those who had used the most methamphetamine had the strongest indications of cell damage. They concluded that methamphetamine was likely substantially toxic to the cells that humans use in thinking.

Methamphetamine vs. Amphetamine: Differences, Similarities, and a Longitudinal Study

Methamphetamine's chemical structure is similar to that of its parent drug, amphetamine; however, it has more pronounced effects on the CNS, specifically the sympathetic nervous system (Hanson, 2002; Smith et al., 2008). Also described as the "first cousin" of amphetamine, methamphetamine has the addition of the methyl radical and exerts its action by releasing dopamine and serotonin, blocking monoamine reuptake mechanisms, and inhibiting monoamine oxidase (Lukas, 1997). In a recent article on animal studies, Goodwin et al. (2009) found that

both amphetamine and methamphetamine release excess dopamine into the dopaminergic neurons' synaptic clefts.

The major difference appears to be in the mechanistic differences between methamphetamine- and amphetamine-mediated changes in DAT [dopamine transporter] activity, DA [dopamine] clearance in the nucleus accumbens, and DAT-mediated cellular responses (Goodwin et al., 2009). Furthermore, these differences likely contribute to the greater euphoric and addictive properties of methamphetamine as the drug releases five times more dopamine, and twice as much from internal stores, when compared with amphetamine (Goodwin et al.).

The Swedish Longitudinal Study. In the 1960s, short-term legalization of drugs of abuse occurred in Sweden. Resulting populations of children who had been prenatally exposed to amphetamines were monitored in the years that followed. In 1976-1977, 65 newborns were selected for a study, due to their mothers' addiction to amphetamine during pregnancy. The cohort was followed prospectively until 14 years of age and compared to the normative population. Children in Groups 1 and 2 remained in their mothers' custody at birth, while children in Group 3 were placed in foster-homes at birth. Reports brought to light multiple prenatal complications resulting in the children's

altered growth and behavior (Eriksson, Billing, Steneroth, & Zetterstrom, 1985, 1989).

These studies, of virtually the same group of children as neonates, 4-year-olds, 8-year-olds, and 14-year-olds, showed that prenatal amphetamine exposure was correlated with poor social adjustment, as well as with increased aggressive behavior at 4 and 8 years of age. (Billing, Eriksson, Jonsson, Steneroth, & Zetterstrom, 1994; Billing, Eriksson, Steneroth, & Zetterstrom, 1988; Eriksson, Billing, Steneroth, & Zetterstrom, 1989). Behavior problems continued at age 14 with a larger number of amphetamine-exposed children having a slightly lower IQ, being retained from grade advancement, and lagging behind in language, mathematics, and physical training when compared with unexposed controls (Billing, Eriksson, Steneroth, & Zetterstrom, 1985; Eriksson, Jonsson, Steneroth, & Zetterstrom, 2000; Eriksson & Zetterstrom, 1994). Also significant was the finding that one-third of the children had social problems at age 14, irrespective of whether they were living with their biological mother or not. In fact, by age eight, 44 of the 65 children had been adopted or placed in foster homes (Eriksson, Jonsson, Steneroth, & Zetterstrom, 2000).

According to authors, another interesting finding was that after 8 years of age, there appeared to be a difference in relation to the timing of

the amphetamine exposure. Children in Group 1 (those who remained in mother's custody at birth) that had been exposed to amphetamine only during the first trimester were less aggressive and performed better in some tests than did those in Group 2 (those who remained in mother's custody at birth) and Group 3 (placed in foster care at birth) that had longer exposures. However, the reasons for the more limited exposure in Group 1 are not known and may also have played an important role in these results. Nevertheless, the authors suggest that their findings indicate that intrauterine exposure may cause prenatal damage that cannot be completely compensated by a good psychosocial environment after birth (Eriksson, Billing, Steneroth, & Zetterstrom, 1989).

Surprisingly, when the children were past puberty (14-years-old), gender differences were noted regarding their growth. The amphetamine-exposed females were shorter and weighed less for their age, while the amphetamine-exposed males were taller and weighed more than the two Swedish standards that were used for comparison (Eriksson, Jonsson, Steneroth, & Zetterstrom, 2000; Plessinger, 1998). According to Plessinger, the findings seem to suggest that normal neural development and adenohypophysis maturation are affected by prenatal amphetamine exposure, with the onset of puberty being accelerated in boys but delayed in girls.

A further finding of the Swedish study was that head circumference at birth and at 1 year of age was a significant predictor for level of achievement in Swedish language and school achievement for males at 14 years of age. Additionally, head circumference at birth and at 1 year of age was a significant predictor for adjustment at 4 years and 8 years of age for females (Eriksson, Jonsson, & Zetterstrom, 2000). These findings seem to correlate with earlier long-term follow-ups in which intrauterine drug exposure was shown to affect the head circumference of children, as well as studies finding a relationship between head size early in life and developmental scores in later life (Azuma & Chasnoff, 1993; Chasnoff, Burns, Burns, & Schnoll, 1986; Doberczak, Thornton, Bernstein, & Kandall, 1987; Hack et al., 1991; Lifschitz, Wilson, O'Brian-Smith, & Desmond, 1985).

Finally, Billing et al. (1994) and Eriksson and Zetterstrom (1994) found a significant correlation between exposure data, socioenvironmental factors, and behavioral characteristics. They discussed that the confounding of these factors and the lack of a true control group would be definite limitations to their study. It was discovered during the course of the longitudinal study that a greater proportion of the children with heavy amphetamine exposure were taken into custody early and placed into foster homes. While approximately

80% left the hospital in their biological mothers' custody, by 4 years of age, 50% were in foster homes, and by 10 years of age, 70% had been taken from their biological mothers and placed into foster care. The most common reason was continuing abuse or failure of supportive measures (Billing et al; Eriksson & Zetterstrom).

Of the children who remained with their biological mothers, a high degree of social support was required and provided, with 75% receiving continuous economic support, 65% having a specially appointed contact person, and 30% being in drug treatment programs (Billing et al., 1994; Eriksson & Zetterstrom, 1994). Moreover, authors found that of the 65 children in the study, there were few reports of child abuse. They suggest that this may be explained by the fact that these children had been surrounded by a protective social network since birth, which likely prevented some of the more serious postnatal environmental risk factors that would have had additional deleterious effects on the infants/children (Billing et al.).

Methamphetamine vs. Cocaine: Differences, Similarities, and a Longitudinal Study

Methamphetamine, amphetamine, and cocaine are all classified as psychostimulants. While methamphetamine is structurally similar to amphetamine and the neurotransmitter dopamine, it is quite different

from cocaine. While the stimulants behave similarly and have similar psychological effects on the body, the major differences of how each work happen at the nerve cell level. Like cocaine, methamphetamine results in an accumulation of the neurotransmitter dopamine. This excessive dopamine concentration produces the stimulation and feelings of euphoria. However, while cocaine is quickly removed and almost completely metabolized in the body, methamphetamine has a much longer duration of action and a much larger percentage of the drug remains unchanged in the body. The result is that methamphetamine is present longer in the brain and this ultimately leads to prolonged stimulant effects for the user (Hanson, 2002).

Nevertheless, studies have shown that prenatal exposure to cocaine is associated with premature birth and lower birth weight (Azuma & Chasnoff, 1993; Hulse, English, Milne, Holman, & Bower, 1997). Some reports also indicate that prenatal cocaine exposure is associated with deficits in cognitive and motor functioning in infants and children over the first two years of life (Arendt, Angelopoulos, Salvator, & Singer, 1999; Singer et al., 1997). However, there had not been large-scale reports of the longitudinal impact of prenatal cocaine exposure prior to the following study.

The Maternal Lifestyle Study (MLS). In the early 1990s, under the leadership of the National Institute of Child Health and Human Development (NICHD), planning began for a collaborative effort involving the NICHD, NIDA, Center for Substance Abuse Treatment (CSAT), and Administration on Children, Youth, and Families (ACYF). This study, the Maternal Lifestyle Study (MLS), became a prospective report of the acute neonatal events and long-term developmental and health outcomes related to drug use during pregnancy (Smerglio & Wilcox, 1999). The MLS attempted to address earlier methodological challenges, including drug use detection, assessment of health and developmental status, small size, and measurements of potentially confounding factors (social class, quality of environment, continuing drug use, maternal mental health indicators). Data collection began in 1993 at the four MLS sites (Detroit, Memphis, Miami, and Providence) and was designed to be a long-term follow-up of the children to age 7 (Smerglio & Wilcox).

In 2001, Lester et al. reported that the meconium specimens of 8,527 newborns had been analyzed by immunoassay with gas chromatography/mass spectrometry (GC/MS) confirmation for metabolites of cocaine, opiates, cannabinoids, amphetamines, and phencyclidine. This study highlighted the polydrug nature of what was

formerly thought of as a cocaine problem. The prevalence of cocaine/opiate exposure in the four sites was 10.7% with the majority (9.5%) exposed to cocaine.

In 2002, Lester et al. looked at the effects of substance exposure during pregnancy on neurodevelopmental outcome in 1-month-old infants. Still a part of the MLS, the sample consisted of 658 exposed and 730 comparison infants matched on race, sex, and gestational age. Researchers found that the site of action for cocaine involves several areas of the brain that are thought to affect decision making, judgment, attention, planning, and mental flexibility (executive functions) in adults. Further, the authors suggest, the long-term implications are that the cognitive deficits likely caused by cocaine may not manifest until a child reaches school age (Lester et al.).

In 2003, using data from the MLS, Lester et al. examined a sample that included 477 exposed and 554 comparison infants matched for race, sex, and gestational age to study the effects of prenatal cocaine and/or opiate exposure on auditory brain response at one month. They found that "…heavy cocaine exposure led to an increase in the I-III, I-V, and III-V interpeak latencies, indicating prolongation in neural transmission with heavy prenatal cocaine use during pregnancy" (p. 284). The I-V interpeak latency represents central brain stem conduction

time from the acoustic nerve to the inferior colliculus in the midbrain and is used as a measure of brainstem maturation, suggesting delayed maturation in the infants (Lester et al.).

In 2004, using data from the MLS, Messinger et al. evaluated the direct effects of prenatal cocaine exposure and opiate exposure on infant mental, motor, and behavioral outcomes between the ages of 1 and 3. The sample included 1,227 infants exposed to cocaine (n=474), opiates (n=50), cocaine and opiates (n=48), and neither substance (n=655) at 1, 2, and 3 years of age. Interestingly, the study found that infant prenatal exposure to cocaine and opiates was not associated with mental, motor, or behavioral deficits after controlling for birth weight and environmental risks. Additionally, the direct impact that cocaine has on developing dopaminergic tissue is likely to depend on the timing and extent of exposure, with the effects becoming more evident as the more advanced motor, cognitive, language, and behavioral skills develop (Messinger et al.).

Given the effects that prenatal exposure to amphetamine and cocaine appears to have on infants and children, the fact that methamphetamine appears to have an even greater toxic effect on users, and that methamphetamine use is highest in the childbearing age group (18-25) (NIDA, 2006; Nordahl, Salo, & Leamon, 2003), it was

important to study the effects that the drug might have on the unborn. The logical place to start was with animal studies.

Methamphetamine: Animals, Humans, and a Longitudinal Study

According to the NIDA (2008), more than 20 years of animal research shows that methamphetamine damages neuron cell-endings. In addition, although the neurons containing dopamine and serotonin do not die after methamphetamine use, their nerve endings are cut back and re-growth is limited. Plessinger (1998) stated that clefting and optic defects have been demonstrated in mice and New Zealand White rabbits prenatally exposed to methamphetamine, along with ocular defects, herniated small intestines, malformed ribs and vertebrae, and exencephaly. Interestingly, Plessinger also found that when male rabbits were treated with methamphetamine three months prior to mating, they sired offspring that were stillborn or suffered from various kidney defects and gastroschisis.

In 2001, Won, Bubula, McCoy, and Heller discovered that maternal administration of methamphetamine in animals resulted in fetal brain drug concentrations that approximated amounts reported in human infants who were prenatally exposed to methamphetamine. Slamberove, Pometlova, Syllabove, and Mancuskova (2005) stated that administration of methamphetamine to pregnant female rats during gestation resulted in

alarming, long-term impairment on the spatial learning of their adult offspring, while Arria et al. (2006) reported maternal and offspring mortality, retinal eye defects, cleft palate, rib malformations, decreased rate of physical growth, and delayed motor development in animals with prenatal methamphetamine exposure. Finally, in a 2007 article, researchers found that rats from mothers exposed to methamphetamine during the prenatal period had impaired sensory-motor coordination (Slamberova, Pometlove, & Rokyta, 2007).

Few studies exist on the effects of prenatal methamphetamine exposure, and the existing literature is hampered by methodological shortcomings such as small sample size, difficulty establishing exposure status, confounding with other drugs, and environmental effects. Additional confusion is that some of the negative effects may be indirectly related to methamphetamine exposure. For example, children who are born small-for-gestational-age (SGA) have an increased risk of developing type 2 diabetes and the metabolic syndrome later in life (Hales & Barker, 2001). Moreover, decreased head circumference has been related to increased incidence of developmental problems in children (Smith et al., 2006). In fact, although children with poor prenatal and postnatal head circumference have the worst neurodevelopmental outcomes, even children with small head circumference at birth, but with

good head growth postnatally, fare worse developmentally than control group children who are appropriate-for-gestation (Smith et al.).

The Infant Development, Environment, and Lifestyle Study (IDEAL). The IDEAL study is an ongoing longitudinal study of the correlates and possible outcomes associated with prenatal methamphetamine exposure. Clinical sites in specific geographic areas known to have methamphetamine problems were selected and include Tulsa, Los Angeles, De Moines, and Honolulu (Arria et al., 2006). Out of a sample of 1,632 mothers (users and non-users of alcohol, tobacco, methamphetamine, and other drugs), 84 (5.2%) were classified as being methamphetamine exposed, meaning they had used methamphetamine at some point during their pregnancy. Additionally, 2.8% were alcohol exposed, 25.3% were tobacco exposed, 6% were marijuana exposed, and 10.7% were any illicit drug exposed. A final sample of 166 were enrolled in the longitudinal follow-up (n=74 exposed, n=92 matched comparison). The method of enrollment ensured a community rather than a convenience or clinical sample of methamphetamine-using women with comparison subjects selected from the same hospital population. Although amphetamine and ecstasy exposed mothers were also included in the methamphetamine group, less than 1% reported using these drugs during pregnancy (Smith et al., 2008).

Early demographic findings in the IDEAL study revealed no differences in race between the methamphetamine-exposed and methamphetamine-unexposed groups (Smith et al., 2006). The study also found that mothers in the methamphetamine-exposed group were more likely to have a lower social-position index, live in a household earning less than $10,000 per year, have public insurance, be without a partner, and be educated less than 12 years. These mothers were also younger, sought prenatal care later in gestation, had fewer prenatal care visits, and gained more weight than the methamphetamine-unexposed group. Additionally, tobacco, alcohol, and marijuana exposures were higher in the methamphetamine-exposed group. Finally, methamphetamine-exposed neonates had lower birth weights and a higher incidence of SGA infants. Length and head-circumference data was not available for the majority of unexposed neonates; therefore, there was limited ability to determine if growth restriction was symmetric or not (Arria et al., 2006).

In the first report from the prospective, matched comparison designed IDEAL study of children exposed to methamphetamine in-utero, Smith et al. (2008) found that, although there were no differences in the one and five minute Apgar scores between the two groups, neurobehavioral patterns of increased physiological stress, and higher

amphetamine metabolite levels were associated with the methamphetamine-exposed group. Additionally, results suggested that decreased arousal, physiological stress, and increased lethargy were associated with heavy methamphetamine exposure (Smith et al.).

Methamphetamine: Additional Findings on Prenatal Exposure

Prenatal methamphetamine exposure, caregiving environment, and attachment security in 12- to 24- month-olds (infants). In 1994, Lutsky conducted a study examining prenatal methamphetamine exposure, caregiving environment, and attachment security in 12- to 24-month-old infants. The study included 20 prenatally methamphetamine-exposed children who had remained in their biological mother's custody since birth (BIO group), 20 prenatally methamphetamine-exposed children who had been placed in foster custody continually for at least three months (FOSTER group), and 20 children who had not been prenatally exposed to drugs or alcohol and who had been in their biological mother's custody since birth (CONTROL group). Findings were that 50 of the 60 children had secure attachments, although there were a significantly greater number of insecure/disorganized attachments among the drug-exposed BIO group versus the non-drug exposed CONTROL group. Additionally, caregiving environment seemed to be unrelated to the quality of attachment among the children

prenatally exposed to methamphetamine as the incidence of insecure/disorganized attachments did not significantly differ between the BIO and FOSTER groups (Lutsky).

Fetal and infant deaths associated with maternal methamphetamine abuse. Stewart and Meeker (1997) studied eight cases of fetal and infant death that were related to maternal methamphetamine abuse. The cause for death in each case was abstracted from the information supplied by pathologists' reports. On average, fetal death occurred at gestation week 30 with a range of 20 to 36 weeks. Fetuses were from five to eight months in maturation, with two newborns being full term. They found that the fetus was at greatest risk during the first trimester of the pregnancy, the time when cells differentiate and develop into limbs and organs, while the risk of spontaneous abortion in the second trimester, and risk of premature birth in the third trimester were also increased with drug use. The brain and nervous system develop throughout pregnancy and were ultimately always vulnerable to damage.

Because methamphetamine also increases heart rate, constriction of the blood vessels, and blood pressure elevation, the mothers were at risk for premature separation of the placenta from the uterine wall, which results in spontaneous abortion or premature delivery. Stewart and

Meeker (1997) reported considerable placental transfer of methamphetamine from maternal to fetal blood because of the drug's low molecular weight and lipid solubility. With this transfer and the immaturity of fetal metabolic abilities, the methamphetamine remained in the fetus' circulatory system much longer than it remained in the mother's blood. Therefore, fetal stroke was also a risk as methamphetamine causes acutely elevated blood pressure in the fetus. According to the authors, "Mechanisms by which methamphetamine can compromise fetal development include fetal acidosis, hypoxernia, decreased uterine blood flow, changes in fetal blood gases, and an increase in fetal glucose levels" (Stewart & Meeker, p. 517).

Brain proton magnetic resonance spectroscopy in children exposed to methamphetamine in utero. In 2001, Smith et al. found evidence for in vivo brain metabolite alterations in children who were prenatally exposed to methamphetamine. Furthermore, these children had increased creatine [Cr] in their basal ganglia but without significant differences in NA [N-acetylaspartate], which is a biochemical marker of neural loss. These findings suggested an abnormality in energy metabolism in the brains of children prenatally exposed to methamphetamine. Interestingly, no differences were found in reported behavior problems among the methamphetamine-exposed children

relative to the unexposed group. This was surprising as, according to authors, “The scant developmental data available on methamphetamine-exposed children suggest they have disorders of executive function manifested by aggressive behavior and hyperactivity” (Smith et al., p. 258).

Effects of prenatal methamphetamine exposure on fetal growth and drug withdrawal symptoms in infants born at term. In a study of the effects of prenatal methamphetamine exposure on fetal growth and drug withdrawal symptoms in infants born at term, Smith et al. (2003) retrospectively identified 134 neonates whose mothers used methamphetamine during pregnancy and matched them to 160 unexposed newborns. Results indicated no differences in infant growth parameters, but found that methamphetamine exposure was associated with decreased growth relative to infants exposed only for the first two trimesters. Additionally, significantly more SGA infants were found in the methamphetamine-exposed group. Withdrawal symptoms requiring pharmacologic intervention were observed in 4% of the methamphetamine-exposed infants. Furthermore, methamphetamine use during all three trimesters was associated with lower birth weight and head circumference. The authors also stated that their findings were

consistent with other studies in which growth parameters at birth were not affected by adequate prenatal care (Smith et al., 2003).

Methamphetamine abuse during pregnancy and its health impact on neonates born at Siriraj Hospital, Bangkok, Thailand. In 2004, Chomchai et al. studied the impact of intrauterine methamphetamine exposure on the overall health of newborn infants using a sample of 47 infants born to methamphetamine abusing mothers and 49 newborns whose mothers did not use methamphetamine during pregnancy. They found that the methamphetamine-exposed group had a significantly smaller gestational age-adjusted head circumference and birth weight. Additionally, methamphetamine exposure was also associated with symptoms of agitation, vomiting, and tachypnea when compared to the nonexposed group. Finally, the authors discuss prior research suggesting that methamphetamine exposure during fetal life can produce problems with behavior, learning, and cognition; results that are sustained through utero-placeptal insufficiency, intracranial hemorrhages, and smaller overall growth (Chomchai et al., 2004).

Smaller subcortical volumes and cognitive deficits in children with prenatal methamphetamine exposure. Chang et al. (2004) studied children between the ages of 3 to 16 with a history of methamphetamine exposure in-utero to examine the possible neurotoxic effects of prenatal

methamphetamine exposure on the developing brain and cognition. Using magnetic resonance imagery (MRI) and various neuropsychological measures on a sample of 13 methamphetamine-exposed children and 15 unexposed children, the authors found that methamphetamine-exposed children scored lower on measures of visual motor integration, attention, long-term spatial memory, and verbal memory. Additionally, compared with the control group, children prenatally exposed to methamphetamine exhibited smaller subcortical volumes and associated neurocognitive deficits. While they found no difference in motor skills, short delay spatial memory, or measures of non-verbal intelligence, the researchers correlated the deficiencies in the brain structures with poor performances on measures of sustained attention and delayed verbal memory. Their conclusion was that prenatal methamphetamine exposure "…may be neurotoxic to the developing brain" (Chang et al., 2004, p. 95).

Cognitive development in methamphetamine exposed and high-risk infants. In a 2006 dissertation, Vaz examined the cognitive development in methamphetamine-exposed and high-risk infants. The study utilized retrospective data collected from a state-funded grant program. To investigate the effects of prenatal methamphetamine use on cognitive development, the author used the Bayley Scales of Infant

Development (BSID) and the Parenting Stress Index (PSI) scores of 34 mother/child dyads. According to the author, the findings suggested that the mothers' educational attainment and enhanced social and emotional support had potentially protective effects on the attachment quality and cognitive development of high-risk and drug-exposed infants (Vaz).

Structural and metabolic brain changes in the striatum associated with methamphetamine abuse. In 2007, Chang, Alicata, Ernst, and Yolkow used MRI and positron emission tomography (PET) scans to evaluate brain structural, chemical, and metabolite changes in methamphetamine subjects and children with prenatal methamphetamine exposure. They found that the children with methamphetamine exposure showed smaller striatal structures and elevated total creatine. Additionally, reduced dopamine transporter [DAT] density and reduced dopamine D_2 receptors in the striatum were consistently shown in the PET scans. The authors suggest that neuroimaging studies convincingly demonstrate that individuals who use methamphetamine, as well as children with prenatal methamphetamine exposure, have abnormalities in brain structure and chemistry, particularly in the striatum (Chang et al.).

Ian: A 7-year-old with prenatal drug exposure and early exposure to family violence. A 2008 case study by Stein, Drahota, and Chavira

revealed physical aggression, attention and focusing difficulties, and repetitive and phobic behaviors in a 7-year-old male who had been exposed to methamphetamine and marijuana throughout gestation. He was also diagnosed with a receptive and expressive language disorder at age 4 years. Moreover, a Gilliam Autism Rating Scale indicated the probability of autism. A Wechsler Intelligence Scale-IV revealed that Ian had a verbal intelligence quotient of 75 and a performance intelligence quotient of 108, with a full scale score of 81. Although he was born by Caesarean section, due to failure to progress, he received normal Apgar scores and followed an unremarkable neonatal course (Stein, Drahota, & Chavira, 2008).

Prenatal exposure to methamphetamine presenting as neonatal cholestasis. Finally, a 2009 study by Dashan revealed neonatal cholestasis related to prenatal exposure to methamphetamine in a 35 week preterm, appropriate for gestational age female. Cholestatic hepatitis is a recognized complication of exposure to specific drugs (carbamazepine and trimethoprim-sulfamethoxazole); however, according to the author, this case was the first recorded of neonatal cholestasis related to prenatal methamphetamine exposure (Dashan, 2009).

Alcohol: Effects of Prenatal Exposure

Although the focus of this study will be on the overarching effects of prenatal methamphetamine, it is important to also recognize another substance, alcohol, whose prenatal exposure has been found to have extremely detrimental effects on infants and children. Studies examining the effects of prenatal alcohol exposure on infants have been numerous. Alcohol use during pregnancy has been found to contribute to effects in exposed children ranging from hyperactivity/attention problems, learning/memory deficits, to problems with social/emotional development (Jacobson & Jacobson, 2002). While the most serious consequences of prenatal alcohol exposure is “fetal alcohol syndrome” (FAS), the term "fetal alcohol effects" (FAE) is used for children whose mothers drank heavily during pregnancy, but who exhibit only some of the characteristics of FAS. Additionally, "alcohol-related neurodevelopmental disorder" (ARND) has been used to describe children whose mothers had confirmed heavy prenatal alcohol exposure and who exhibit measurable, but subtler, neurobehavioral deficits than individuals with FAS (Jacobson & Jacobson). A 2002 study conducted by Jacobson and Jacobson found that although the most severe patterns of intellectual/cognitive deficits (hyperactivity, sustained attention, cognitive flexibility, planning abilities, learning, memory, and socioemotional

functioning) are typically found in children with FAS, children who have been prenatally exposed to much lower levels of alcohol frequently exhibit similar problems. Likewise, in an earlier study exploring the long-term outcome of children with FAS, psychopathology, behavior, and intelligence assessments were conducted on children from preschool age to late school age (greater than 13 years of age). Findings included a strong persistence over time of excessive psychopathology. Symptoms included hyperkinetic disorders, emotional disorders, sleep disorders, and abnormal habits and stereotypes. Further, cognitive functioning was marked by a large proportion of mentally retarded children. The long-term outcome study reflected the severe handicapping effects of FAS (Steinhausen & Spohr, 1998).

In a more recent study evaluating the social problem solving skills of adolescents with histories of fetal alcohol exposure, researchers found that alcohol-exposed adolescents had substantial impairments, even in the absence of mental retardation, in their abilities to solve problems in everyday life. These impairments were also likely to have a significant impact on social and academic functioning (McGee, Fryer, Bjorkquist, Mattson, & Riley, 2008). Finally, in a 2009 study, the language abilities of children (ages 3 to 5) with heavy prenatal alcohol exposure were evaluated. Results indicated that the alcohol exposed group had

significantly poorer language skills than did a control group. However, the language performance did not deviate significantly from what would be predicted by full scale IQ scores for either group. The authors suggested that while receptive and expressive language abilities are impaired in children with heavy prenatal alcohol exposure, they are not more impaired than the children's general intellectual functioning. They further posited that the deficits are likely to impact the social interactions and behavioral adjustments of children with prenatal alcohol exposure (McGee, Bjorkquist, Riley, & Mattson, 2009).

Marijuana: Effects of Prenatal Exposure

Finally, as marijuana is one of the most commonly used drugs by pregnant women, Karila, Cazas, Danel, & Reynaud reviewed the literature in 2006 to examine the association between cannabis use during pregnancy and the resulting effects upon growth, cognitive development, and behavior of newborns, children and teenagers. They found that cannabis use during pregnancy was related to diverse neurobehavioral and cognitive outcomes, including symptoms of inattention, impulsivity, deficits in learning and memory, and a deficiency in aspects of executive functions. In conclusion, in a 2008 prospective study of the effects of prenatal marijuana exposure on the intelligence test performance of children, Goldschmidt, Richardson, Willford, & Day

found a significant nonlinear relationship between marijuana exposure and child intelligence. Heavy marijuana use (one or more cigarettes per day) during the first trimester was associated with lower verbal reasoning scores, while heavy use during the second trimester predicted deficits in composite, short-term memory, and quantitative scores. Additionally, heavy use during the third-trimester was negatively associated with the quantitative score. The authors concluded that prenatal marijuana exposure has a significant effect on school-age intellectual development (Goldschmidt, Richardson, Willford, & Day, 2008).

Limitations and Confounding Variables in Previous Studies

Human studies examining the effects of methamphetamine use on the developing fetus have been limited by small sample sizes with 20 participants or less (Chang et al., 2004; Smith et al., 2001). Additionally, limitations have included reliance on maternal self-report for confirmation of drug use, multidrug abuse, and comparisons with normative peer samples, rather than control groups (Wouldes et al., 2004). Moreover, a major difficulty lies in distinguishing between the negative impact of methamphetamine exposure in-utero and the exposure that occurs postnatally through home manufacture or chronic maternal use of the substance (McGuinness & Pollack, 2008). Furthermore, difficulty lies in the potential confounding effects of mothers' educational attainment, as

well as emotional and social support (Vaz, 2006). Finally, while methamphetamine has been a significant drug problem since the 1990s, studies investigating the long-term effects of prenatal exposure to the drug are sparse, while the numbers of exposed infants appears to be rising. For example, the facility in this study noted a startling increase in the numbers of very young children (under the age of 2½ years) presenting with prenatal methamphetamine exposure: from 155 between the years of 1997 through 2007; to 89 over the past year and two months. Although the IDEAL study is now following children with prenatal methamphetamine exposure, the investigators are still in the beginning stages of collecting data on these subjects (Smith, et al., 2008).

Chapter 3

Method

Overview

This study analyzed retrospective data collected from an outpatient facility that conducts multidisciplinary developmental evaluations of children from 1 month to 7 years of age with prenatal exposure to alcohol and/or drugs. The facility is part of a state-funded university health complex located in a large Southwestern city. The program is funded by a grant from the Oklahoma Department of Mental Health and Substance Abuse Services (ODMHSAS), and offers services provided by psychologists, social workers, and interdisciplinary staff, including a physical therapist and developmental pediatrician.

Demographic information, as well as measures of cognitive, language, motor, emotional and behavioral functioning, and physical indicators of development were completed on each infant and child and entered into a database. Positive prenatal drug exposure was determined by mother self-report, caregiver-report, and/or a positive toxicology screening at the time of the child's birth.

Participants

The program in this study provides a model for early identification and intervention of fetal alcohol and drug exposed infants and toddlers.

As the only program in the state specifically designed to work with infants and children with prenatal exposure to drugs and/or alcohol and their families, referrals come to this program from across the state. There were 1,556 records in the program's database of children between the ages of 1 month to 7 years, for the time period of April 23, 1997 through June 15, 2009, who were administered the Bayley Scales of Infant Development – Second Edition (BSID-II; Bayley, 1993), Bayley Scales of Infant Development – Third Edition (BSID-III; Bayley, 2006), Wechsler Preschool and Primary Scales of Intelligence – Revised Edition (WPPSI-R; Wechsler, 1989), and Wechsler Preschool and Primary Scales of Intelligence – Third Edition (WPPSI-III; Wechsler, 2002). However, many of the children were assessed multiple times and at different ages. Therefore, while a child may have been included in more than one measurement grouping in the current study (e.g., completed the BSID-II at age 12 months; completed the WPPSI at a return visit at age 36 months; scores at each visit will be included in the study), each child was only included in a measurement grouping one time (e.g., completed the BSID-II at 6 months; completed the BSID-II again at a return visit at age 12 months; only scores for one of the visits will be included in the study).

Participants were grouped according to reported prenatal substance exposure. Group 1 included children who were prenatally

exposed to methamphetamine only; Group 2 included children who were prenatally exposed to methamphetamine plus other substances; and Group 3 included children who were prenatally exposed to other substances not including methamphetamine. A caveat to the Group 1 description was that several of these children's prenatal exposure also included nicotine. According to a 2008 unpublished manuscript by Gurwitch, et al. that analyzed patients from the same clinic as in this study, no significant differences were observed between a group of methamphetamine-only exposed children and a group of methamphetamine plus nicotine exposed children in terms of cognitive, language, or behavioral variables. The only area in which a significant difference was found included motor scores. Specifically, children in the methamphetamine-only group performed significantly lower than children in the methamphetamine and nicotine group (Gurwitch, Mignogna, Wagener, & Wolfe-Christensen, 2008).

Fifteen hundred and fifty-six child records were included in this study. However, because of missing data, not all records were included in all analyses.

Measures

Demographic information was obtained using clinic intake forms. Depending upon the child's age and the year of administration, cognitive development was assessed using the Bayley Scales of Infant and Toddler Development – Second Edition, Mental Developmental Index (BSID-II, MDI; Bayley, 1993), Bayley Scales of Infant and Toddler Development – Third Edition, Mental Scale (BSID-III; Bayley, 2006), the Wechsler Preschool and Primary Scales of Intelligence-Revised (WPPSI-R; Wechsler, 1989), or Wechsler Preschool and Primary Scales of Intelligence, Third Edition (WPPSI-III; Wechsler, 2002). Language development was assessed using the BSID-II, MDI, (Bayley, 1993), BSID-III Language Scale (Bayley, 2006), the Preschool Language Scale, Third Edition (PLS-3; Zimmerman, Steiner, & Pond, 1992) or Preschool Language Scale, Fourth Edition (PLS-4; (Zimmerman, Steiner, & Pond, 2008) depending upon the child's age and the year of administration. Motor development was assessed using the BSID-II, Psychomotor Developmental Index (BSID-II, PDI; Bayley, 1993), BSID-III Motor Scale (Bayley, 2006), or the Peabody Developmental Motor Scales, Second Edition (PDMS-2; Folio & Fewell, 1983) depending upon the child's age. Emotional functioning was assessed using the Behavior Assessment System for Children, Parent Rating Scale (BASC-PRS; Reynolds &

Kamphaus, 1992) or Child Behavior Checklist (CBCL; Achenbach, 1991), and behavioral functioning was assessed using the Eyberg Child Behavior Inventory (ECBI; Eyberg & Pincus, 1999). Head circumference was obtained using medical forms and/or the Child Health Screening Physical Indicators of Development form (PID).

Demographics. A clinic intake form was used to collect the infant/child and family information. Often, these children do not reside with their biological mother or father; therefore, the information regarding the biological parents and developmental history of the child is obtained from the current caregiver (i.e., foster parent, adoptive parent, or case worker). These individuals are generally knowledgeable about the child's history from personal experience or from Oklahoma Department of Human Services (OKDHS) records.

Information was gathered during an intake interview conducted with the child's caregiver(s) by a clinic professional at the time of the child's assessment visit. In the current study, the child's age, sex, ethnicity/race, birth prematurity, and prenatal substance exposure was extracted for descriptive purposes. Additionally, extracted information included the number of primary caregiver changes, length of time with current caregiver, primary caregiver relationship, primary caregiver socioeconomic status, biological parents' ethnicities/races, biological

parents' dates of birth, biological parents' education levels, and biological parents' marital status. Finally, to aid in developing as complete a picture as possible of these children, previous and current levels of Department of Human Services (DHS) involvement, abuse and neglect charges, domestic violence charges, prenatal care, number of pregnancies, number of children, and number of children residing with biological mother was also included.

BSID-II and BSID-III. The Bayley Scales of Infant Development (BSID) was developed by Nancy Bayley in 1969 and was a derivative of several theoretically eclectic scales of infant development (Bayley, 2006). The 2006 BSID Third Edition (BSID-III) is the revised edition of the 1993 BSID Second Edition (BSID-II); both instruments are utilized to measure development in infants aged 1 month to 42 months, as well as to diagnose developmental delays and to plan intervention strategies. Composite raw scores are converted to standardized scores (M=100, SD=15) for ease of comparison with other measures and between subjects (Bayley, 2006).

While the BSID-II consisted of a Mental Developmental Index (MDI; which assesses current cognitive and language functioning), a Psychomotor Developmental Index (PDI; which evaluates fine and gross motor functioning), and a Behavior Rating Scale score (BRS; which

assesses the qualitative aspects of test-taking behavior), only the MDI and PDI scores of the BSID-II will be utilized in this study. The MDI was used as a measure of cognitive and language functioning, as it evaluates sensory-perceptual abilities, object permanence skills, memory, learning, verbal communication, and abstract thinking skills. The PDI was used as a measure of motor functioning, as it evaluates gross and fine motor skills and overall body control.

The creation of a separate Language Scale in the BSID-III not only reduced the number of items within the BSID-II Mental Scale, it also permitted expansion of the cognitive concepts and constructs being assessed within the BSID-III Cognitive Scale. Additionally, the separate Language Scale made it possible to measure receptive and expressive language skills, two areas that require different abilities and that can develop independently. The ability to assess these separately is important when diagnosing critical delays and in determining the etiology of the delay (Bayley, 2006). The BSID III is comprised of five scales designed to assess young children's developmental functioning across the Cognitive, Language (receptive and expressive), Motor (fine and gross), Social-Emotional, and Adaptive (conceptual, social, and practical) behavior domains. The Cognitive, Language, and Motor portions of the BSID-III are completed by professionals, while the Social-Emotional and

Adaptive portions are assessed using questionnaires completed by the child's caregiver (Bayley, 1993, 2006). The facility in this study utilizes only the Cognitive, Language, and Motor portions of the BSID-III; therefore, these were the three domains of the BSID evaluated in this paper.

According to Tobin and Hoff (2004), the BSID-III maintained the objectives and general assessment approach of its predecessors while improving the psychometric properties. In general, the psychometric properties of the Bayley-III far exceed the guidelines recommended by the American Educational Research Association, American Psychological Association, and National Council on Measurement in Education. Reliability coefficients for the Bayley-III composites are presented by age group with the average reliability coefficients calculated using Fisher's *z* transformation (Silver & Dunlap, 1987; Strube, 1988). The average reliability coefficients for the Cognitive, Language, and Motor composite scores were .91, .93, and .92, respectively, with the highest subtest being .98 and the lowest subtest being .71. The majority of the subtest reliability coefficients across special groups are similar to or higher than those coefficients reported for the normative sample, which suggests that the Bayley-III is an equally reliable tool for the assessment of children with clinical diagnoses, as

well as children from the general population (Bayley, 2006). Test-retest reliability was estimated using Pearson's product-moment correlation coefficient, with Cohen's *d* used to report standard differences (Cohen, 1996). Bayley-III scores possess a high degree of stability over time and show a slight increase in stability across age groups. The data show an increase between the first and second testing of approximately .3 points in the Receptive and Expressive Communication subtests and .9 points in the Cognitive Scale across all ages. Additionally, the data show an increase of 2.1 points on the Language composite and 3.5 points on the Motor composite (Bayley, 2006).

In validity studies, Bayley–III composite and subtest standard scores met theoretical expectations and were consistent with the results of the WPPSI–III, the PLS–4, and the Peabody Developmental Motor Scales, Second Edition (PDMS–2; Folio & Fewell, 2000). The BSID-III Cognitive Scale correlates highly with the WPPSI-III FSIQ (r = .79), yet seems more related to the VIQ (r = .79) than the PIQ (r = .72). Regarding language, the data show very little difference between the means of the Bayley-III composites and the PLS-4 scores. The highest correlation was between the Bayley-III Language composite and the PLS-4 Expressive Communication subtest (r = .71). The pattern of correlations and lack of difference between the means suggest that the

Bayley-III Language Scale and the PLS-4 assess similar constructs. Finally, regarding motor, the data show very little difference between the means of the Bayley-III composites and the PDMS-2 quotients. The highest correlations were between the BSID-III Fine Motor subtest and the PDMS-2 Fine Motor Quotient (*r* = .59), and between the BSID-III Gross Motor subtest and the PDMS-2 Gross Motor Quotient (*r* = .57). A moderate correlation is also seen between the BSID-III Motor composite and the PDMS-2 Total Motor Quotient (*r* = .55). Evidence has also been provided to show that the Bayley-III is sensitive to performance differences between children in the normative sample and samples of children with various conditions placing them at risk for developmental delay (Bayley, 2006).

WPPSI-R and WPPSI-III. The Wechsler Preschool and Primary Scales of Intelligence (WPPSI) is a standardized test designed to measure intelligence in children between the ages of 2 years, 6 months {Record Form Ages 2:6-3:11} and 7 years, 3 months of age {Record Form Ages 4:0-7:3}. The 2002 WPPSI Third Edition (WPPSI-III) is the revised edition of the 1989 WPPSI Revised Edition (WPPSI-R). Both versions of the WPPSI contain two core batteries in which subtests yield a Verbal IQ (VIQ) and a Performance IQ (PIQ). When combined, the two scales produce a Full Scale IQ (FSIQ). The VIQ is a measure of verbal

ability, including assessment of word knowledge, ability to acquire, retain, and retrieve general factual knowledge, analogic and general reasoning ability, and ability to integrate and synthesize different types of information. The PIQ is a measure of nonverbal ability, including perceptual recognition and discrimination, spatial analysis, abstract visual problem solving, and visual-motor coordination (Wechsler, 1989, 2002).

The WPPSI-R contains 12 subtests, while the WPPSI-III includes 14 subtests. In both versions, the child's general intellectual functioning is represented using an FSIQ with a mean of 100 and standard deviation of 15. The same metric is employed for all composites as raw scores on each subtest are converted to scaled scores with a mean of 10 and standard deviation of 3. The scaled scores were used to calculate the VIQ and PIQ (Wechsler, 1989, 2002). In the current study, only the core tests were utilized and the FSIQ reported.

The WPPSI-R and WPPSI-III have been shown to have high concurrent validity at .70 for the Performance Scale, .86 for the Verbal Scale, and .85 for the Full Scale IQ. They also produced split-half reliability estimates of .83 to .95, with only a few subtests being less than .80 at specific ages. The average Full Scale internal consistency coefficient was high at .96 (Wechsler, 2002). In the current study, use of

the specific version of the WPPSI depended upon the child's age and the year of the evaluation.

PLS-3 and PLS-4: The Preschool Language Scale (PLS) was developed by Irla Lee Zimmerman, Ph.D.; Violette G. Steiner, B.S.; and Roberta Evatt Pond, M.A. The measure was designed to be individually administered by professionals to identify language disorders or delays in children, birth through 6 years, 11 months of age. A revision of the 1992 PLS Third Edition (PLS-3), the 2008 PLS Fourth Edition (PLS-4) features expanded language coverage and updated norms.

The PLS yields receptive and expressive subtest scores, which combine to form a Total Language Composite score. Language skills are targeted in the areas of language structure, vocabulary, phonological awareness, vocal development, social communication, integrative language skills, gesture, concepts, attention, and play. The Auditory Comprehension score is comprised of 62 items (each correct answer earns one point) and measures the ability to understand words and their relationships (i.e., receptive language). The Expressive Communication score is comprised of 68 items (each correct answer earns one point) and measures the ability to use words and sentences to express ideas, wants, and needs. Each of the scores, Auditory Comprehension, Expressive Communication, and Total Language Score, is standardized

with a mean of 100 and a standard deviation of 15 (Zimmerman, Steiner, & Pond, 1992, 2008).

On the PLS-3, concurrent validity for Auditory Comprehension was .69, for Expressive Communication was .75, and for Total Language was .82. Internal consistency reliability ranged from .47 to .86 for Auditory Comprehension, from .68 to .86 for Expressive Communication, and from .74 to .92 for the Total Language Score. Interrater reliability was .98 (Zimmerman et al., 1992).

On the PLS-4, extensive evidence of validity based on test content, response processes, internal structure, relationships with other variables, and consequences of testing has been reported. A clinical validity study was conducted with a sample of 150 children (75 with a language disorder, 75 typically developing children). Sensitivity and specificity information for PLS-4 scores for children in this study were: Auditory Comprehension sensitivity .80, specificity .92; Expressive Communication sensitivity .77, specificity .84; and Total Language Score sensitivity .80, specificity .88. Test-retest reliability coefficients ranged between .82 and .95 for subscale scores and .90 to .97 for Total Language Score. Internal consistency reliability coefficients range from .66 to .96 with coefficients of .81 and higher for most ages. Inter-rater reliability was scored with an agreement percentage of 99%

(Zimmerman, Steiner, & Pond, 2008). In the current study, use of the specific version of the PLS depended upon the year of the child's evaluation.

PDMS-2. The Peabody Developmental Motor Scales Second Edition (PDMS-2) was developed by M. Rhonda Folio and Rebecca R. Fewell. An early childhood motor development program that provides both in-depth assessment and training or remediation of gross and fine motor skills, the assessment was designed to be used in settings that provide services to preschool age children from birth through 5 years of age. The PDMS-2 is composed of two primary scales (Gross Motor and Fine Motor), six subtests (Reflexes, Stationary, Locomotion, Object Manipulation, Grasping, and Visual-Motor), and 72 items (the score for each item ranges from 0 to 2). The Gross Motor development score and Fine Motor development score yield a Total Motor Quotient that is a measure of the interrelated motor abilities that develop early in life. The subtests within the domains of Gross Motor and Fine Motor yield scores with a mean of 10 and a standard deviation of 3. Scores are presented as percentiles, standard scores, and age equivalents, with norms that are stratified by age and based on a nationally representative sample of more than 2,000 children (Folio & Fewell, 1983). In the present study,

the standardized scores will be utilized for ease of comparison with other measures and between subjects.

Concurrent validity evidence for the PDMS-2 and the BSID had high correlations for the Fine Motor scales (*r* = .87) and the Gross Motor scales (*r* = .83). Criterion-prediction validity measured (*r* = .80) in comparisons with the first edition of the PDMS, as well as with another comparable test (Bunker, 2000). According to Anastasi and Urbina (1997), overall reliability is based on three sources of test error (content, time, and scorer) and showed a high degree of consistency. The Fine Motor coefficients were content sampling (*r* = .96), time sampling (*r* = .93), and interscorer differences (*r* = .98). Gross Motor coefficients were content sampling (*r* = .96), time sampling (*r* = .89), and interscorer differences (*r* = .97).

BASC-PRS. The Behavior Assessment System for Children (BASC) was developed by Cecil R. Reynolds, Ph.D. and R.W. Kamphaus, Ph.D. in 1992. A multimethod, multidimensional system intended to assess observable behavior and self-perception ratings of individuals ages 2-25, the BASC self-report forms contain items that tap multiple emotional and behavioral domains and are completed by the parent, teacher, and child. Producing scaled scores that represent pathological and adaptive characteristics as quantitative deviations from

the mean (Doyle et al., 1997), the data included in this study were based only on the parent self-report forms for ages 2 years, 6 months through 5 years (PRS-P, 131 items) and ages 6 years through 11 years (PRS-C, 138 items).

The BASC Parent Rating Scale (BASC-PRS) is completed by a parent, guardian, foster parent or other custodial caregiver with regard to a child's adaptive and problem behaviors in the home and community settings. Assessing adaptive and problem behaviors, the PRS scale is completed using a four-choice response format, ranging from Never (0) to Almost Always (3). The PRS yields *T*-scores in broad internalizing and externalizing domains, as well as in specific content areas (Doyle et al., 1997). The Clinical Scales include Hyperactivity, Aggression, Anxiety, Depression, Somatization, Atypicality, Withdrawal, and Attention Problems, while the Adaptive Scales include Adaptability and Social Skills. Internal consistency of the various BASC-2 forms is relatively high (Doyle et al.).

According to Hughes and Melson (2008), validity of the BASC-2 measures appear to be high with evaluations largely focused on the instrument’s correlation with other assessment scales. Regarding predictive validity, children in clinical samples demonstrated that the PRS correctly identified 78.1% of children tested. Additionally, to increase the

validity of the BASC, the PRS has built-in validity checks to ensure that the responder understands the instrument, responds honestly, and pays close attention to each item. Median Cronbach alpha values were .81, .85, and .85 respectively for preschool, child, and adolescent levels. Test-retest reliability coefficients were .76, .84, and .82, respectively, while interrater reliability coefficients ranged from .46 to .71 (Hughes & Melson).

CBCL. To measure the child's emotional and behavioral functioning, the Child Behavior Checklist (Achenbach, 1991; Achenbach & Rescorla, 2000, 2001), which was developed in the 1960s, is completed by the child's primary caregiver at the time of the child's evaluation. A multidimensional tool that assesses a range of behavioral and emotional problems, the CBCL includes multi-informant reports for parents, teachers, and other caregivers. In the current study, the CBCL for ages 1½ to 5 years and the CBCL for ages 6 to 18 years were used. Respondents read a description of a behavioral or emotional problem and rate how true the behavior is for their child (currently and over the past two or six months, depending on the version) on a 3-point Likert-type scale. Choices range from "Not True" to "Very or Often True" with 100 items on the CBCL for ages 1½ to 5 years and 113 items on the CBCL for ages 6 to 18 years. This measure yields profile scores

identifying the presence of affective problems, somatic problems, anxiety problems, attention deficit/hyperactivity problems, oppositional defiant problems, and conduct problems (Achenbach, 1991; Achenbach & Rescorla, 2000, 2001). The current study utilized the internalizing and externalizing scores as a measure of emotional functioning.

The CBCL appears to be a reliable instrument as individual item intraclass correlations (ICC) of greater than .90 were obtained between item scores obtained from mothers filling out the CBCL at 1-week intervals, mothers filling out the CBCL on their clinically-referred children, and three different interviewers obtaining CBCLs from parents of demographically matched triads of children. Stability of ICCs over a 3-month period was .84 for behavior problems and .97 for social competencies. Test-retest reliability of mothers' ratings was .89 (Achenbach & Rescorla, 2000, 2001). Furthermore, the CBCL appears to have good validity as tests of criterion-related validity using clinical status as the criterion (referred/non-referred) support the validity of the instrument. Importantly, demographic variables such as race and SES accounted for a relatively small proportion of score variance (Achenbach & Rescorla, 2000, 2001).

ECBI. The Eyberg Child Behavior Inventory (ECBI) is a widely used parent rating scale that was developed by Sheila Eyberg in 1999.

Designed for use as a quick screening tool in clinical pediatric settings to quantify disruptive behavior in children between 2 and 16 years of age, the measure contains 36 items rated on two scales. To obtain a measure of conduct problem severity, parents/caregivers rate the frequency of behaviors on a Likert-type Intensity Scale from Never (1) to Sometimes (4) to Always (7). To determine a measure of parental tolerance, parents/caregivers then complete the Problem Scale by circling "Yes" or "No," to indicate whether they consider each behavior to be a problem (Eyberg & Pincus, 1999).

In psychometric studies, both scales have shown high internal consistency and stability, as well as convergent and discriminant validity with ratings scales of psychopathology and behavioral observation measures. Internal consistency reliability studies indicated Cronbach alpha values for the ECBI Intensity Scale ranging from .95 to .98. Kuder-Richardson 20 values for the ECBI Problem Scale were reported to be in the .90s as well. Test-retest reliability ranged between the 70s and 80s for both the Intensity and Problem scales. Interrater reliability for parents ranges from .61 to .86 (Rich & Eyberg, 2001).

Medical/Physical Examination. The infant/child's head circumference was obtained by one of two methods. A short medical evaluation was conducted by the developmental pediatrician on staff at

the facility, with the information recorded on the child's medical chart. The second method utilized a Child Health Screening Physical Indicators of Development (PID) evaluation that was conducted by a clinic staff member. In each case, the information included the child's weight, height, and head circumference. For the current study, only the child's head circumference percentile was reported.

Research Design

In this study, the independent variable was a status variable, in that the participants were grouped by prenatal exposure of methamphetamine and other illicit drugs on fetuses. The constructs of cognitive functioning, language functioning, motor functioning, emotional functioning, behavioral functioning, and head circumference were the dependent variables, as measured by scores obtained on the: BSID-II, BSID-III , WPPSI-R, and WPPSI-III (cognitive functioning); BSID-II, BSID-III, PLS-3, and PLS-4 (language functioning); BSID-II, BSID-III, and PDMS-2 (motor functioning); BASC-PRS and CBCL (emotional functioning); ECBI (behavioral functioning); and PID or medical examination (head circumference).

An alpha level of .05 was used for all statistical tests, with *r* calculated as the effect size. The data analyses for the study began with descriptive statistics to determine whether any of the demographic

variables were significantly related to any of the outcome variables (i.e., child cognitive, language, motor, emotional and behavioral functioning, and head circumference).

Simple, univariate between-groups analysis of variance (ANOVA) tests were used to determine if children who were prenatally exposed exclusively to methamphetamine differed significantly from those who were exposed to other substances including methamphetamine and those who were exposed to other substances not including methamphetamine.

Ancillary analysis utilizing T-tests were also conducted to compare the cognitive, motor, language, emotional and behavioral functioning scores, and head circumference of children in the current sample to published norms on each of the measures. These were conducted to determine if the scores of children with prenatal exposure to methamphetamine differ significantly from the normative population or what is expected in children without prenatal exposure to illicit substances. According to an unpublished manuscript by Gurwitch et al., infants with prenatal exposure to methamphetamine obtained cognitive mean scores (BSID-II MDI, WPPSI-R, and WPPSI-III), language mean scores (PLS-3), and motor mean scores (BSID-II PDI) that were

significantly lower than the published norms for each of the tests utilized (Gurwitch et al., 2008).

Chapter 4

Results

Statistical Analyses

Screening for accuracy of data entry and missing values distributions was conducted prior to the main data analysis. Methamphetamine exposure, cognitive development, language development, motor development, emotional development, behavioral scores, and head circumference were examined. The primary problematic screening issue in the current dataset was missing data and children whose prenatal exposure was unknown. Hence, the resulting sample size was 288 for cognitive scores, 540 for language scores, 216 for motor scores, 169 for emotional scores, 367 for behavioral scores, and 1469 for head circumference measurements. Individuals whose prenatal exposure was unknown are noted. Descriptive statistics were used to determine the demographic results, ANOVA analyses were used to examine the research questions, and T-tests were used to compare the sample to the published norms of each assessment measure.

Demographic Results

The Children. The sample consisted of 1556 children with prenatal substance exposure. Of the 1556, 108 (7%) were prenatally exposed to methamphetamine only, 487 (31%) were prenatally exposed

to methamphetamine plus other substances, 872 (56%) were exposed to substances not including methamphetamine, and 89 (6%) were exposed to unknown substances.

The sample consisted of 875 males (56%) and 677 females (44%); the gender of 4 children was unknown. The mean age was 38.23 months, with a minimum age of 2 months and a maximum age of 96 months. Children designated as Caucasian made up 52% of the sample. The remaining sample fell into a distribution of African American (19%), American Indian (12%), Multiracial (11%), and Hispanic (5%). Only 5 children in the sample were listed as Asian. The mean height percentile was 34th, the mean weight percentile was 45th, and the mean head circumference percentile was 40th.

There were 108 children in the sample with methamphetamine only prenatal exposure. Of this group, 74 (68%) were males and 34 (32%) were females. The mean age of children at the time of their clinic visit was 30 months. Children designated as Caucasian made up 72% of the group, while 15% were Native Americans, 9% were Multiracial, 3% were Hispanic, and less than 1% were African American. The mean height percentile was 29th, the mean weight percentile was 41st, and the mean head circumference percentile was 41st.

Biological Mothers of the Children. The biological mothers of children in the sample indicated (or the information was provided by the current caregiver or child's medical records) that only 21% received prenatal care during their first trimester of pregnancy, while 77% did not. Regarding second trimester prenatal care, 31% received care and 68% did not receive care. During the third trimester, 33% received prenatal care, while 65% received no care. The mean education level of the biological mothers was 10th grade. Regarding marital status, 56% of mothers were single, divorced, cohabitating, separated, or widowed, while 20% were married. Caucasians were the largest group represented at 59%, followed by African Americans with 16%, American Indians at 10%, and Hispanics at 4%. Only 5 of the biological mothers were listed as Asian. In an alarming number of cases (73% of the sample), abuse or neglect had been reported at one time or another against the biological mother. It is unknown whether the abuse/neglect was regarding the child in the sample or another child in the home. Additionally, an overwhelming number of biological mothers reported experiencing domestic violence (75%).

The biological mothers of children in the methamphetamine only group indicated (or the information was provided by the current caregiver or child's medical records) that only 10% received prenatal care during

their first trimester of pregnancy, while 86% did not. Regarding second trimester prenatal care, 24% received care and 72% did not receive care. During the third trimester, 32% received prenatal care, while 64% received no care. The mean education level of the biological mothers was 10th grade. Regarding marital status, 51% of mothers were single, divorced, cohabitating, separated, or widowed, while 21% were married. Caucasians were the largest group represented at 68%, followed by American Indians at 14%, and those listing Other as their race made up 7% of this group. Again, in an alarming number of cases (78% of the sample), abuse or neglect had been reported at one time or another against the biological mother. It is unknown whether the abuse/neglect was regarding the child in the sample or another child in the home. Additionally, an overwhelming number of biological mothers reported experiencing domestic violence (82%).

Current Primary Caregivers of the Children. For children in the sample, the mean length of time with the current primary caregiver was 24 months. Regarding relationship to the primary caregiver, 35% lived with a foster parent, 21% lived with an adoptive parent, 18% lived with a grandparent, 17% lived with their biological parent, and 7% lived with another relative. Caucasians made up the largest group of current primary caregivers at 66%, followed by African Americans at 14%,

Multiracials at 6%, and Hispanics at 2%. No Asians were represented in this group. Regarding marital status, 61% were married, while 28% were single, divorced, cohabitating, separated, or widowed. The mean education level of current primary caregivers was 11th grade. A table of demographic information for the sample, along with demographic graphs can be found in Appendices A, B, C, and D.

For children in the group with methamphetamine only prenatal exposure, the mean length of time with their current primary caregiver was 15 months. Of children in the sample, 49% lived with a foster parent, 20% lived with a grandparent, 16% lived with their biological parent, 10% lived with an adoptive parent, and 5% lived with another relative. Caucasians again made up the largest group of current primary caregivers at 77%, followed by Native Americans at 8%, and less than 1% were listed as African Americans. Regarding marital status, 69% were married, while 21% were single, divorced, cohabitating, separated, or widowed. The mean education level of current primary caregivers was 11th grade.

Research Question ANOVA Results

Research question one. Are there differences in the cognitive scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to

methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Table 1, results of ANOVA indicate no significant differences between exposure groups on scores of cognitive development $F(3,288) = .087$, $p = 0.46$. That is, the differences between the cognitive scores of children who were prenatally exposed to methamphetamine only, children who were prenatally exposed to methamphetamine plus other substances, and children who were prenatally exposed to other substances not including methamphetamine did not reach statistical significance.

Table 1

Cognitive Summary

Variable	Df	F value	Pr(>F)	
Exposure	3	0.87	0.46	
Age	1	12.37	0.00	***
Sex	1	0.05	0.83	
Race	4	2.43	0.05	*
HeightLogit	1	0.99	0.32	
WeightLogit	1	1.93	0.17	
Bio Mom Education	1	4.15	0.04	*
Bio Mom Marital	5	0.40	0.85	
Bio Dad Education	1	3.57	0.60	.
Prenatal Care 1st Tri	1	0.12	0.73	
Prenatal Care 2nd Tri	1	5.41	0.21	*
Prenatal Care 3rd Tri	1	2.53	0.11	
Abuse/Neglect	1	0.06	0.80	
Domestic Violence	1	0.06	0.81	
DHS Custody	1	1.40	0.24	
Primary Caregiver Changes	1	0.22	0.64	
Primary Caregiver Relation	5	2.66	0.02	*
Length Time w/ Current CG	1	1.84	0.18	
Residuals	288			

*p < .05. **p < .01. ***p < .001

Research question two. Are there differences in the language scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Tables 2 and 3, results of ANOVA indicate nonsignificant differences between exposure groups on scores of language development at the .05 level, $F(3, 540) = 2.38$, $p = .069$. However, exposure was not found to account for a large amount of variance as the exposure variable dropped only slightly below p=.07 and the R-squared was never above 10%. Multiple R-squared: 0.07307; adjusted R-squared: 0.03702; F-statistic: 2.027 on 21; and 540 DF; p-value: 0.004605. In the results, methamphetamine only exposure had the lowest mean language summary while those with unknown exposure had the highest.

Table 2

Language Summary

Variable	Df	F value	Pr(>F)	
Exposure	3	2.38	0.06905	.
Age	1	2.71	0.10024	
Race	5	2.39	0.03670	*
Height Logit	1	5.09	0.02443	*
Weight Logit	1	2.19	0.13939	
Bio Mom Marital Status	5	0.51	0.77165	
Primary Caregiver Relationship	5	2.19	0.05401	.
Residuals	540			

*p < .05. **p < .01. ***p < .001

Table 3

Language Summary Coefficients

Coefficients	Estimate	Std. Error	T value	Pr(>|t|)	
(Intercept)	88.40	3.97	22.25	< 2e-16	***
Exposure Meth only	0				
Exposure Meth plus	2.73	3.32	0.83	0.41	
Exposure Other	1.11	3.27	0.34	0.73	
Exposure Unknown	8.98	4.44	2.02	0.04	*
Age	-0.09	0.04	-2.33	0.02	*
Race White	0				
Race African American	-0.93	2.20	-0.42	0.67	
Race Native American	0.21	2.32	0.09	0.93	
Race Hispanic	-7.42	3.12	-2.38	0.02	*
Race Asian	39.40	17.44	2.26	0.02	*
Race Multiracial	-2.58	2.60	-0.99	0.32	
Height Logit	0.24	0.64	0.37	0.71	
Weight Logit	0.85	0.58	1.47	0.14	
Bio Mom Marital Single	0				
Bio Mom Marital Married	-0.90	1.77	-0.51	0.61	
Bio Mom Marital Divorced	5.01	3.45	1.45	0.15	
Bio Mom Marital Widow	-4.46	17.60	-0.25	0.80	
Bio Mom Marital Separated	0.86	4.99	0.17	0.86	
Mio Mom Marital Cohabitate	-0.64	3.50	-0.18	0.85	
Primary Caregiver Relationship Bio Parent	0				
Primary Cgiver Relationship Foster	3.06	2.29	1.33	0.18	
Primary Cgiver Relationship Adoptive	7.57	2.40	3.15	0.00	**
Primary Cgiver Relationship Grandparent	3.63	2.30	1.58	0.11	
Primary Cgiver Relationship Other Relativ	5.16	3.13	1.64	0.10	
Primary Cgiver Relationship Other	-0.96	7.36	-0.13	0.89	

*p < .05. **p < .01. ***p < .001

Research question three. Are there differences in the motor scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Table 4, results of ANOVA indicate nonsignificant differences between exposure groups on scores of motor development at the .05 level, F(3, 216) = 2.29, p = .08.

Table 4

Motor Summary

Variables	Df	F value	Pr(>F)	
Exposure	3	2.29	0.08	.
Age	1	0.34	0.56	
Sex	1	0.28	0.60	
Race	4	1.07	0.37	
HeightLogit	1	0.02	0.88	
WeightLogit	1	1.60	0.21	
Bio Mom Education	1	0.02	0.89	
Bio Mom Marital	4	0.69	0.60	
Bio Dad Education	1	1.34	0.25	
Prenatal Care 1st Tri	1	0.99	0.32	
Prenatal Care 2nd Tri	1	4.70	0.03	*
Prenatal Care 3rd Tri	1	0.47	0.49	
Abuse/Neglect	1	0.05	0.82	
Domestic Violence	1	0.19	0.66	
DHS Custody	1	0.57	0.45	
Primary Caregiver Changes	1	0.90	0.34	
Primary Caregiver Relation	5	1.01	0.41	
Length Time w/ Current CG	1	0.46	0.50	
HeightLogit: WeightLogit	1	0.64	0.43	
Residuals	216			

*p < .05. **p < .01. ***p < .001

Research question four. Are there differences in the emotional functioning scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Table 5, results of ANOVA indicate no significant differences between exposure groups on scores of emotional development, $F(3, 169) = 2.45$, $p = .65$. That is, the differences between the emotional functioning scores of children who were prenatally exposed to methamphetamine only, children who were prenatally exposed to methamphetamine plus other substances, and children who were prenatally exposed to other substances not including methamphetamine did not reach statistical significance.

Table 5

Emotional Summary

Variables	Df	F value	Pr(>F)	
Exposure	3	2.45	0.65	.
Age	1	11.29	0.00	***
Sex	1	0.16	0.69	
Race	4	1.30	0.27	
HeightLogit	1	1.20	0.27	
WeightLogit	1	4.14	0.43	*
Bio Mom Education	1	0.04	0.84	
Bio Mom Marital	5	1.73	0.13	
Bio Dad Education	1	1.14	0.29	
Prenatal Care 1st Tri	1	0.18	0.67	
Prenatal Care 2nd Tri	1	3.79	0.05	.
Prenatal Care 3rd Tri	1	0.51	0.48	
Abuse/Neglect	1	0.09	0.76	
Domestic Violence	1	0.74	0.39	
DHS Custody	1	1.74	0.19	
Primary Caregiver Changes	1	0.02	0.90	
Primary Caregiver Relation	5	1.24	0.29	
Length Time w/ Current CG	1	0.01	0.93	
HeightLogit: WeightLogit	1	0.52	0.47	
Residuals	169			

*p < .05. **p < .01. ***p < .001

Research question five. Are there differences in the behavioral functioning scores of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Table 6, results of ANOVA indicate no significant differences between exposure groups on scores of behavioral development, $F(3, 367) = .83$, $p = .83$. That is, the differences between the behavioral functioning scores of children who were prenatally

exposed to methamphetamine only, children who were prenatally exposed to methamphetamine plus other substances, and children who were prenatally exposed to other substances not including methamphetamine did not reach statistical significance.

Table 6

Behavioral Summary

Variables	Df	F value	Pr(>F)	
Exposure	3	0.29	0.83	
Age	1	0.38	0.54	
Sex	1	0.58	0.45	
Race	5	0.74	0.59	
Height Logit	1	0.34	0.56	
Weight Logit	1	0.55	0.46	
Bio Mom Education	1	1.35	0.25	
Bio Mom Marital Status	5	0.56	0.73	
Bio Dad Education	1	0.15	0.70	
Prenatal Care 1st Trimester	1	1.66	0.20	
Prenatal Care 2nd Trimester	1	1.66	0.20	
Prenatal Care 3rd Trimester	1	2.64	0.11	
Abuse/Neglect	1	1.18	0.28	
Domestic Violence	1	1.18	0.28	
DHS Custody	1	1.34	0.25	
Primary Caregiver Changes	1	0.09	0.77	
Primary Caregiver Relationship	5	1.29	0.27	
Length of Time with Current Caregiver	1	0.06	0.81	
Height Logit: Weight Logit	1	0.10	0.76	
Residuals	367			

*p < .05. **p < .01. ***p < .001

Research question six. Are there differences in the head circumference measurements of children who have been prenatally exposed to methamphetamine only, children who have been prenatally exposed to methamphetamine plus other substances, and children who have been prenatally exposed to other substances not including methamphetamine?

As shown in Tables 7, 8 and 9, analysis on head circumference was conducted controlling for height and weight (height logit and weight logit is an interaction between two continuous variables). This suggests a significant effect for exposure on head circumference. While methamphetamine plus other substances is 1 percentile point above methamphetamine only, other exposure and unknown exposure are near 3.5 percentile points below methamphetamine only. The residual standard error is 1.506 on 1469 degrees of freedom. Multiple R-squared is 0.3559 while Adjusted R-squared is 0.3532. This indicates a predicting of approximately 35% of the variance. The F-statistic is 135.3 with a p-value of < 2.2e-16 or p <.001. It is interesting that Exposure becomes a better variable when height and weight are included in the model. It might be expected that physical variables would account for much of the variance; however, Exposure's p-value drops from .13 to .03

Table 7

Head Circumference Summary

Variables	Df	F value	Pr(>F)	
Exposure	3	2.95	0.03	*
Height Logit	1	550.18	<2.2e-16	***
Weight Logit	1	196.18	<2.2e-16	***
Height Logit: Weight Logit	1	56.43	1.006e-13	***
Residuals	1469			

*p < .05. **p < .01. ***p < .001 (i.e. 2.2e-16 indicates 2.2 * 10^-16, which is also .00000000000000022. This is typically reported as < .001).

Table 8

Head Circumference

	Df	F value	Pr(>F)	
Exposure	3	1.91	0.13	
Residuals	1472			

*p < .05. **p < .01. ***p < .001

Table 9

Head Circumference Coefficients

Coefficients	Estimate	Std. Error	T value	Pr(>|t|)	
(Intercept)	-0.07	0.15	-0.45	0.65	
Exposure Meth only	0				
Exposure Meth plus	0.01	0.17	0.08	0.94	
Exposure Other	-0.20	0.16	-1.28	0.20	
Exposure Unknown	-0.25	0.22	-1.11	0.27	
Height Logit	0.17	0.03	5.39	8.36e-08	
Weight Logit	0.31	0.03	9.29	<2e-16	
Height Logit: Weight Logit	-0.07	0.01	-7.51	1.01e-13	

*p < .05. **p < .01. ***p < .001

Comparison of Sample to Published Norms

WPPSI FSIQ Cognitive T-Test. Using T-tests, results found that the methamphetamine-only group was statistically significantly different from the normative mean, t = -4.893, p < .001. As shown in Tables 10 and 11, the methamphetamine-only group had a mean FSIQ of 87.89, which puts them in approximately the 20th percentile with a range of 51 – 109. The standard deviation (14.337) indicated a large range of variability.

Table 10

WPPSI FSIQ Cognitive T-Test Results

One-Sample Statistics

WPPSI	N	Mean	SD	Std. Error Mean
FSIQ	33	87.79	14.337	2.496

Table 11

WPPSI FSIQ Cognitive T-Test Results 2

One-Sample Test

WPPSI	Test Value = 100					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
FSIQ	-4.893	32	.000	-12.212	-17.30	-7.13

PLS Language Total T-Test. As shown in Tables 12 and 13, the methamphetamine-only group is statistically significantly different from the normative mean, t = -2.531, p = .016. Statistically significant results were likely influenced by high variability in scores, range of ages of subjects, and the small sample size. The mean of 91.72 puts the group in the 27th – 30th percentiles. Guidelines for the PLS-4 indicate scores of 1.5 standard deviations (less than 85) are qualification for language improvement programs (Zimmerman et al., 2008).

Table 12

PLS Language Total T-Test Results

One-Sample Statistics

PLS	N	Mean	SD	Std. Error Mean
PLSTotalSS	36	91.72	19.626	3.271

Table 13

PLS Language Total T-Test Results 2

One-Sample Test

PLS	Test Value = 100					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
PLSTotalSS	-2.531	35	.016	-8.278	-14.92	-1.64

PDMS Motor Functioning T-Test Results. As indicated in Tables 14 and 15 regarding overall motor functioning, the methamphetamine-only sample was found to be statistically significantly different from the normative group on measures of total motor skills, t=-2.960, p=.006. The sample was found to have lower scores on measures of total motor skills than the normative group. Overall, the sample differs at the total level and the fine and gross level so the differences are more global rather than related to a particular type of motor control. This may suggest that methamphetamine-only adversely affects motor control, in general.

Table 14

PDMS Overall Motor T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyTotalMotor	29	91.55	15.371	2.854

Table 15

PDMS Overall Motor T-Test Results 2

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyTotalMotor	-2.960	28	.006	-8.448	-14.29	-2.60

As indicated in Tables 16 and 17, in gross motor functioning, the methamphetamine-only sample (males and females combined) were found to be statistically significantly different from the normative group on measures of gross motor skills, t=-3.277, p=.003. The sample was found to have lower scores on measures of gross motor skills than the normative sample.

Table 16

PDMS Gross Motor T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyGrossMotorQuotient	29	92.31	12.638	2.347

Table 17

PDMS Gross Motor T-Test Results 2

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyGrossMotorQuotient	-3.277	28	.003	-7.690	-12.50	-2.88

As indicated in Tables 18 and 19 regarding fine motor functioning, the methamphetamine-only sample was found to be statistically significantly different from the normative group on measures of fine motor skills, t=-3.048, p=.005. The sample was found to have lower scores on measures of fine motor skills than the normative group.

Table 18

PDMS Fine Motor T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyFineMotorQuotient	29	89.55	18.460	3.428

Table 19

PDMS Fine Motor T-Test Results 2

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyFineMotorQuotient	-3.048	28	.005	-10.448	-17.47	-3.43

As indicated in Tables 20 and 21 regarding total motor functioning in males, the methamphetamine-only male sample was found to statistically significantly differ from the normative male group, t=-2.356, p=.028. The sample was observed to have lower total motor skill scores than the normative male group.

Table 20

PDMS Overall Motor – Males T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyTotalMotor	22	90.59	16.741	3.569

Table 21

PDMS Overall Motor – Males T-Test Results 2

One-Sample Test

	Test Value = 99					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyTotalMotor	-2.356	21	.028	-8.409	-15.83	-.99

As indicated in Tables 22 and 23 regarding gross motor functioning in males, the methamphetamine-only male sample was found to statistically significantly differ from the normative male sample on measures of gross motor skills, t=-2.523, p=.020. The sample was observed to have lower gross motor scores than the normative samples. This means the differences observed at the overall level remain consistent in the gross motor level.

Table 22

PDMS Gross Motor – Males T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyGrossMotorQuotient	22	91.73	13.520	2.882

Table 23

PDMS Gross Motor – Males T-Test Results 2

One-Sample Test

	Test Value = 99					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyGrossMotorQuotient	-2.523	21	.020	-7.273	-13.27	-1.28

As shown in Tables 24 and 25 regarding fine motor functioning in males, the methamphetamine-only male sample was found to be statistically significantly different from the normative male group on measures of fine motor skills, t=-2.608, p=.016. The sample was observed to have lower fine motor scores than the normative male group. Again, motor skills overall and at more specific levels of fine and gross were lower, presumably negatively impacted by methamphetamine exposure.

Table 24

PDMS Fine Motor – Males T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyFineMotorQuotient	22	87.82	20.111	4.288

Table 25

PDMS Fine Motor – Males T-Test Results 2

One-Sample Test

	Test Value = 99					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyFineMotorQuotient	-2.608	21	.016	-11.182	-20.10	-2.27

As indicated in Tables 26 and 27 regarding overall motor functioning in females, the methamphetamine-only female group was not found to statistically significantly differ from the normative female group on measures of total motor skills, t=-1.640, p=.152. Data indicates that although the sample had lower scores, they did not meet significance. However, small sample size is an issue as there were only seven scores. Overall it does not appear that females in the sample showed significant differences as compared to the normative group. Although this could be a result of too small a sample, the data trends could also point to an

increased susceptibility of males (over females) to the effects of methamphetamine on motor skills.

Table 26

PDMS Overall Motor – Females T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyTotalMotor	7	94.57	10.374	3.921

Table 27

PDMS Overall Motor – Females T-Test Results 2

One-Sample Test

	Test Value = 101					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyTotalMotor	-1.640	6	.152	-6.429	-16.02	3.17

As shown in Tables 28 and 29 regarding gross motor functioning in females, the methamphetamine-only female sample did not statistically significantly differ from the female normative sample on measures of gross motor skills, t=-1.546, p=.173. The sample had lower, but not significantly lower, scores on gross motor. Again, the small sample size is an issue, but it could be indicative of the same things mentioned regarding overall motor functioning.

Table 28

PDMS Gross Motor – Females T-Test Result

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyGrossMotorQuotient	7	94.14	10.024	3.789

Table 29

PDMS Gross Motor – Females T-Test Result 2

One-Sample Test

	Test Value = 100					
					95% Confidence Interval of the Difference	
	t	df	Sig. 2-tailed)	Mean Difference	Lower	Upper
PeabodyGrossMotorQuotient	-1.546	6	.173	-5.857	-15.13	3.41

As shown in Tables 30 and 31 regarding gross motor functioning in females, the methamphetamine-only female sample did not statistically significantly differ from the female normative sample on measures of gross motor skills, t=-1.631, p=.154. The sample had lower, but not significantly lower, scores on fine motor. Although the sample is very small, it could indicate a true difference between the effects of methamphetamine on males and females.

Table 30

PDMS Fine Motor – Females T-Test Result

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
PeabodyFineMotorQuotient	7	95.00	11.358	4.293

Table 31

PDMS Fine Motor – Females T-Test Result 2

One-Sample Test

	Test Value = 102					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
PeabodyFineMotorQuotient	-1.631	6	.154	-7.000	-17.50	3.50

BASC Emotional Functioning. Due to the small sample sizes and high degree of variability among scores, data from the BASC could not be interpreted.

CBCL Emotional Functioning Internalizing and Externalizing Scales T-Test. As indicated on Tables 32 and 33, the methamphetamine-only sample was found to statistically significantly differ from the clinical cutoff on the Internalizing Scale, t=-2.048, p=.047. The methamphetamine-only group was observed to have Internalizing Problems scores below the clinical and borderline clinical ranges. The

methamphetamine-only sample was found to statistically significantly differ from the clinical cut-off on the Externalizing Scale, t=-4.199, p<.001. The methamphetamine-only group was observed to have Externalizing Problems scores below the clinical and borderline clinical ranges.

Table 32

CBCL Emotional Internalizing & Externalizing Scales T-Test

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CBCLIntTScore	40	58.30	17.598	2.783
CBCLExternal TScore	40	55.18	13.293	2.102

Table 33

CBCL Emotional Internalizing & Externalizing Scales T-Test 2

One-Sample Test

	Test Value = 64					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CBCLIntTScore	-2.048	39	.047	-5.700	-11.33	-.07
CBCLExternal TScore	-4.199	39	.000	-8.825	-13.08	-4.57

CBCL Emotional Functioning Internalizing and Externalizing Scales T-Test Male. As shown in Tables 34 and 35, the methamphetamine-only males sample was found to statistically

significantly differ from the clinical cutoff on the Internalizing Scale, t=-2.639, p=.014. The methamphetamine-only group was observed to have Internalizing Problems scores below the clinical and borderline clinical ranges. The methamphetamine-only sample was found to statistically significantly differ from the clinical cut-off on the Externalizing Scale, t=-3.136, p=.004. The methamphetamine-only group was observed to have Externalizing Problems below the clinical and borderline clinical ranges.

Table 34

CBCL Emotional Internalizing & Externalizing Scales Male

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CBCLIntTScore	26	57.08	13.377	2.624
CBCLExternal TScore	26	56.12	12.820	2.514

Table 35

CBCL Emotional Internalizing & Externalizing Scales Male 2

One-Sample Test

	Test Value = 64					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CBCLIntTScore	-2.639	25	.014	-6.923	-12.33	-1.52
CBCLExternal TScore	-3.136	25	.004	-7.885	-13.06	-2.71

CBCL Emotional Functioning Internalizing and Externalizing Scales T-Test Female. As shown in Tables 36 and 37, no statistically significant difference was observed between the methamphetamine-only female group and the borderline clinical cutoff on the Internalizing Problems scale, t=.089, p=.930. The mean Internalizing Problem score indicates the sample falls within the borderline clinical range, but does not meet the criteria for the clinical range. No statistically significant difference was observed between the methamphetamine-only female group and the Externalizing Problem scale borderline clinical cutoff, t=-1.701, p=.113. The mean Externalizing Problems scores for the group did not meet the threshold for borderline clinical range, which the CBCL sets at T-scores of 60 through 63, or approximately the 84th through the 90th percentiles, and the clinical range at T > or = 64.

Table 36

CBCL Emotional Internalizing & Externalizing Scales Female

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
CBCLIntTScore	14	60.57	24.009	6.417
CBCLExternal TScore	14	53.43	14.458	3.864

Table 37

CBCL Emotional Internalizing & Externalizing Scales Female 2

One-Sample Test

	Test Value = 60					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
CBCLIntTScore	.089	13	.930	.571	-13.29	14.43
CBCLExternal TScore	-1.701	13	.113	-6.571	-14.92	1.78

ECBI Behavioral Functioning Problem Scale T-Test. As shown in Tables 38 and 39, the methamphetamine-only sample (males and females combined, 24-82 months) was not found to be statistically significantly different from the restandardized normative sample (all children ages 2-6 years) on the Problem Scale, t = -1.330, p = .188.

Table 38

ECBI Behavioral Functioning Problem Scale T-Test

One-Sample Statistics

ECBI Problem	N	Mean	SD	Std. Error Mean
EybergProblem	65	4.97	8.068	1.001

Table 39

ECBI Behavioral Functioning Problem Scale T-Test 2

One-Sample Test

	Test Value = 6.3					
	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Eyberg Problem	-1.330	64	.188	-1.331	-3.33	.67

ECBI Behavioral Functioning Intensity Scale T-Test. As shown in Tables 40 and 41, the methamphetamine-only sample (males and females combined, 24-82 months) was statistically significantly different from the restandardized normative sample (all children ages 2-6 on the Intensity Scale, $t = -4.277$, $p < .001$. The methamphetamine-only sample had lower scores on the Intensity Scale, but the standard deviation is approximately twice that of the normative sample, indicating a large amount of variability in the sample.

Table 40

ECBI Behavioral Functioning Intensity Scale T-Test

One-Sample Statistics

	N	Mean	SD	Std. Error Mean
EybergIntensity	65	61.54	70.990	8.805

Table 41

ECBI Behavioral Functioning Intensity Scale T-Test 2

One-Sample Test

	Test Value = 99.2					
					95% Confidence Interval of the Difference	
	t	df	Sig.(2-tailed)	Mean Difference	Lower	Upper
Eyberg Intensity	-4.277	64	.000	-37.662	-55.25	-20.07

ECBI Behavioral Functioning Problem and Intensity Scales by Sex. As shown in Tables 42, 43, and 44, no statistically significant differences were observed on either scale between methamphetamine-only males and methamphetamine-only females. Intensity F(1, 63) = .209, p = .649, Problem F(1, 63) = .103, p = .749.

Table 42

ECBI Behavioral Functioning Problem/Intensity Scales – Sex

Descriptives

		N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Min	Max
						Lower	Upper		
Eyberg Problem	Male	46	4.76	8.409	1.240	2.26	7.26	0	28
	Female	19	5.47	7.366	1.690	1.92	9.02	0	22
	Total	65	4.97	8.068	1.001	2.97	6.97	0	28
Eyberg Intensity	Male	46	58.93	72.074	10.627	37.53	80.34	0	216
	Female	19	67.84	69.804	16.014	34.20	101.49	0	179
	Total	65	61.54	70.990	8.805	43.95	79.13	0	216

Table 43

ECBI Behavioral Functioning Problem/Intensity Scales – Sex 2

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
EybergProblem	.038	1	63	.846
EybergIntensity	.022	1	63	.883

Table 44

ECBI Behavioral Functioning Problem/Intensity Scales – Sex 3

ANOVA		Df	F	Sig.
EybergProblem	Between Groups	1	.103	.749
	Within Groups	63		
	Total	64		
EybergIntensity	Between Groups	1	.209	.649
	Within Groups	63		
	Total	64		

ECBI Behavioral Functioning Problem ScaleT-Test Males. As shown in Tables 45 and 46, no statistically significant difference was observed between the methamphetamine-only males (ages 24-82 months) and the restandardized normative group (males ages 2-6 years) on the Problem Scale, t = -.999, p = .323.

Table 45

ECBI Behavioral Functioning Problem Scale T-Test Male

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EybergIntesity	46	4.76	8.409	1.240

Table 46

ECBI Behavioral Functioning Problem Scale T-Test Male 2

One-Sample Test

	Test Value = 6.0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EybergIntesity	-.999	45	.323	-1.239	-3.74	1.26

ECBI Behavioral Functioning Problem ScaleT-Test Females. As shown in Tables 47 and 48, no statistically significant difference was observed between the methamphetamine-only females (ages 24-82 months) and the restandardized normative group (females ages 2-6 years) on the Problem Scale, t = 1.629, p = .138. Again, it appears that females in the sample had higher scores than the normative group, but the small sample size makes interpretation difficult as to whether the difference occurred simply in this small sample of females or is indicative of a methamphetamine-group difference.

Table 47

ECBI Behavioral Functioning Problem Scale T-Test Female

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EybergProblem	10	10.40	7.183	2.272

Table 48

ECBI Behavioral Functioning Problem Scale T-Test Female 2

One-Sample Test

	Test Value = 6.7					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EybergProblem	1.629	9	.138	3.700	-1.44	8.84

ECBI Behavioral Functioning Intensity ScaleT-Test Males. As shown in Tables 49 and 50, methamphetamine-only males (ages 24-82 months) were observed to statistically significantly differ from the restandardized normative group (males ages 2-6 years) on the Intensity Scale, t = -3.648, p = .001. The methamphetamine-only males had lower scores on the Intensity Scale; however, the standard deviation was double that in the normative group.

Table 49

ECBI Behavioral Functioning Intensity Scale T-Test Male

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EybergIntensity	46	58.93	72.074	10.627

Table 50

ECBI Behavioral Functioning Intensity Scale T-Test Male 2

One-Sample Test

	Test Value = 97.7					
				Mean Difference	95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)		Lower	Upper
EybergIntensity	-3.648	45	.001	-38.765	-60.17	-17.36

ECBI Behavioral Functioning Intensity ScaleT-Test Females. As shown in Tables 51 and 52, methamphetamine-only females (ages 24-82 months) were observed to statistically significantly differ from the restandardized normative group (females ages 2-6 years) on the Intensity Scale, t = 2.770, p = .022. Although the methamphetamine-only females had higher scores on the Intensity Scale with the standard deviation approximately equivalent to that in the normative group, the sample included only ten individuals. For this reason, it is difficult to know whether it is due to being a part of the methamphetamine group or is just a function of this particular sample.

Table 51

ECBI Behavioral Functioning Intensity Scale T-Test Female

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
EybergIntensity	10	128.90	31.628	10.002

Table 52

ECBI Behavioral Functioning Intensity Scale T-Test Female 2

One-Sample Test

	Test Value = 101.2					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
EybergIntensity	2.770	9	.022	27.700	5.07	50.33

Height, Weight, and Head Circumference. As shown in Table 53, the methamphetamine-only sample (ages 3-76 months) means for height percentile fell into the 30th percentile, weight fell into the 42nd percentile, and head circumference fell into the 43rd percentile.

Table 53

Height, Weight, and Head Circumference

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
HeightPercentile	99	87	3	90	30.07	23.834
WeightPercentile	99	95	4	99	42.20	27.314
HeadPercentile	97	96	2	98	43.30	25.282
Valid N (listwise)	96					

As shown in Tables 54 and 55 regarding the height of males and females, the methamphetamine-only sample was found to be statistically significantly different from the normative mean of 50th percentile, t=-

8.320, p<.001. The children in the sample were shorter than the mean scores of children in the normative group.

Table 54

Height – Males and Females T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
HeightPercentile	99	30.07	23.834	2.395

Table 55

Height – Males and Females T-Test Results 2

One-Sample Test

	Test Value = 50					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
HeightPercentile	-8.320	98	.000	-19.929	-24.68	-15.18

As shown in Tables 56 and 57 regarding the weight of males and females, the methamphetamine-only sample was found to be statistically significantly different from the normative mean of 50th percentile on weight, t=-2.841, p=.005. This indicates that children in the sample had lower weights than the mean weight of children in the normative group.

Table 56

Weight – Males and Females T-Test Results

One-Sample Statistics

	N	Mean	Std. Deviation	Std. Error Mean
WeightPercentile	99	42.20	27.314	2.745

Table 57

Weight – Males and Females T-Test Results 2

One-Sample Test

	Test Value = 50					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
WeightPercentile	-2.841	98	.005	-7.798	-13.25	-2.35

As shown in Tables 58, 59, and 60 regarding height, weight, and head circumference in methamphetamine-only males versus females, the ANOVA was not significant for either weight or head circumference, F(1,97)=.611, p=.436 and F(1,97)=.089, p=.767. Therefore, there were no statistically significant difference between male and females on weight or head circumference. A Levine Test of Homogeneity of Variance was significant for height percentile indicating the assumptions of equivalent variance between groups necessary for ANOVA were not met. This may be due to unequal sample sizes (68 versus 31); however,

it calls into question the validity of the comparison of the two means (32nd percentile for males and 24th for females). This test shows no statistically significant difference F(1,97)=2.670, p=.106; however, as basic assumptions of ANOVA were not met, the interpretation may not be accurate.

Table 58

Height, Weight, and Head Circumference – Males and Females

Descriptives

		N	Mean	SD	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Height Percentile	Male	68	32.69	26.159	3.172	26.36	39.02	3	90
	Female	31	24.32	16.664	2.993	18.21	30.44	3	65
	Total	99	30.07	23.834	2.395	25.32	34.82	3	90
Weight Percentile	Male	68	40.75	27.779	3.369	34.03	47.47	5	95
	Female	31	45.39	26.429	4.747	35.69	55.08	4	99
	Total	99	42.20	27.314	2.745	36.75	47.65	4	99
Head Percentile	Male	66	42.77	23.529	2.896	36.99	48.56	2	95
	Female	31	44.42	29.051	5.218	33.76	55.08	2	98
	Total	97	43.30	25.282	2.567	38.20	48.39	2	98

Table 59

Height, Weight, and Head Circumference – Levene Statistic

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
HeightPercentile	12.540	1	97	.001
WeightPercentile	.672	1	97	.414
HeadPercentile	2.023	1	95	.158

Table 60

Height, Weight, and Head Circumference – ANOVA Results

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
HeightPercentile	Between Groups	1491.216	1	1491.216	2.670	.106
	Within Groups	54179.289	97	558.549		
	Total	55670.505	98			
WeightPercentile	Between Groups	457.855	1	457.855	.611	.436
	Within Groups	72658.105	97	749.053		
	Total	73115.960	98			
HeadPercentile	Between Groups	57.191	1	57.191	.089	.767
	Within Groups	61303.139	95	645.296		
	Total	61360.330	96			

Chapter 5

Discussion

Implications

Methamphetamine abuse is an emerging problem in all regions of the United States (Arria et al., 2006). Despite the growing methamphetamine abuse problem, knowledge about the effects of prenatal methamphetamine exposure on the fetus is limited. Prior to the current study, no study focused solely on the differences in the cognitive, language, motor, emotional functioning, behavioral functioning, and head circumference of young children prenatally exposed to methamphetamine only, young children prenatally exposed to methamphetamine plus other substances, and young children prenatally exposed to other substances not including methamphetamine. The present study attempted to address these issues by utilizing a large database of scores on children who were referred to a specialty clinic specifically because of their prenatal exposure to substances.

Conclusions regarding the effects of prenatal methamphetamine exposure on cognitive, language, motor, emotional and behavioral development and head circumference cannot be drawn without considering other environmental and genetic variables. Accordingly, demographic and environmental variables were also examined.

Analyses revealed that of the 1467 children whose prenatal substance exposure was identified, 41% had been exposed to methamphetamine with 59% of biological mothers confirming that they had abused methamphetamine while pregnant. This is in agreement with studies finding that methamphetamine is a growing problem among pregnant women (CDC; 2005; Rawson et al., 2002). Also consistent with the literature, over half (52%) of the exposed children in the larger sample were Caucasian, along with 72% of the children in the methamphetamine-only group. Fifty-nine percent of biological mothers in the overall sample were listed as Caucasian, with 68% of the methamphetamine-only abusing group. Interestingly, while the second largest group (19%) in the overall sample of children was made up of African Americans (with 16% of biological mothers), African American children and biological mothers accounted for less than 1% of the methamphetamine-only group. American Indian children ranked third at 12% of the overall sample (with 10% of biological mothers), but second (15%) in the methamphetamine-only group (with 14% of biological mothers). This seems to also agree with previous findings suggesting that the methamphetamine problem is most prevalent in Caucasians, while substances such as cocaine and its derivatives are a more common problem in the African American population. Additionally, that

methamphetamine is a growing concern with American Indians. Although the Asian population was very small in the methamphetamine exposed group, this mirrors the findings of the overall sample. Therefore, the numbers suggest that educational focus on the deleterious effects of methamphetamine might be best focused through programs targeting Caucasians and American Indians.

Disturbing findings in this study related to biological mothers. An extremely large number, 86%, received no first trimester prenatal care, while 72% and 64% received no second and third trimester prenatal care, respectively. It was not reported at what trimester or trimesters the substance abuse was taking place, but might be assumed that abuse during any trimester would be harmful. Also troubling was the finding that child abuse and/or child neglect had been reported against 78% of biological mothers while the child in the study was in their care. This was not surprising; however, given that only 17% of children in the overall sample and 16% of children in the methamphetamine-only exposed group were living with their biological parent at the time of their visit to the clinic. The others had been removed from the biological mothers' care as 56% of children in the overall sample and 59% of children in the methamphetamine-only group lived with either a foster or adoptive parent at the time of their clinic visit. Further, 82% of biological mothers

in the methamphetamine-only group reported being victims of domestic violence and only 21% reported “married” as their marital status. Finally, the mean education level of biological mothers was 10th grade. These findings indicate, prenatal exposure aside, just how detrimental it is for a child to be raised in a home in which methamphetamine is the primary drug of choice. It might be assumed that in many of these homes, methamphetamine was not only being used, but manufactured as well. This also underscores the harmful environmental effects of post-natal exposure to the drug. It might also be suggested that marital status, education level, and prenatal care could be resilience factors for these women and their children.

For children in the sample, the mean length of time with their current primary caregiver was 24 months while the mean length of time for children in the methamphetamine-only group was 15 months at the time of their clinic visit. As the vast majority of children in this study had multiple placements in their history, could this indicate that those with methamphetamine-only exposure were more difficult to place or were less likely to remain in a placement for as long a time as children with other exposures? It was beyond the scope of this study to answer that question.

Results of ANOVAs showed various findings. Although no significant differences were found between exposure groups on scores of cognitive development, emotional development, and behavioral development, a nonsignificant difference was found on language development. Additionally, significant differences were found between exposure groups on scores of motor development and head circumference measurements, indicating that when compared to the normative sample, the methamphetamine-exposed group had delayed motor development, as well as smaller head circumference. This seems to suggest that prenatal exposure to methamphetamine is as harmful as prenatal exposure to other substances; however, it does not appear to cause increased cognitive, language, emotional, or behavioral damage, nor does it appear to compound the effects of other drugs. However, findings of significant differences in the motor development and head circumference categories seem to indicate that these areas may be at risk of increased damage through prenatal exposure to methamphetamine.

When compared to children in the normative samples, significant differences were observed in children with methamphetamine-only exposure in the areas of cognitive functioning, language functioning, motor functioning, emotional functioning, and head circumference. This

indicates that children with methamphetamine exposure had lower cognitive, language, motor, and emotional functioning scores, and a smaller head circumference than did children in the normative sample. However, longitudinal research has also shown that family income and poverty status were significant predictors of IQ scores in five-year-olds with low socioeconomic status (SES) being positively related to IQ scores (McLoyd, 1998). Without clear information regarding the SES of the children in this study, it is not possible to determine whether lower scores on the cognitive assessments were related to the prenatal drug exposure, the family's SES, or both. Although differences were not found to reach significance in the number of behavioral problems exhibited by children in the methamphetamine-only group when compared to the normative sample, significance was reached in the intensity of the problems exhibited. This could suggest that children with prenatal methamphetamine exposure are a more challenging group for caregivers, and thus are more difficult to place.

A caveat exists in the results of the motor skills. In examination of overall, gross, and fine motor functioning, the methamphetamine-only group was found to have statistically significantly lower scores than the normative sample. However, further examination found that while the methamphetamine-only male group was statistically significantly different

in overall, gross, and fine motor functioning, the methamphetamine-only female group did not statistically significantly differ from the normative female group on measures of total motor skills. This was also shown in gross motor functioning, as well as fine motor functioning. Although the sample of methamphetamine-only females was very small (7), it is possible that a true difference exists between the effects of methamphetamine on males and females. This appears to be an area in which increased research might be valuable.

Although the height, weight, and head circumference of methamphetamine-only exposed boys and girls were found to be lower than the normative sample, weight and head circumference were very close to the mean of the normative sample (50^{th} percentile). However, height fell into the 30^{th} percentile for the methamphetamine-only group, significantly lower than would be expected for children in the targeted age groups. Again, further research into these differences may be warranted by these findings.

These findings hold several implications for the field of psychology. While drug abuse programs now exist in most major cities across the country, programs for the pregnant addict are less prevalent. Clearly, programs that emphasize prenatal care, as well as counseling and psychological care, should be more available to drug-abusing

pregnant women. Programs should emphasize information on having a healthy baby and the effects of methamphetamine exposure on infant development, along with providing comprehensive care for those who seek it. In each of these instances, the opportunity exists for psychologists/counselors to intervene and perhaps lessen the damage inflicted upon unborn children. An additional area in which methamphetamine abusing pregnant women might receive intervention is suggested in this study's finding that these women had a mean education level of 10th grade. School counselors, as well as counselors in alternative education programs should be alert to girls in their care who are pregnant in order to provide appropriate information, education, and referrals regarding methamphetamine use while pregnant. While prenatal methamphetamine exposure is a growing problem for all ethnic groups, findings in this study, as well as others, indicate that American Indian children and their mothers are growing in numbers of methamphetamine exposure and methamphetamine abuse. This is a prime area for information regarding the detriments of prenatal methamphetamine exposure to be relayed. Perhaps, this information could be provided through counselors that work in medical and/or mental health clinics that provide services to this ethnic group, in particular. As more newborn infants and children with prenatal methamphetamine

exposure are encountered by health care professionals, it is increasingly important to identify these drug-exposed infants as early as possible. Assessments for motor development, with measures such as the Bailey Scales of Infant and Toddler Development (Bayley, 2006), along with measurements for head circumference could alert professionals to conduct a more extensive interview with mothers and, when appropriate, expedite interventions for these children. Additionally, given that this study found 78% of methamphetamine abusing biological mothers had child abuse/neglect reported against them, it will also be important for professionals to be vigilant in scrutinizing for children who could be in dangerous situations. Furthermore, that 82% of biological mothers in the methamphetamine abusing group reported being victims of domestic violence, it would also be imperative for counselors in domestic violence shelters to be alert for signs of methamphetamine use/abuse in pregnant women and women with young children in order to offer assessment or intervention. This study also showed that the vast majority of children with prenatal methamphetamine exposure had multiple placements in their history. This might be another opportunity for professionals with child welfare to identify these children through assessment referrals and thus begin intervention sooner, rather than later. Finally, an intervention component that it is of paramount importance is enhancing normal infant

development and ensuring a strong caregiver-infant bond. This type of education should begin early enough so that caregivers can learn appropriate and effective caregiving and avoid compounding the problems of the already at-risk infant. Professionals in hospitals, as well as those in human services positions are in an excellent position to direct mothers (biological, foster, or adoptive) to appropriate counseling programs in order to strengthen the parent-child bond and offer early support for those who will be caring for an infant with prenatal methamphetamine exposure.

Limitations and Future Research

Given the preliminary nature of this study, the conclusions should be interpreted in light of several limitations. The data from this study were obtained via retrospective report, so faulty reporting of prenatal drug exposure was a concern. Future studies would benefit from prospective investigations of the effects of prenatal drug exposure, with subjects being identified by positive toxicology screens at some point during the pregnancy or immediately after birth. According to a publication issued by the Arizona Department of Economic Security (2005), meconium testing is the most reliable and comprehensive toxicology screen in newborns. Meconium formation starts between 16 to 20 weeks gestation, and continues until birth. Newborn meconium

testing identifies most substances used by the mother after 20 weeks, such as: cocaine, marijuana, opiates, barbiturates, benzodiazepines, amphetamines, and PCP. Future research might extend this investigation to also look at gestational age of prenatal methamphetamine exposure to explore whether there are particular gestational stage effects on cognitive development, language development, motor development, emotional development, behavioral development, and head circumference measurements, and, if so, what those effects might be.

As toxicology was not available, many of the retrospective records did not list the specific substances to which the subjects were prenatally exposed. Therefore, the sample in this study was limited by the lack of control for substances of abuse other than methamphetamine. Future research could be strengthened by the use of subjects who were positively identified as having prenatal exposure to methamphetamine only or, perhaps, by knowledge of which specific drug was involved in the subjects' exposure.

An additional limitation of the current study is that it involved subjects who had experienced in-vivo exposure; however, their environmental exposure to drugs and alcohol was not documented. The physical and family environments provided by parents who use

methamphetamine often are chaotic, neglectful, and abusive, exposing children to criminal behavior and dangerous substances (Altshuler, 2005). Common behavioral issues exhibited by chronic methamphetamine users include unpredictability, paranoia, auditory and visual hallucinations, compulsive behavior, labile moods, rages, and depressed mood (Srisurapanont et al., 2003). Sustained use of methamphetamine causes memory deficits, learning impairment, and difficulty in processing information (Meredith et al., 2005). Current studies have not yet demonstrated whether some of the effects of methamphetamine are reversible, given adequate time. As a result, children whose parents use methamphetamine are likely to experience their parent's poor decision-making abilities, with both lack of supervision and basic necessities neglected. Additionally, characteristics of methamphetamine production and use create physical and environmental conditions that can be extremely detrimental. Children of users and producers are exposed to toxic by-products of the drug's manufacture that contaminate the places that serve simultaneously as the parent's methamphetamine lab and the child's home (Lineberry & Bostwick, 2006). Important future research could include the effects of environmental exposure to methamphetamine on children.

The archival nature of the study resulted in missing data, especially with respect to various assessment scores and demographic information. The use of prospective, methodologically sound studies would eliminate this limitation. Also included in this limitation is the lack of SES information for families of the children in this study. It would be important for future studies to address this issue considering the impact that low SES has on development, most notably cognitive functioning scores.

An additional limitation of the current study was the lack of a control population. Only children who have been prenatally exposed to drugs and alcohol receive developmental evaluations at the clinic in this study, so inclusion of a non-drug exposed control group was not possible. Future research should aim to compare groups matched on demographic variables in order to control for the effects of these variables.

Finally, although the current study is not without limitations, there are also notable strengths. A noteworthy strength is the relatively large size for research in this area. To date, most studies examining the effects of prenatal methamphetamine exposure on the developing fetus have been limited by small sample sizes (Chang et al., 2004; Smith et al., 2001). Additionally, this study examined a more homogenous

sample of children in that it included children with methamphetamine-only prenatal exposure in addition to children with methamphetamine plus other substances, as well as children with prenatal exposure to substances not including methamphetamine. The inclusion of the methamphetamine-only group is indeed a strength of this study.

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Appendix A
Child, Biological Mother, and Current Primary Caregiver Demographic Information Table

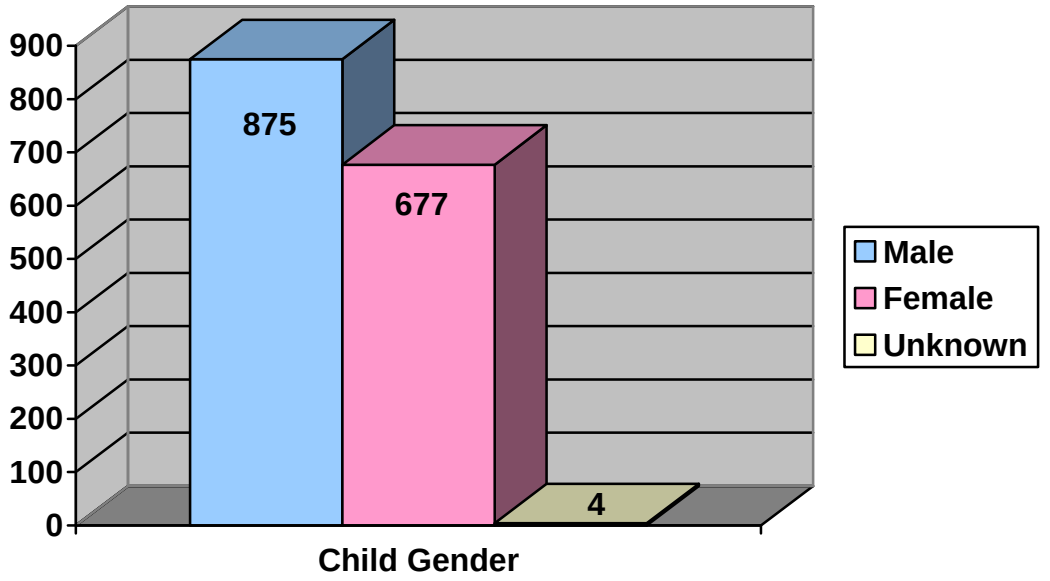
Demographic Information – Child *(n = 1556)*	
Child Gender	
Male	875
Female	677
Unknown	4
Child Age (in months)	
Minimum	2
Median	36
Mean	38.23
Maximum	96
Child Race	
Caucasian	804
African American	293
American Indian	190
Multiracial	174
Hispanic	75
Asian	5
Other	2
Unknown	13
Child Height Percentile	
Minimum	0.00
Median	25.00
Mean	34.74
Maximum	98.00
Unknown	68
Child Weight Percentile	
Minimum	1.00
Median	50.00
Mean	45.36
Maximum	99.00
Unknown	66
Child Head Circumference Percentile	
Minimum	1.00
Median	40.00
Mean	40.26
Maximum	99.00
Unknown	74

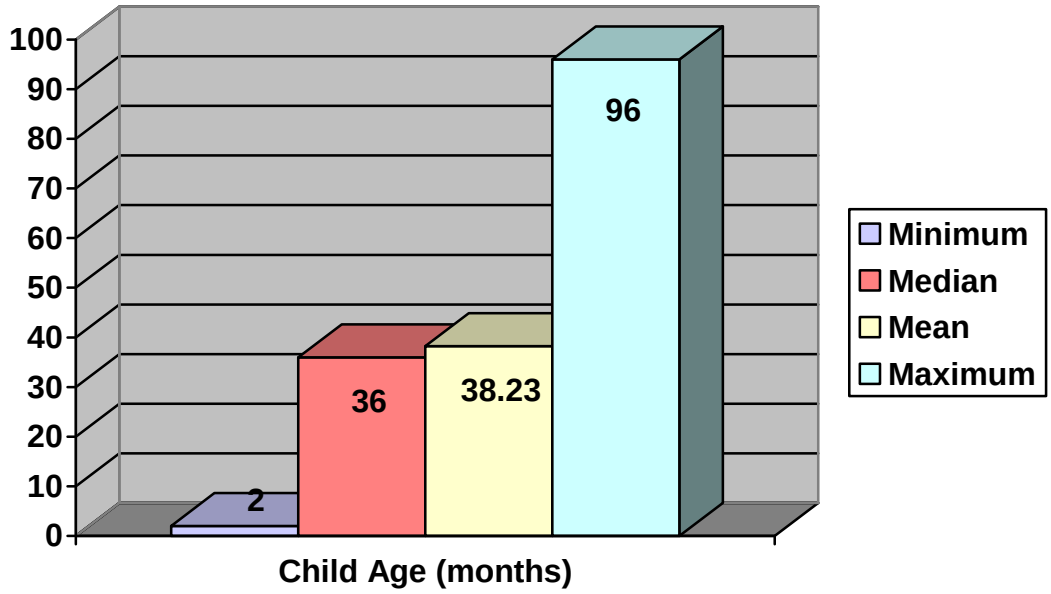
Demographic Information – Biological Mother *(n = 1556)*	
Prenatal Care 1st Trimester	
Yes	334
No	1200
Unknown	22
Prenatal Care 2nd Trimester	
Yes	479
No	1055
Unknown	22
Prenatal Care 3rd Trimester	
Yes	519
No	1015
Unknown	22
Biological Mother Education Level	
Minimum	1.00
Median	11.00
Mean	10.73
Maximum	18.00
Unknown	674
Biological Mother Marital Status	
Single	712
Married	316
Divorced	69
Cohabitate	57
Separated	30
Widow	2
Unknown	370
Biological Mother Race	
Caucasian	918
African American	253
American Indian	151
Multiracial	0
Hispanic	58
Asian	5
Other	42
Unknown	129
Abuse/Neglect Reported	
Yes	398
No	1133
Unknown	25
Domestic Violence Reported	
Yes	369
No	1162

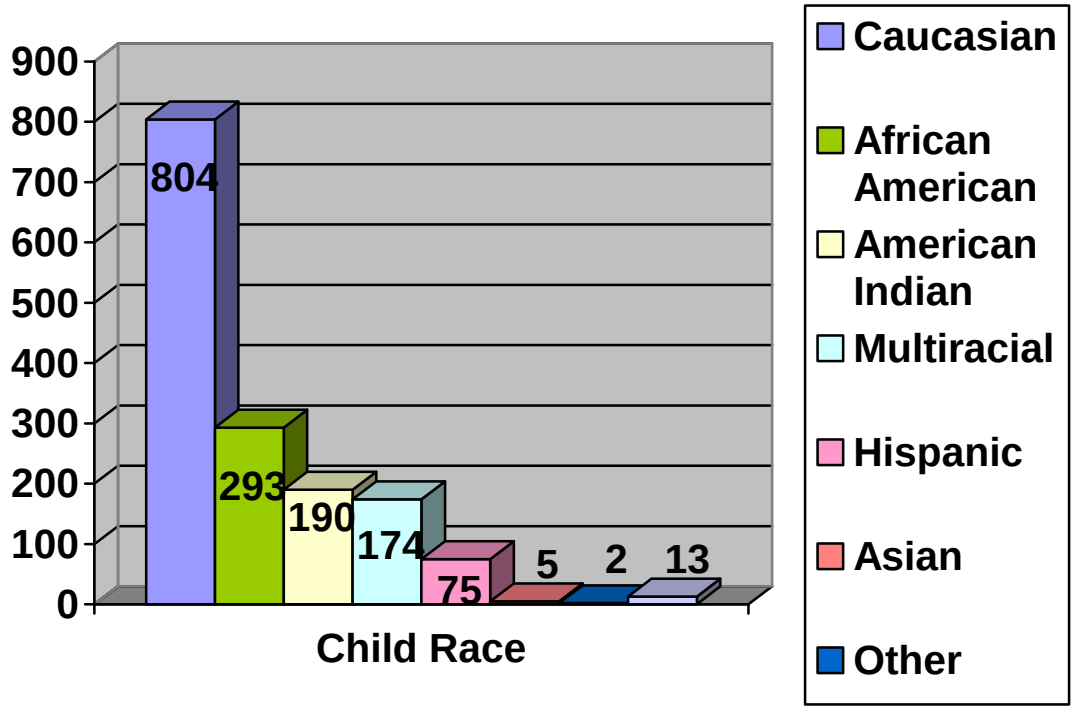
Unknown	25

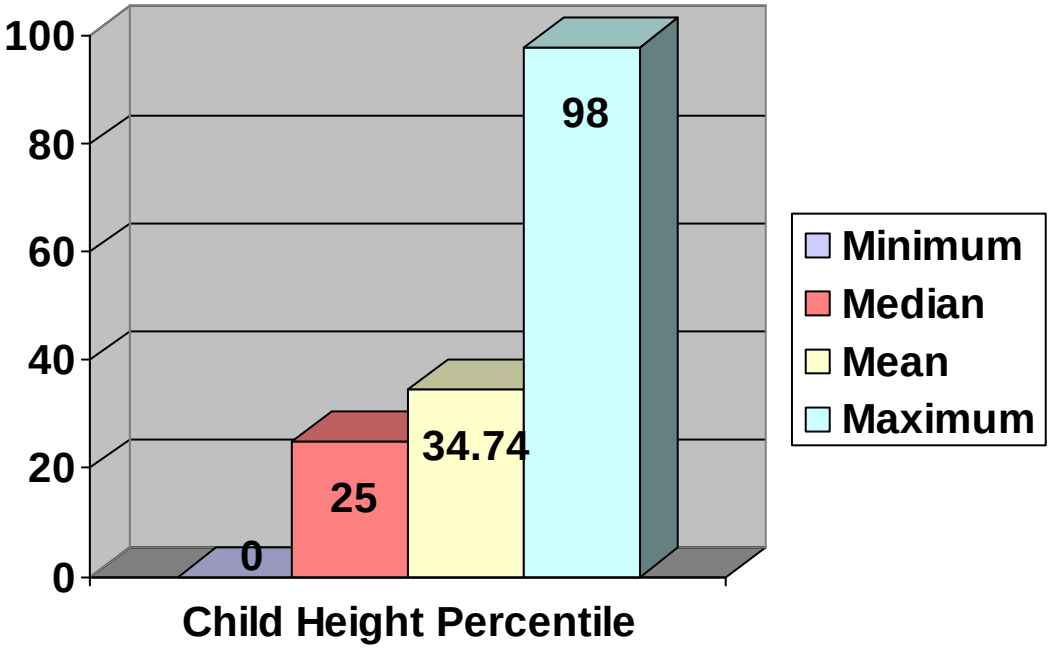
Demographic Information – Current Primary Caregiver *(n = 1556)*	
Length of Time with Current Primary Caregiver (in months)	
Minimum	0
Median	18
Mean	24
Maximum	87
Unknown	22
Relationship with Current Primary Caregiver	
Biological Parent	268
Foster Parent	542
Adoptive Parent	331
Grandparent	276
Other Relative	112
Other	13
Unknown	14
Current Primary Caregiver Race	
Caucasian	1030
African American	223
American Indian	91
Multiracial	0
Hispanic	38
Asian	0
Other	21
Unknown	153
Current Primary Caregiver Marital Status	
Single	256
Married	950
Divorced	87
Cohabitate	16
Separated	33
Widow	37
Unknown	177
Current Primary Caregiver Education Level	
Minimum	0.00
Median	12.00
Mean	11.89
Maximum	24.00
Unknown	163

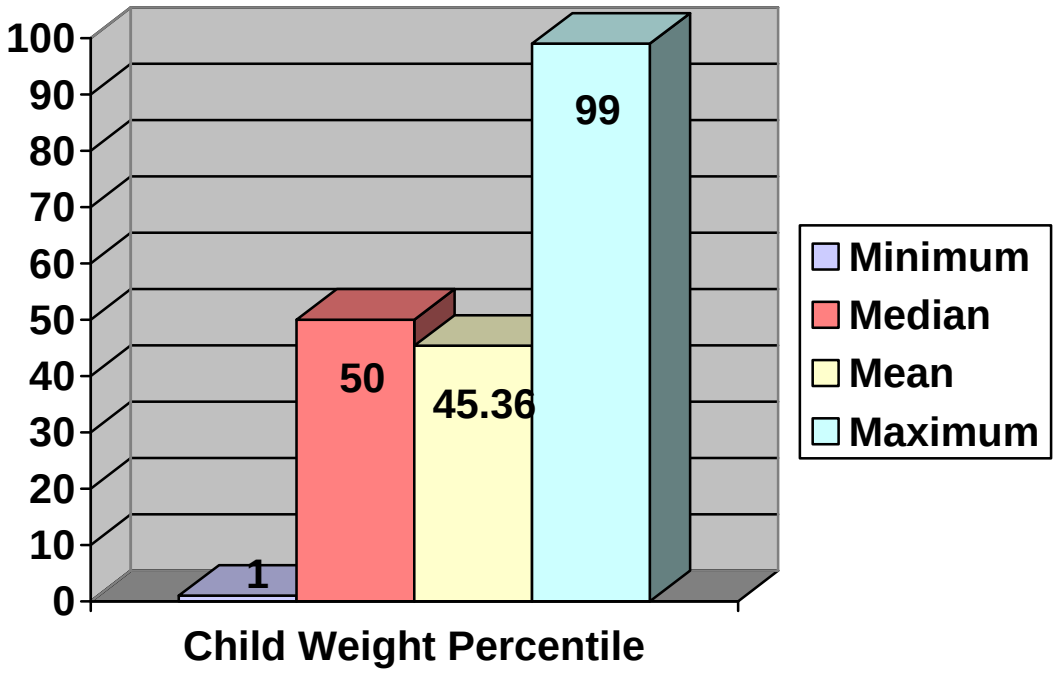
Appendix B
Child Demographic Information

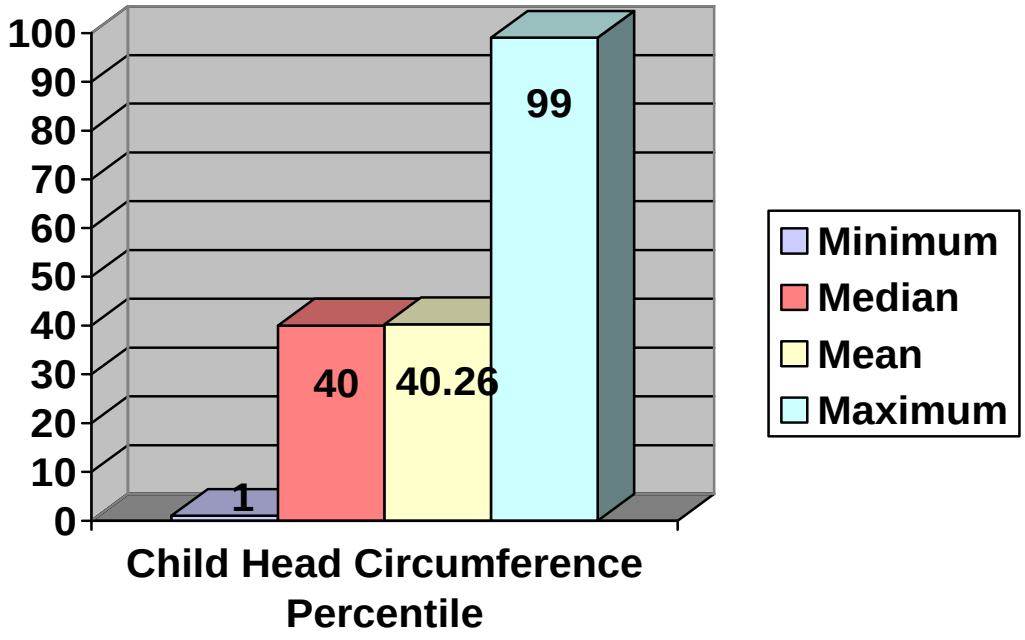




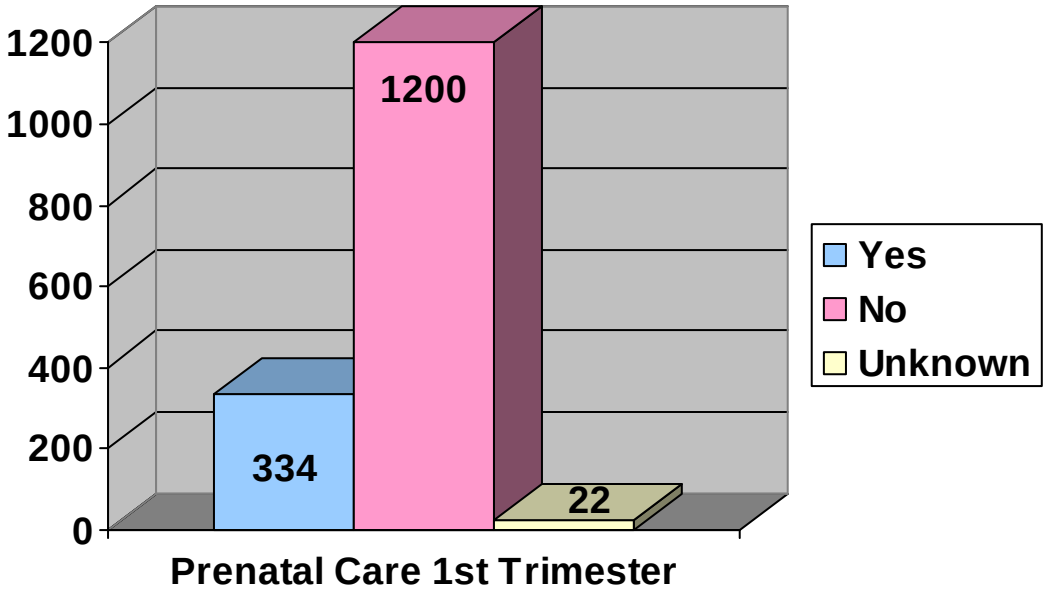

900
800
700
600
500
400
300
200
100
0
804
293
190
174
75
5
2
13
Child Race
Caucasian
African American
American Indian
Multiracial
Hispanic
Asian
Other

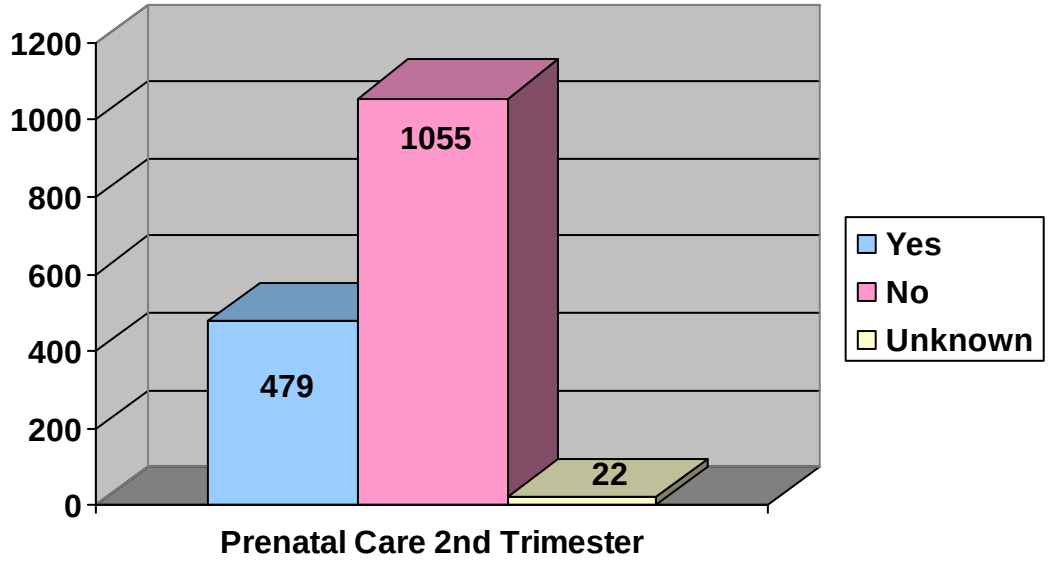

100
80
60
40
20
0
0
25
34.74
98
Child Height Percentile
Minimum
Median
Mean
Maximum

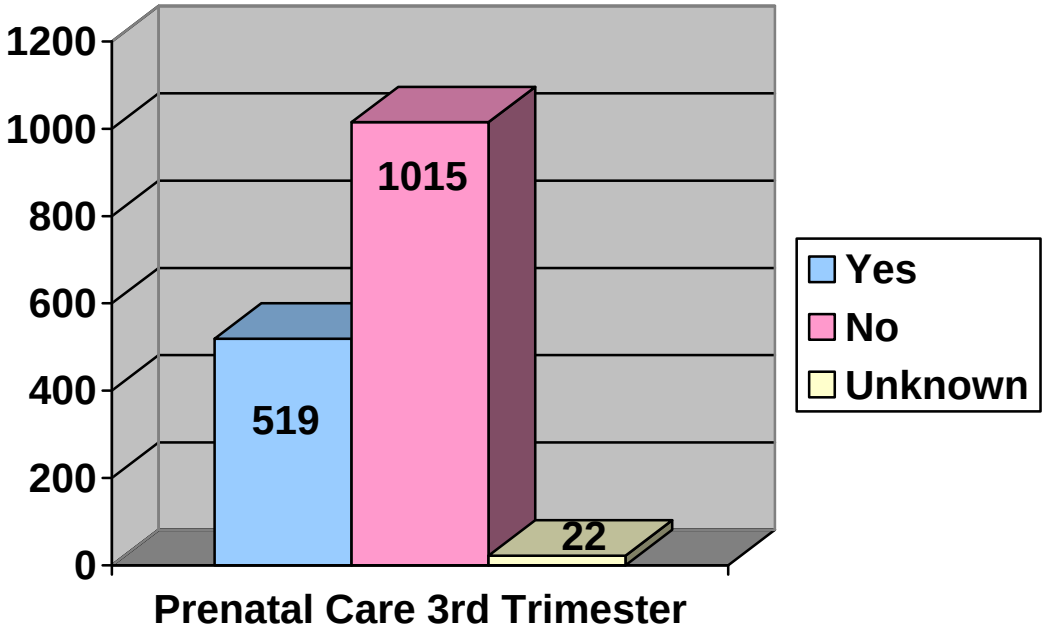

100
90
80
70
60
50
40
30
20
10
0
1
50
45.36
99
Minimum
Median
Mean
Maximum
Child Weight Percentile

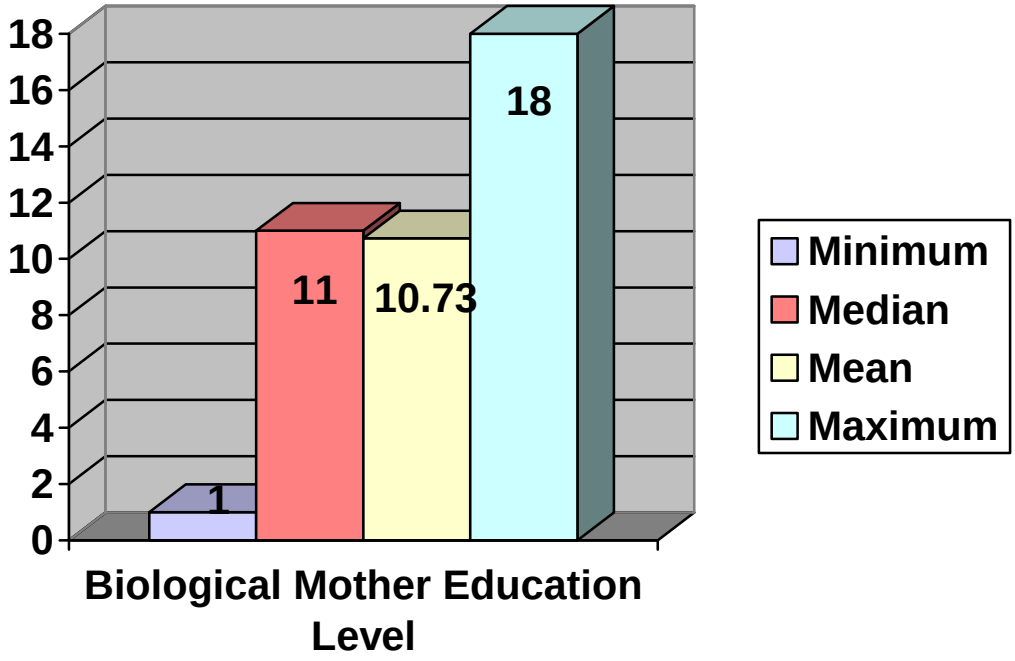

100
90
80
70
60
50
40
30
20
10
0
1
40
40.26
99
Minimum
Median
Mean
Maximum
Child Head Circumference Percentile

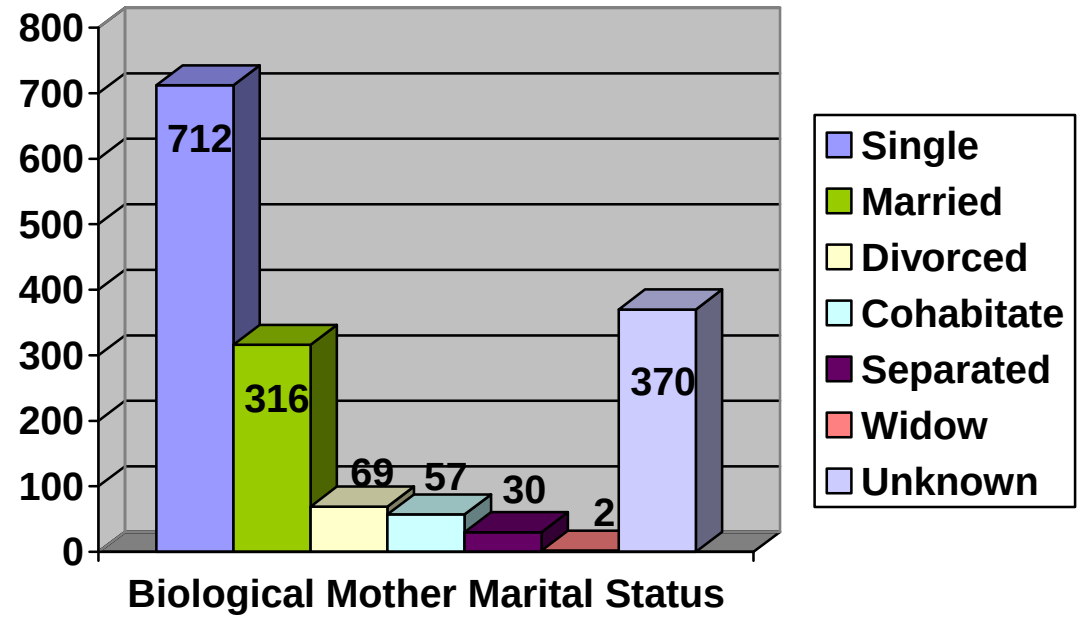
Appendix C
Biological Mother Demographics

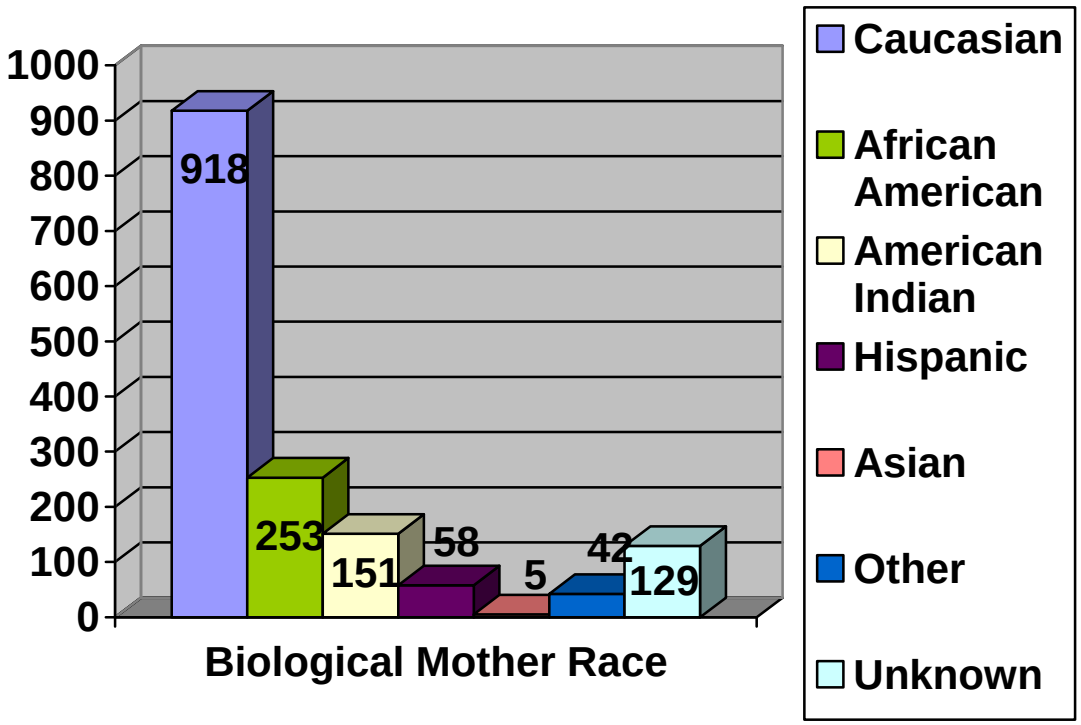


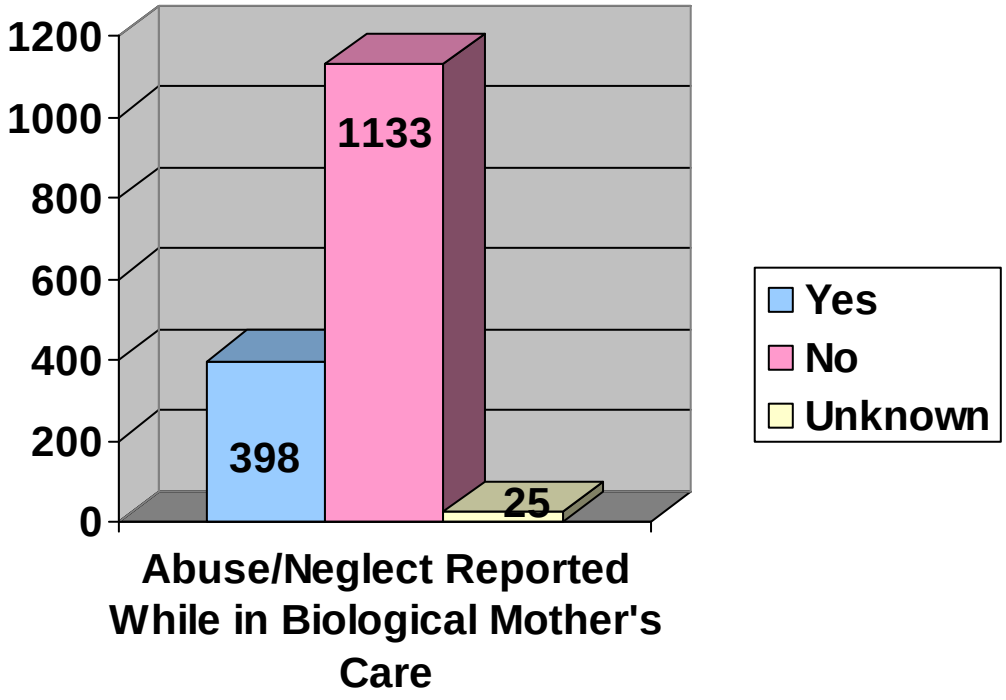


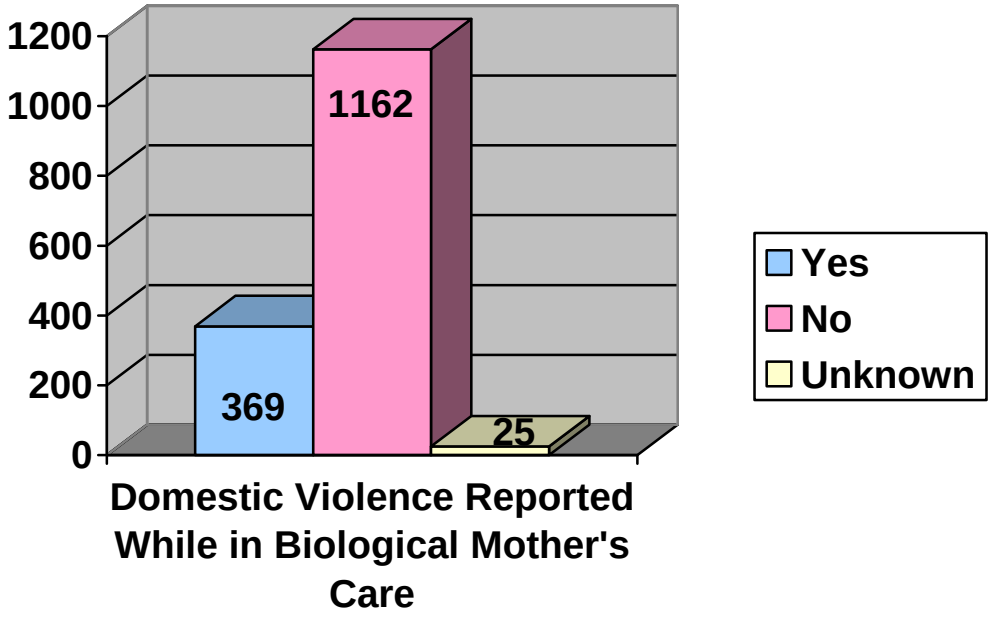

1200
1000
800
600
400
200
0
519
1015
22
Yes
No
Unknown
Prenatal Care 3rd Trimester


18
16
14
12
10
8
6
4
2
0
1
11
10.73
18
Minimum
Median
Mean
Maximum
Biological Mother Education Level

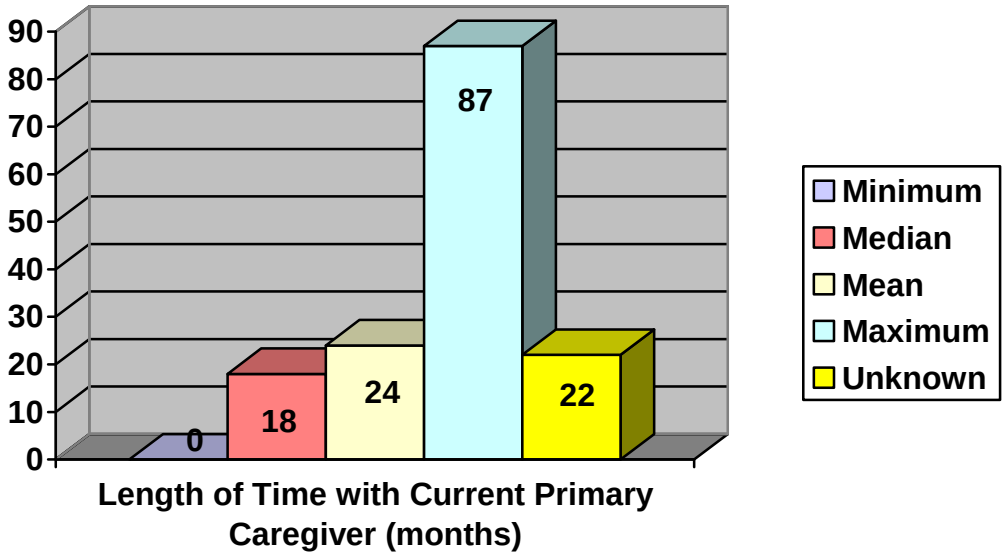

800
700
600
500
400
300
200
100
0
712
316
69
57
30
2
370
Single
Married
Divorced
Cohabitate
Separated
Widow
Unknown
Biological Mother Marital Status

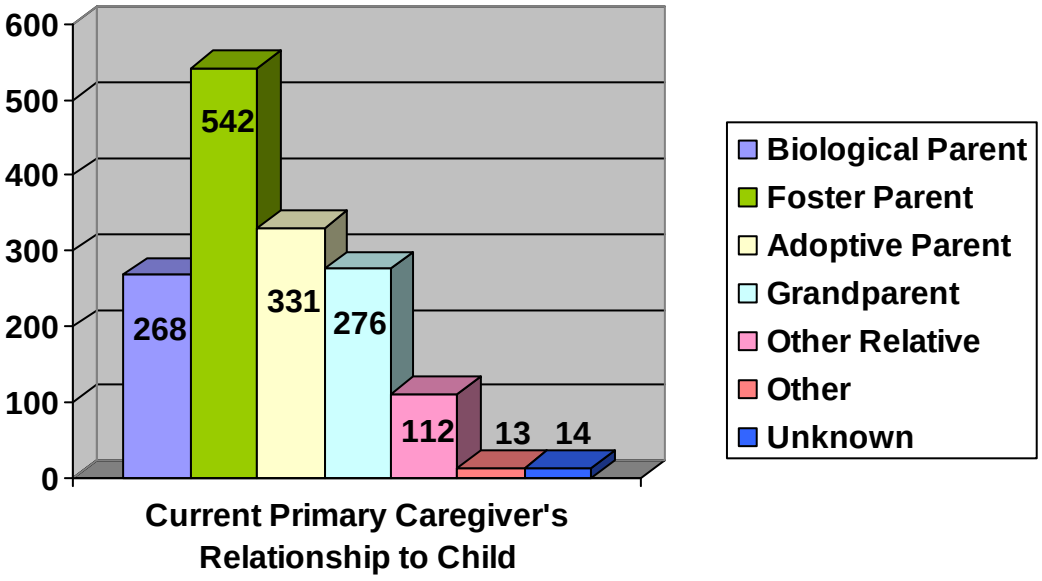

1000
900
800
700
600
500
400
300
200
100
0
918
253
151
58
5
42
129
Caucasian
African American
American Indian
Hispanic
Asian
Other
Unknown
Biological Mother Race

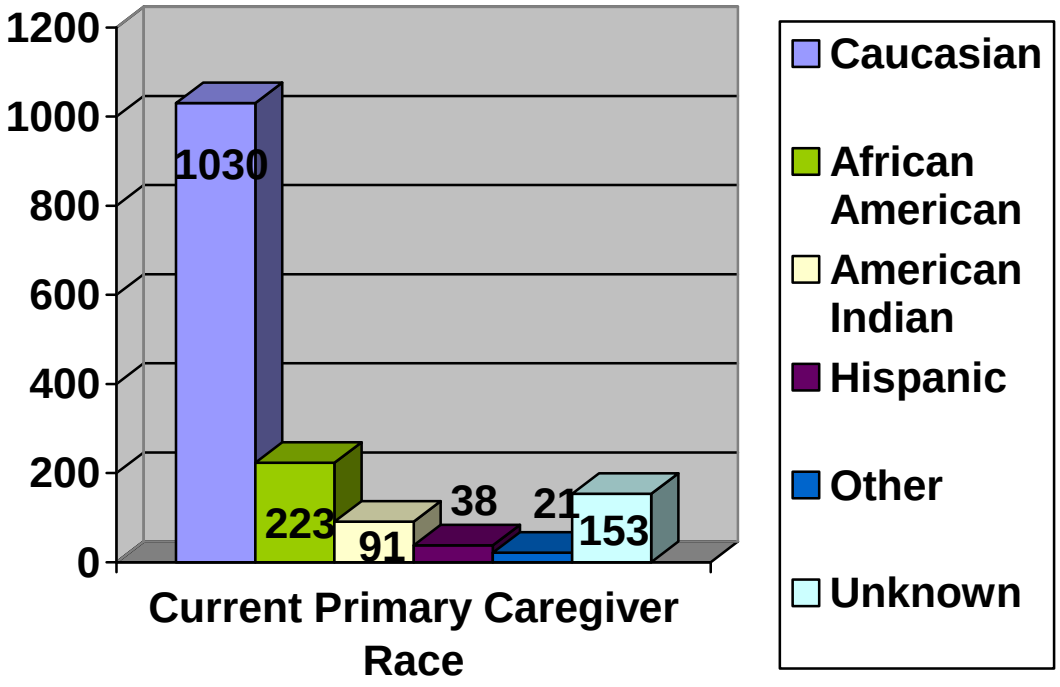

1200
1000
800
600
400
200
0
1133
398
25
Yes
No
Unknown
Abuse/Neglect Reported While in Biological Mother's Care

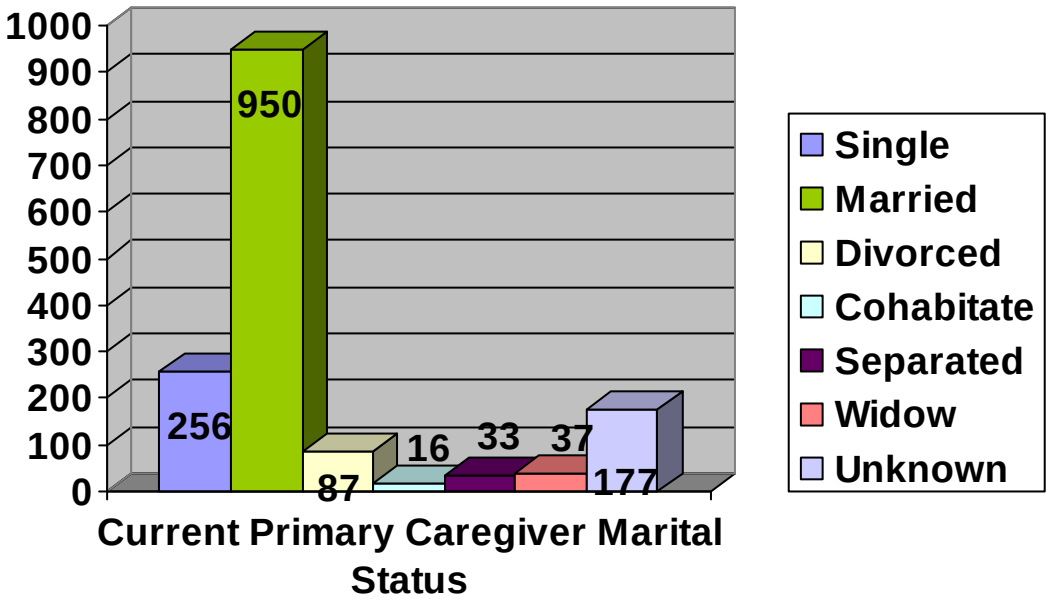

1200
1000
800
600
400
200
0
1162
369
25
Yes
No
Unknown
Domestic Violence Reported While in Biological Mother's Care

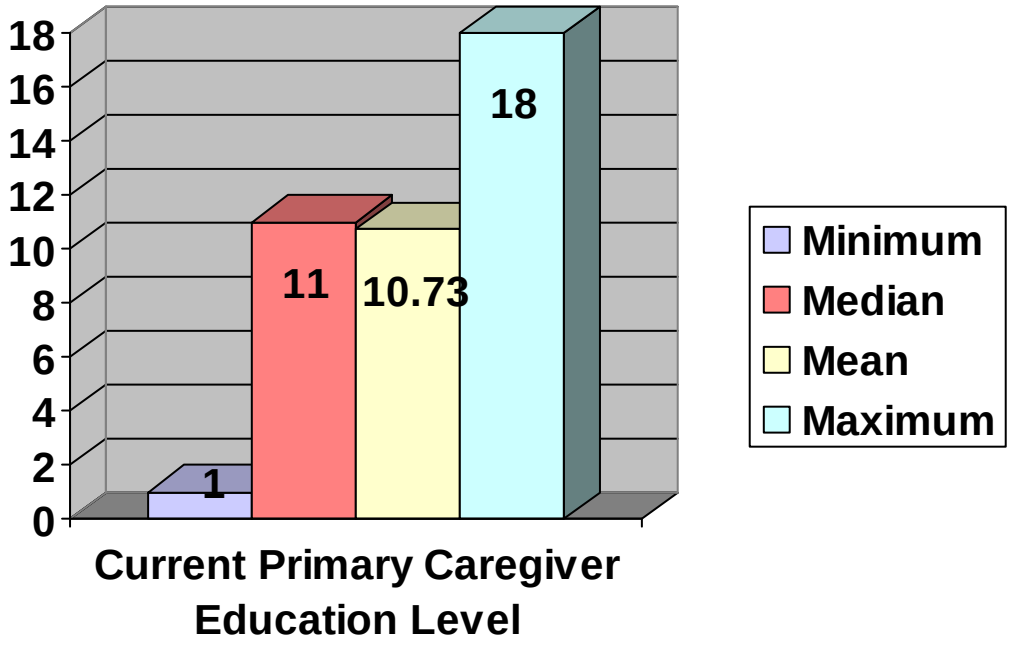
Appendix D
Current Primary Caregiver Demographics



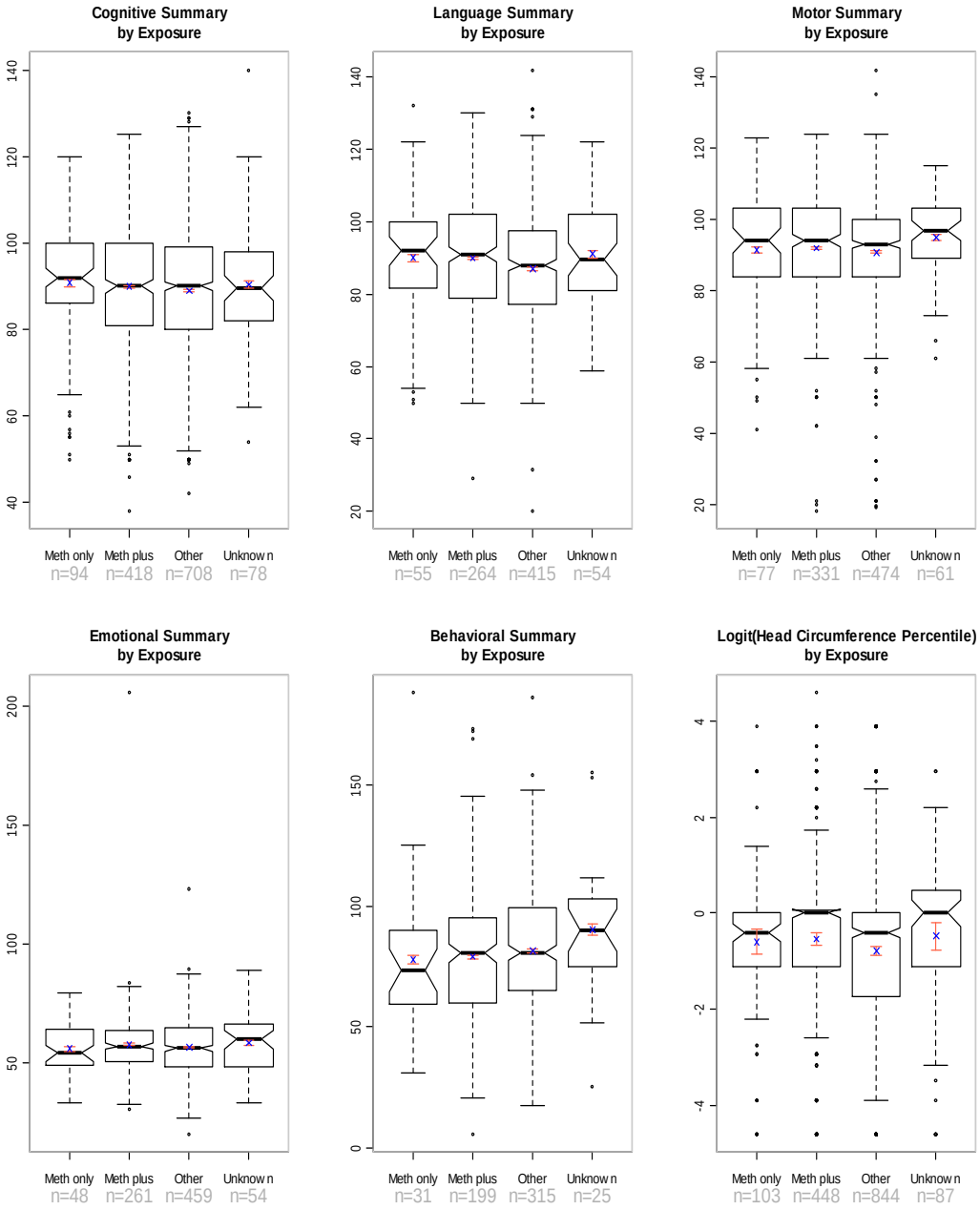



1200
1000
800
600
400
200
0
1030
223
91
38
21
153
Current Primary Caregiver Race
Caucasian
African American
American Indian
Hispanic
Other
Unknown

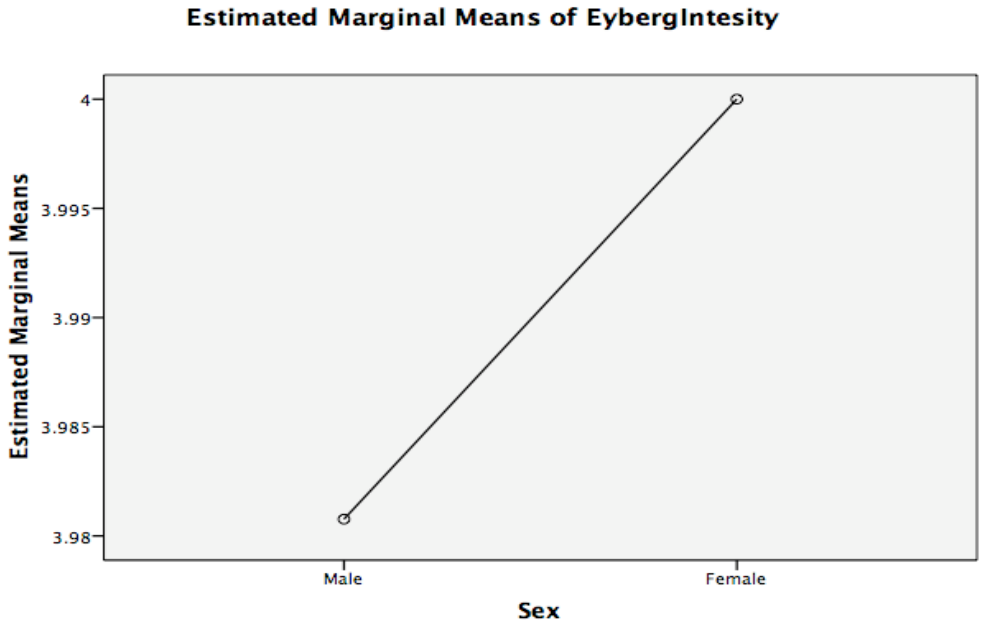

1000
900
800
700
600
500
400
300
200
100
0
256
950
87
16
33
37
177
Current Primary Caregiver Marital Status
Single
Married
Divorced
Cohabitate
Separated
Widow
Unknown

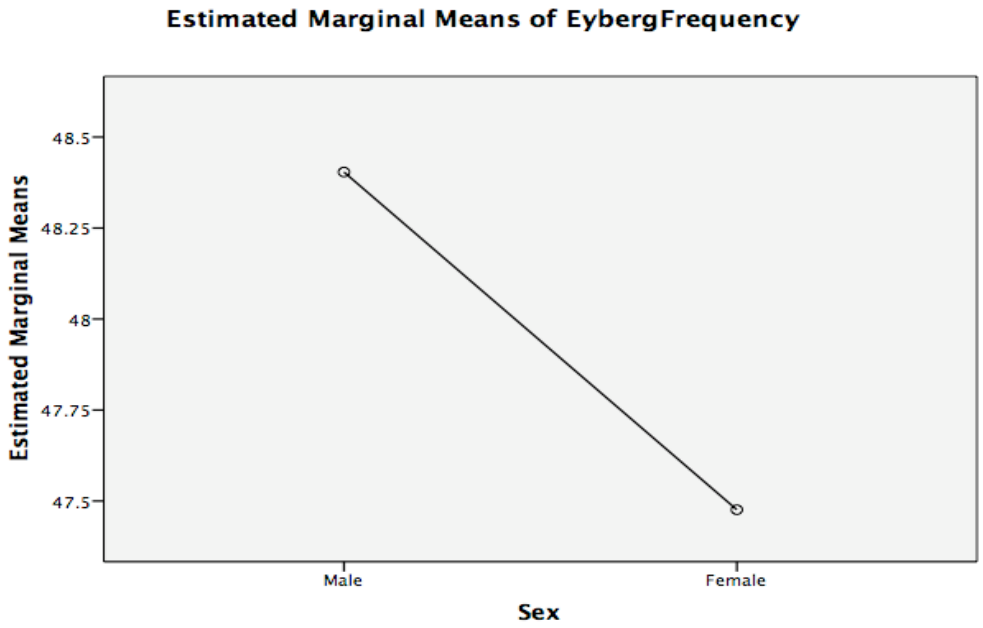

18
16
14
12
10
8
6
4
2
0
1
11
10.73
18
Minimum
Median
Mean
Maximum
Current Primary Caregiver Education Level

Appendix E
Boxplots for Variables by Exposure

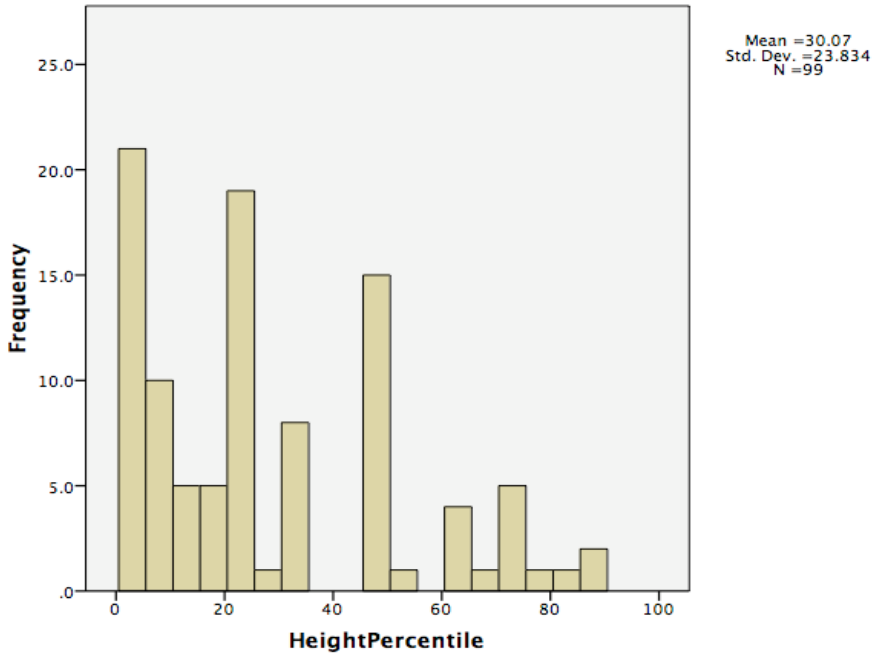


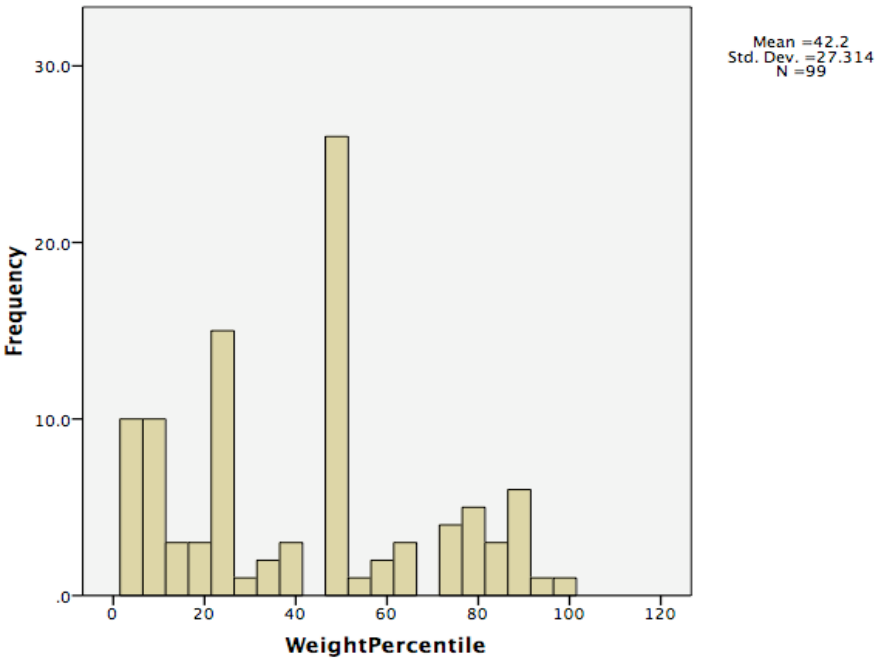
Appendix F
Estimated Marginal Means of Eyberg Scales

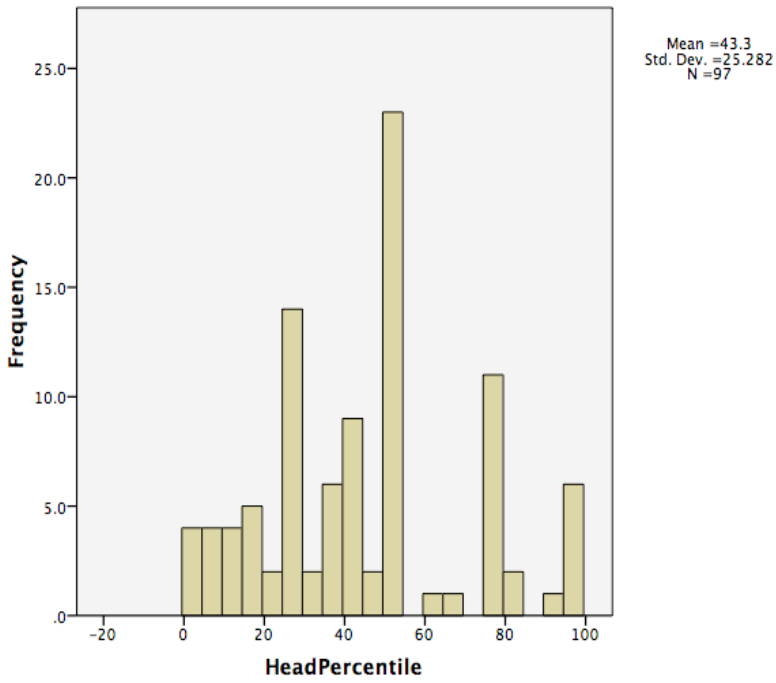




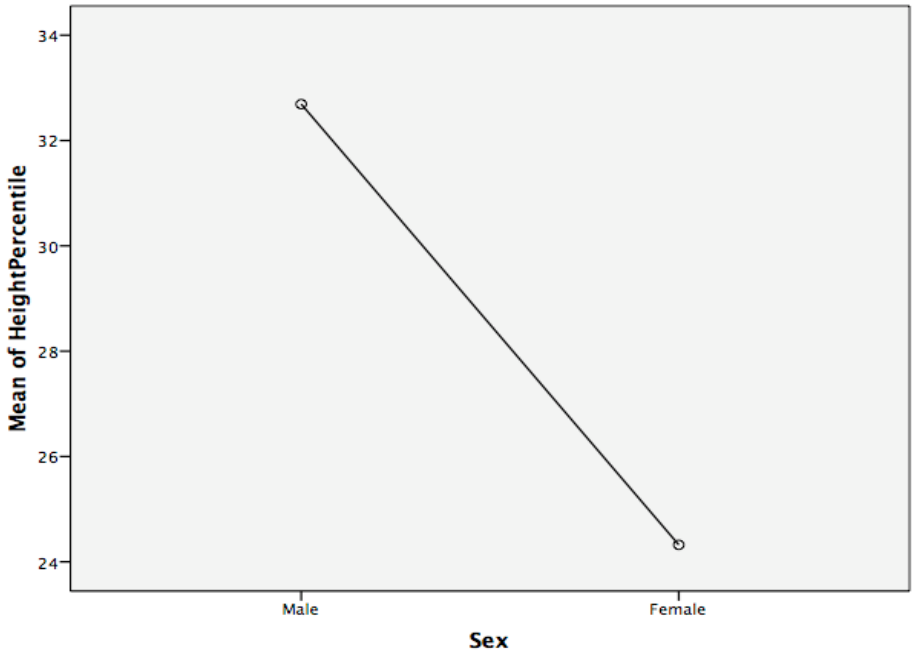
Appendix G
Methamphetamine-Only Height, Weight,
and Head Circumference Graphs

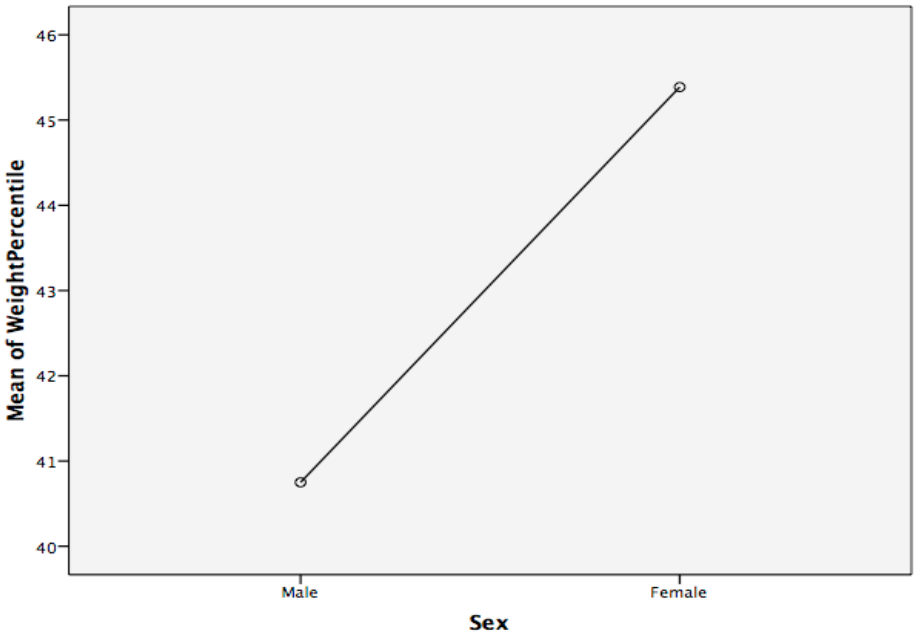


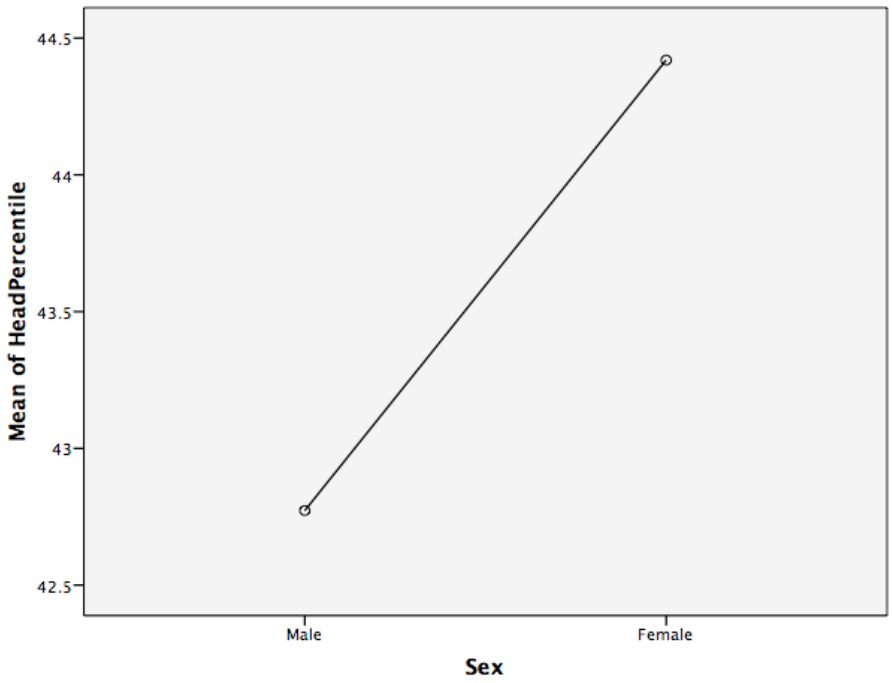



Mean =43.3
Std. Dev. =25.282
N =97
Frequency
25.0
20.0
15.0
10.0
5.0
.0
-20
0
20
40
60
80
100
HeadPercentile

Appendix H
Mean of Height, Weight, and
Head Circumference by Gender Graphs






44.5
44
43.5
43
42.5
Mean of HeadPercentile
Male
Female
Sex