EFFECTS OF LEAD EXPOSURE ON HEAD START CHILDREN'S SOCIAL SKILL DEVELOPMENT

by

MARISA SCHLIEBER

(Under the Direction of Stacey M. Neuharth Pritchett)

ABSTRACT

The current study examined the effect of lead exposure on the development of children's social skills from kindergarten through third grade. Participants had been enrolled in Head Start and were selected from a larger national project on Head Start children's transition to public school. Two groups of children were compared; children with lead poisoning and children without lead poisoning. Parents reported lead exposure on a measure of children's health. Parents and teachers provided ratings on children's social skills assessed from kindergarten to third grade. Results suggest that children whose parents reported lead exposure for their child rated their children as having poorer social skills than children who were not exposed to lead. The same outcome was found for teacher ratings of children's social skills with regard to lead exposure. Implications for future research are provided.

INDEX WORDS: lead exposure, social skills, Head Start

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CHAPTER 1

INTRODUCTION

Lead, a potent environmental neurotoxin, poses serious adverse risks to children's health and places them on a negative trajectory for academic achievement and other developmental markers. As one of the most researched heavy metals, lead continues to be a major public health concern, particularly among young children (CDC, 2005). Lead contributes to cognitive deficits, lowered intelligence (Canfield, Gendle & Cory-Slechta, 2004), behavioral issues (Chiodo, Jacobson, & Jacobson, 2004), and the emergence of Attention Deficit Hyperactivity Disorder (Nigg, et al., 2008). Currently, the Center for Disease Control's (CDC) safe threshold for exposure is 10 ug/dl (micrograms per deciliter). According to the CDC, any level less than 10 ug/dl is considered safe and does not pose significant risks on the developing brain or body (Nelson & Espy, 2009). Despite the government's stated threshold, recent studies indicate that no safe threshold exists for lead exposure where even small traces in the blood could produce deleterious effects (Social Policy Report Brief, 2010). Childhood lead poisoning is a relevant and important issue on which to focus because of lead's relationship to poor developmental outcomes for children.

Substantial efforts have been made to reduce the amount of lead found in the environment. Public health agencies have aggressively worked to decrease the amount of lead found in previously highly accessible sources such as paint and gasoline (Lidsky & Schneider, 2003). Despite these public health efforts, lead exposure remains a critical health concern because while the public generally is not exposed to toxic levels, lead remains accessible in our environment with levels that can negatively affect development (Nelson & Espy, 2009). Low-level amounts of lead are linked with cognitive deficits and behavioral disorders (Chiodo, Jacobson, & Jacobson, 2004). In the United States, it is estimated that seven million children under the age of six have elevated blood lead levels (Social Policy Report Brief, 2010). The prevalence of lead in the young child population suggests concerns for developmental scholars. The CDC estimate differs greatly from other lead prevalence figures where the federal agency notes only 235,000 have blood lead levels that post risks (Centers for Disease Control, 1991). These CDC figures are only for children with blood lead levels above 10 ug/dl, not taking into account those children who are at risk with levels below the government noted safe threshold. These alternative prevalence estimates suggest a significant number of children not accounted for under the CDC's estimates who are at risk for developmental deficits.

Lead places children at risk for academic failure while hindering school readiness as cognitive deficits associated with lead result in reduced intelligence and executive cognitive functioning. Lead influences the developing, immature brain during critical periods of development. Research on the physical, cognitive, and behavioral aspects of lead notes relationships with performance on IQ tests and in the classroom. Lead exposure negatively affects intelligence, as children with lead exposure underperform on IQ tests compared to their peers and have lowered executive cognitive functioning (Canfield, Gendle, & Cory-Slechta, 2004). Lowered IQ is assumed to be the result of cognitive deficits caused by exposure early in development. Children who have been exposed to lead are more likely to be referred to special education classes because of underperformance in the classroom (Canfield, Gendle & Cory-Slechta, 2004). Cognitive deficits place children at an academic disadvantage compared with their peers and affect their school performance, often leading to eventual drop out in the later years of formal schooling. The effects on the developing brain, specifically cognition, are significant and place the child at risk for school underachievement.

In addition to underachievement, lead has been linked with the emergence of Attention-Deficit Hyperactivity Disorder (ADHD); another susceptibility placing children at risk for academic failure and impinging on classroom performance (Wang, et al., 2008). Children with early lead exposure are more likely to develop ADHD compared to peers with no exposure. The symptoms of ADHD include impulsivity, hyperactivity, and developmentally inappropriate levels of inattention (Wang, et al., 2008). These symptoms are often problematic for classroom performance, as children have a harder time with sitting still, paying attention, and self-regulating behavior ultimately negatively influencing their classroom performance.

Low- socioeconomic (SES), urban young children are the population most susceptible to the deleterious effects of lead. Children, specifically infants, toddlers, and preschoolers, are more vulnerable to the harmful effects of lead because their bodies and brains are in critical stages of development. As the brain and nervous systems are still in early formation, exposure to lead can negatively hinder development. Children from low socio-economic environments are at greater risk as a result of their environments. These children are more likely to live in older houses built before 1975 when lead was still used in paint. When houses become dilapidated or undergo renovations without careful monitoring, children become exposed to lead through paint chips ingested either orally or through the inhalation of dust particles. Lead paint is the primary source of lead exposure for children (Lidsky & Schneider, 2003).

Children from low socio-economic environments are even more susceptible due to dietary conditions, such as deficiencies in calcium, iron, protein and zinc, which allow lead to become easily absorbed in the system (Lidsky & Schneider, 2003).

Children from low socioeconomic environments are exposed to many risk factors that set them up for academic failure, with lead being yet another factor. There exists “environmental injustice” conceptualized as the exposure of minority and low-income populations to heavy toxic metals and environmental hazards (Landrigan, Rauh, & Galvez, 2010). These families tend to live in areas of high pollution and other environmental hazards, exposing them to these metals. Medicaid, the government medical insurance program, mandates that children be tested at 12, 24, and 36 months as these time points are considered to pose the most risk for developing negative effects if exposed to lead (Wendogrovitz & Brown, 2009). Children enrolled in programs for families who live in poverty such as Head Start and who often have Medicaid are supposed to be tested at these critical time periods, however not all families participating in the program comply with the well-child physician’s appointments despite reinforcement from their Head Start health workers.

Lead is an entirely preventable environmental problem as the sources and causes of lead are known. Of all the metals and environmental neurotoxins in existence, lead is one of the most studied and the effects on children’s intelligence have long been known (Lidsky & Schneider, 2003). Recent research notes the severity of being exposed to lead, even at very low-low levels. The resurgence of this research further highlights the harmful effects of this metal, even with low amounts, given its effects on long-term development. As the effects of lead are found to be completely irreversible, preventing initial lead exposure is essential for positive developmental outcomes. Treatments can be utilized, but the effects of lead are long-term, irreversible, and persistent. It is estimated that lead's effects will sum to $172-270 billion for treatment and the loss of revenue due to school drop out and loss of productivity (Social Policy Report Brief, 2010).

The Current Study

The current study examines the effect of lead on children's social skill development. While much research has investigated the physical, cognitive, and behavioral effects of lead on development, little is known about the effects of lead on a child's social skill development. Social skills are important for making a smooth adjustment to school and to navigate the social structure of life, therefore, this study adds to the literature on lead's effects on this area of development. The research question guiding the study was: How do former Head Start children with lead exposure compare to former Head Start children who have not been exposed to lead in their social skill development?

By investigating these relationships, we may expand our knowledge of lead's effects on a child's social skill development. Much is known about how lead contributes to cognitive deficits, lowered intelligence, and behavioral issues like ADHD; this study adds to the literature on another area of development. This study examines how lead effects social skill development for former Head Start children with lead poisoning compared to those without exposure. Given the lack of information on the topic of social skills, this question fills a gap in the literature about the association between lead and these skills. Another significant contribution of the study was that it followed children through third grade to measure their social skills starting from kindergarten entry. This context will allow us to understand how lead exposure early in development affects children's social skills as they progress through the first few years of elementary school.

CHAPTER 2

LITERATURE REVIEW

Lead as Environmental Neurotoxin

Neurotoxins, harmful agents that destroy or inhibit the functions of neurons in the brain, are widely dispersed in the environment in the form of chemicals or heavy metals. These neurotoxins are referred to as exogenous gases, as these gases are ingested or absorbed into the body from external sources found in the environment (National Scientific Council on the Developing Child, 2006). The organ of the body most affected by neurotoxins is the brain as these agents obstruct the function of genes, proteins, and molecules that are necessary for the brain's architectural make-up (National Council of the Developing Child, 2006). Insult to the brain through exposure of neurotoxins is most harmful when ingested by children in early development when the brain is still forming (Children's Environmental Health Project, 2000). These harmful agents modify a young child's developmental pathway by altering the brain or the nervous system. Sources of neurotoxins found in the environment are heavy metals such as lead or mercury, pesticides, cigarette smoke, and solvents such as cleaning fluid (Children's Environmental Health Project, 2000; National Council on the Developing Child, 2006). Research on neurotoxins has found a link between early exposure and later development of cognitive impairments, learning disabilities, and behavioral issues (Children's Environmental Health Project, 2000).

The environmental context to which a child is exposed, including residence, family make-up, and relationships with others has a profound influence on overall development. Every child is reared in his or her unique environmental context and this contributes to differential outcomes between children. It is not just nature or nurture that plays an active role, but the interplay of the two that shape the child's overall development. A child's environment can directly influence their gene expression or biological makeup by facilitating or inhibiting certain genes (National Council on the Developing Child, 2006). The interaction between the child and his or her environment may have either a stimulating or negative effect on development often with long-term implications. According to the National Scientific Council on the Developing Child (2006), growing up in environments that are stimulating, such as being provided nutrients and vitamins in one's diet, help to aid in successful growth and development. Growing up in environments that are negative, such as being exposed to adverse environments with heavy metal or chemical exposure, such as lead in drinking water, may cause serious impairments. Being exposed to neurotoxins poses persistent, life-long risks setting children on a negative developmental trajectory that is often irreversible. Neurotoxins may affect a fetus by crossing the placenta barrier in-vitro. This information suggests the necessity for expectant mothers to be in a stimulating environment during pregnancy and reduce negative exposure as this negative exposure affects the developing fetus, with severe developmental outcomes when the child is born (National Scientific Council on the Developing Child, 2006; Children's Environmental Health Project, 2000).

Lead is an established neurotoxin prominent in the literature as its harmful effects have been extensively researched and documented (Children's Environmental Health Project, 2000; Needleman, 2004). Lead is a highly potent metal that poses adverse risks to a young child's development, and is especially harmful to the central nervous system. Lead has been found to contribute to cognitive deficits, lowered intelligence (Canfield, Gendle & Cory-Slechta, 2004), behavioral issues (Chiodo, Jacobson, & Jacobson, 2004), and the emergence of Attention Deficit Hyperactivity Disorder (Nigg, et al., 2008). This environmental neurotoxin changes the structure and mechanisms of the brain during critical periods of development. Critical periods are times when the brain is most susceptible to environmental stimuli and when the brain is developing based on experiences and stimuli to which the child is exposed. If development is influenced during critical stages from exposure to toxins such as lead, it alters the brain for life highlighting the importance of limiting neurotoxic exposures in the environment. According to the National Scientific Council of the Child (2006), lead produces deleterious effects on development as it hinders the biological function of genes, proteins, and other small molecules that aid in the development of the brain's structure. Disturbances from neurotoxins such as lead, either prenatally or in early stages of development, demonstrate effects either directly following exposure or present symptoms later in development (National Council on the Developing Child, 2006; Shonkoff & Marshall, 1990).

History/ Effects of Lead

In the United States, childhood lead poisoning is one of the most common pediatric issues facing the medical community (Centers for Disease Control, 1991). It was not until the last century that childhood lead poisoning was noted as a significant health issue. In the United States, lead poisoning was first described in 1914. During this time it was falsely believed that lead had two outcomes: death or recovery without any negative side effects. However, in 1943 after a follow up with children who recovered from lead poisoning serious cognitive deficits, learning difficulties, and behavioral problems were found. School failure was also a significant issue (Needleman, 2004). The U.S Environmental Protection Agency and the Centers for Disease Control (CDC) recommend a safe threshold of exposure as any blood lead level below 10 microgram by deciliters (ug/dl). Any level above 10 ug/dl is considered unsafe, with the possibility of causing harm and prompting the need for intervention (Center for Diseases Control, 1991; Chiodo, Jacobson, & Jacobson, 2004; Olympio, Gonclaves, Gunther, & Bechara, 2009). Levels below this threshold are considered by the CDC as safe with no possibility of harm or need for intervention. Acceptable levels have been revised continuously based on the results of research studies. The last revision occurred in 1991 when the CDC moved the safe threshold from 25 ug/dl to the current 10 ug/dl, a recommendation based on results of empirical studies (Chiodo, Jacobson, & Jacobson, 2004; Olympio, Gonclaves, Gunther, & Bechara, 2009).

High levels of lead, between 50 – 70 ug/dl, produce physical symptoms such a lethargy, abdominal cramps, irritability, anorexia, diarrhea, and headaches. Left untreated coma, seizures, and death can occur at very high levels. Often these symptoms are not identified as associated with lead until it becomes serious, as other causes are examined first. The most serious of these outcomes could be mental retardation, which occurs when symptoms are left untreated (Committee on Environmental Health, 2005; Olympio, Gonclaves, Gunther, & Bechara, 2009). Lower lead blood levels are problematic and often considered ‘asymptomatic’, meaning that no physical symptoms present in the child (Lidsky & Schneider, 2003). Cases are commonly left undiagnosed or untreated, as the child does not present any physical symptoms to alert the parents of a serious medical issue (Centers for Disease Control, 1991). When physical symptoms do present, it is in the form of decreased growth, decreased hearing acuity, and inability to maintain steady posture (Centers for Disease Control). Research has established that lead exposure produces cognitive deficits, lowered intelligence (Canfield, Gendle & Cory-Slechta, 2004), behavioral issues (Chiodo, Jacobson, & Jacobson, 2004), and the emergence of Attention Deficit Hyperactivity Disorder (Nigg, et al., 2008). Left untreated, low lead levels produce harmful effects on a child's development.

Effects of Lead Exposure on Intelligence

Empirical research suggests that lead greatly reduces a child's ability on tasks assessing cognition and intelligence. Children exposed to lead are consistently found to display reduced cognition on tasks and have lower IQ scores compared to peers (Lamphear et al., 2005, Needleman, 2004). Cognitive ability and intelligence are measured through psychometric intelligence tests or assessments such as Working Memory Tasks or Spatial Span Tasks (Canfield, Henderson, Cory-Slechta, Cox, Jusco, & Lanphear, 2003; Lamphear et al., 2005;Lidsky & Schneider, 2003; Needleman, 2004 and Wigg, 2001). As cognitive ability is a critical component of school achievement, children with lead exposure often perform poorly in school and are at risk for academic failure (Lidsky & Schneider, 2003; Needleman, 2004). Canfield, Gendle, Cory-Slechta (2004) assessed many factors of neuropsychological functioning in children with early exposure to lead at various levels, including both high and low levels. Children were enrolled in the study at 5-7 months and had their abilities tested at around 5 years of age. The median blood-lead level was 7.5 ug/dl. The children were assessed using the Working Memory and Planning Battery with tasks consisting of motor screening, big-little circle, spatial span, spatial working memory, intradimensional-extradimensial shift, and the stockings of Cambridge task. The big-little circle task required children to touch either the small or large circle when instructed and the correct touch were recorded. The spatial span task was a sequential memory task, where children had to remember the order of different colored boxes. The spatial span working memory task incorporates spatial memory and efficient search strategies that feature two-dimensional boxes where children have to observe if there are tokens placed in each. The intradimensional-extradimensial shift is a task measuring selective attention and attentional shift changing. The task involved nine different stages in which a shape was shown followed by random shapes, then appeared again for the child to recognize. During certain stages the shape was shifted and altered to understand if child would still recognize it. The Stocking of Cambridge task was a modification of the Tower of London, assessing the areas of planning, inhibitory control, and executive functioning. This task required the child to replicate a certain shape created by a computer model. Results indicated chronic low-level exposure across development had a negative effect on the children's neuropsychological performance. Children with lead exposure demonstrated impairments on the tasks of spatial memory, spatial working memory, intradimensional and extradimensional shifts, and an analog Tower of London task. This study highlighted the detrimental effect of lead exposure on the child's cognitive development, specifically the core aspects of executive functioning.

Research on low-level lead exposure on cognitive ability and intelligence indicates that exposure early in development produces cognitive deficits and lowered intelligence. A major focus has been to understand how low-levels of lead may produce similar cognitive deficits to those associated with high lead levels. Canfield, Henderson and colleagues (2003) observed the effects of low-level of lead on neurocognitive functioning. Participants in the study had their blood levels measured at various ages and the Standford Binet Intelligence Scale was administered twice, at ages 5 and 7. Results indicated blood lead levels over 10 ug/dl over a child's lifetime was associated with a 4.6 point decrease in intelligence quotient (IQ). For the subsample of children with blood lead levels below 10 ug/dl the change in lead concentration resulted in a much larger change in IQ where blood lead concentrations were found to be inversely associated with IQ at ages 3 and 5; and that declines in IQ were greater at lower concentrations. This study was effective in assessing exposure through early development and testing at two different time points. Similar findings examining low-level lead exposure on reduced cognition in comparable tasks have been replicated by various research studies (Chiodo, Jacobson, & Jacobson, 2004; Nelson & Espy, 2009).

Lanphear et al. (2005) conducted a longitudinal international pooled analysis where they examined children who had both high and low lead blood levels early in development. The study focused on IQ rather than on cognitive task abilities. The researchers tested the hypothesis that the effects of lead at low levels and even at lower levels, for a given change in exposure, were associated with greater deficits. At the time of assessment, blood lead levels were below 10 ug/dl. This allowed the researchers to study the effects of high and low exposure on overall trajectory of development, even when the level was reduced. Participants included 1,333 children who were followed from birth or infancy until around 5-10 years of age. The outcome measure was a composite score of verbal and performance tests. The administration of a version of the Wechsler Intelligence Scales for Children was given. The median peak of the highest blood lead levels was 18 ug/dl, and 9.7 ug/dl was the median level at 5-7 years old. Results revealed that as blood lead levels increased, intellectual deficits for children with levels below 7.5 ug/dl were greater than those with levels above 7.5 ug/dl. Lanphear et al. (2005) concluded that children with levels below 7.5 ug/dl were at risk for intellectual cognitive deficits.

The severity of lead exposure on a child's intelligence is persistent and stable throughout development, with the cognitive deficits being observed in adolescence. This finding highlights the harmful, permanent nature of lead's influence on the brain during the formative years of development (National Council on the Developing Child, 2006). Ris, Dietrich, Succop, Berger, and Bornshein (2003) examined participants in the Cincinnati Lead Study, a longitudinal study looking at lead exposure during early childhood, when the children became adolescents. Results indicated that those who experienced early childhood lead exposure displayed cognitive deficits and impaired performance during adolescence, especially compared those without lead exposure. This study highlights the progressive nature that this neurotoxin has on modifying the brain's biological make-up. A study by Ris and colleagues (2003) replicates similar findings indicating the persistent, long-term effects of lead (Cecil et al., 2008; Pabello & Bolivar, 2005).

Lead Exposure on Behavior- ADHD

Research on lead exposure suggests a link with blood lead levels and behavioral issues. Children with lead exposure have been reported as being listless, inattentive, impulsive, and even aggressive (Needleman, 2004). In addition to deficits associated with intelligence, research has also suggested a link with Attention Deficit Hyperactivity Disorder (ADHD) (Lidsky & Schneider, 2003; Nigg et al., 2008; Roy et al, 2009; and Wigg, 2001). Similar to intelligence, ADHD has also been associated with low-level exposure to lead. ADHD is characterized by hyperactivity, inattention, and impulsivity (Nigg et al, 2007). The causes of ADHD are uncertain, however genetics and environmental factors are considered as influencing the etiology. Heavy metal exposures, specifically focusing on lead, have been researched to investigate the link between contact with metal and the emergence of this disorder (Wang et al., 2008). Compared with other neurotoxins lead is most connected to the emergence of ADHD. Nircolescu et al. (2010) examined Romanian children and found that compared with other toxic metals such as aluminum and mercury, lead had the strongest association with ADHD whereas the other two metals did not show an effect. ADHD is another risk factor setting children up for academic failure as the nature of the disorder inhibits attention in the classroom and optimal academic performance.

Research examined the influence of both high and low blood lead levels on the emergence of this disorder in children. Wang et al. (2008) conducted a case-control study in China investigating the link between blood lead levels and ADHD. Blood lead levels were assessed and other risk factors were adjusted to gain a more comprehensive understanding of the association between lead and ADHD. Results indicated that children with ADHD were more likely to have been exposed to lead. Children with blood lead levels above and below the safe threshold of 10 ug/dl were susceptible for ADHD. Those above 10 ug/dl had a 4.1-8.7 higher risk for ADHD, and those below had 3.5-7 increase. By controlling for other risk factors, Wang et al. (2008) effectively established that lead is an environmental risk factor influencing the etiology of this disorder, both at low and high blood lead levels. The limitation of the study concerned the focus of one nationality of subjects, possibly affecting the results ability to generalize. As recent research emerges suggesting low-level effects on intelligence, the importance of low-level exposure has been examined.

ADHD features three subgroups depending on symptoms: inattentive, hyperactivity, or a combination of the two. Nigg et. al (2008) explored lead's effects based on subtype. Examining low-lead levels, observed the relationship in a community-based sample of children who have been exposed to average levels of lead and have ADHD established by clinical criteria. This study focused on the different subgroups of ADHD: predominately inattentive, predominately hyperactive, and a combination of both. Results suggested ADHD for the combined subtype was associated with effects from lead that was not observed for the inattentive subtype. The strengths of the study were that average levels of lead were examined were similar to the levels of exposure to which children in the United States are exposed. The researchers also focused on the three subgroups of ADHD instead of just at the disorder as a whole although the hyperactive group was too rare to be included in the results. Excluding this group could have affected the results. This group could be affected by lead exposure and maybe that is a reason for the link between the combined subtype and lead.

Lead Exposure in Early Childhood

Young children are more susceptible when compared to older children or adults to the effects of lead as their brain and central nervous system are in critical stages of development (National Council on the Developing Child, 2006). Exposure early in development contributes to more significant and long-lasting effects than exposure later in development or as adults. Effects resulting from early exposure are persistent throughout the life course. The age group having the highest risk of exposure is one to six years of age, as this group engages in hand to mouth behavior that facilitates that transfer or ingestion of lead from the environment into the body (Landigran, Rauh, & Galvez, 2010; Needleman, 2004). Diets deficient in calcium, zinc, and iron tend to absorb more lead into their system (Currie, 2010). Hornung, Lanphear, and Dietrich (2009) found the age of greatest susceptibility to lead exposure is at 2 years old, however high blood lead levels measured during 5-7 years old are associated with greater cognitive deficits persistent through development. This highlights the need of implementing good nutrition into young children's diets. Cecil et al. (2008) examined brain volume in adults who had lead exposure during early childhood and found that adults with childhood exposure had lower brain volume and had region-specific reductions, including the prefrontal cortex, the area of the brain responsible for executive functions, mood regulation, and decision-making (Cecil et al. 2008). This finding might explain the link with cognitive deficits, reduced intelligence, and ADHD.

Socioeconomic Status

Children who live in poverty are more susceptible to exposure to lead, mostly as a result of their living environments. The primary source of lead in the United States is paint from older housing or buildings that becomes chipped or turns into dust. Children from low socioeconomic environments (SES) tend to live in older houses built before 1975 when lead was still used in paint. Older housing is typically located in urban areas where families with more limited economic resources reside (Levin et al, 2008; Lindsky & Schneider, 2003). As houses become dilapidated or are renovated, the paint peels becoming chips and dust the child ingests through hand-mouth activity or through inhalation (Committee on Environmental Health, 2010; Olympio, Gonclaves, Gunther, & Bechara, 2009). Amount of exposure is stratified by socioeconomic status, as 16.3% of children from low SES families had blood lead levels above 10 ug/dl compared to only 5.4 and 4% of middle and high income families in a recent study (Lindsky & Schneider, 2003). Because of the detrimental effects of lead on intelligence, this environmental factor could contribute to the significant achievement gap between low SES children compared to middle and upper class peers (Miranda, Kim, Reiter, Galeano, & Maxson, 2009).

Literature suggests that low socioeconomic status is associated with reduced school achievement and readiness compared to middle or upper class status (Currie, 2005;Lidsky & Schneider, 2003; Miranda, Kim, Reiter, Galeano, & Maxson, 2009). Socioeconomic status is measured by occupation, wealth, education, income and/or homeownership (Miranda, Kim, Reiter, Galeano, & Maxson, 2009). These factors are calculated in measuring an individual's socioeconomic status. Socioeconomic status is important for a child's life path as the literature indicates positive correlations between high socioeconomic status and educational attainment such as children's reading levels, placement in high achievement tracks in school, staying in school, matriculation into college, and attending elite colleges (Miranda, Kim, Reiter, Galeano, & Maxson, 2009). Low socioeconomic status is associated with much poorer outcomes for educational achievement. Lindsky and Schneider (2003) proposed that SES makes children more vulnerable to the detrimental effects of lead on intelligence as SES by itself has a relationship with intelligence, but when coupled with lead becomes more harmful. Bellinger (2008) replicated this research by suggesting that socioeconomic status may modify lead neurotoxicity. Children living in poverty are more likely to be exposed to lead, and socioeconomic status by itself is a factor that affects intelligence. Bellinger (2008) suggests that socioeconomic status be deconstructed to understand its psychological, biological, and sociological effects. These authors indicate that the effects of lead coupled with socioeconomic status pose a more serious risk for children living in poverty.

Those living in poverty often are exposed to many harmful neurotoxic chemicals due to their residence or their occupation, putting them at risk for various health-related problems. A disproportionate amount of minorities and those in poverty are exposed to toxic substances such as lead due to living in conditions of lower quality and working in occupations putting them at risk (Dilworth-Barth & Moore, 2006). Landigran, Rauh, and Galvez (2010) described how environmental injustice may cause disparities in health across populations of children resulting from factors such as socioeconomic status, ethnicity, and race. The authors define environmental injustice as the “inequitable and disproportionately heavy exposure of poor, minority, and disenfranchised populations to toxic chemicals and other environmental hazards” (p.178). This inequality is conceptualized as the high frequency of the low SES population living or working in areas with exposure to toxic heavy metals and other environmental hazards that give rise to potential serious health risks.

According to Landigran, Rauh, and Galvez (2010), the environments to which children are exposed have changed drastically in the past century and it is estimated that children are exposed to more than 80,000 synthetic chemicals. Most of these chemicals found in the environment have not been studied as extensively as lead, so there is a general lack of knowledge about the potential effects. The authors discussed how the highest concentrations of lead poisoning are in poor, minority areas, which is discussed in a great deal of literature (Dilworth-Barth & Moore, 2006). They further explained how older housing units built with lead paint are disproportionately represented in these neighborhoods, often in need of repair. Stark environmental injustice can be evidenced in elevated blood lead levels by race and income. Those living in poorer neighborhoods are exposed to lead through sources that children in more affluent areas do not have exposure to in their environment.

Lead's effects on school readiness and achievement have been a focus following research establishing a link between lead exposure and cognitive deficits. Currie (2005) extended upon the literature of health disparities examining the impact on school readiness. The author replicates the finding that a child's environmental exposure to hazard substances is due in large part to their housing or neighborhood. Due to segregation of socioeconomic status, race, and ethnicity, certain groups have a greater likelihood of exposure to environmental neurotoxins. In the author's view, lead poisoning directly affects cognition and behavior that leads to problems performing in the classroom. Currie (2010) notes that children with diets deficient in calcium, iron, and zinc absorb lead more easily. Low SES children often do not have their nutritional needs met, so this serves as another risk factor for blood lead levels compared to affluent peers.

Chen, Matthews, and Boce (2002) examined how socioeconomic differences on health disparities between children differ with age. Literature notes that SES has a large effect on health, with low SES associated with higher rates of disease and overall poorer health. The authors had an interest in exploring the impact of SES on health during childhood and how the relationship changes throughout development. The findings indicate that SES-health relationships varied across specific health outcomes, meaning that the lower that a child was in the SES hierarchy the more health risks that were posed. However, the types of health outcomes related to SES changed as a function of age during a child's development (Chen, Matthews, & Boce, 2002). This study was effective in establishing the link between SES and health disparities, and how the function of this association during different ages in development.

Tong, McMichael, and Baghurst (2000) observed the interaction between lead exposure and sociodemographics on cognitive development. The authors were interested in how lifetime blood-lead concentration and sociodemographic factors such as gender, maternal intelligence, home quality, and parent's occupation affected intelligence. Participants included 375 children from Port Pirie, South Australia who were followed from birth to 11-13 years old. Blood – lead level was assessed and intelligence was measured through the Wechsler Intelligence Scale for Children (WISC-R). To measure the sociodemographic variables the Daniel's Scale of Prestige of Occupations was used for social status, the WAIS-R was used for maternal intelligence, the Home Observation for Measurement of the Environment (HOME) inventory was used for the care-giving environment. Family functioning was assessed through Family Assessment Device. Other measures were used to assess birth weight, birth rank, gender, and other factors. Results indicated that the impact of lead concentration on intelligence (IQ) was strongest for low SES children compared to children from more affluent families. It was also stronger for children from poorer quality home environments than those of higher quality.

Davis, Chang, Burns, Robinson, and Dossett (2004) examined the effect of lead exposure on attention regulation for children from low SES backgrounds. The authors were also concerned with how lead exposure affects regulation in parent-child interactions within the care-giving environment as this interaction facilitates the development of regulation. Participants were 57 children split between a lead exposed group and non-exposed group that were all from low-income families. The children were between 4 and 5 years old, and blood lead levels ranged from 10 to 29 ug/dl. Participants were given the Kaufman Brief Intelligence Test as a measure of intelligence. A puzzle-matching task measured attention regulation, first with the mother, second by the child alone. Results revealed that the mean IQ score was lower from the lead exposed group compared to the non-exposed group. Regarding the puzzle task, performance between the two groups was the same on the number of times for task completion. General findings were that lead exposed children performed more poorly on the task both when working with the parent alone. Children exposed to lead used a less efficient attention allocation pattern. This study was effective in highlighting how a different environmental context and parent-child interaction can mediate the association with lead for low SES families.

Research has established a link between environmental stressors that confront those living in poverty, and how the stress produced by the adrenal cortical glucocorticoids produces reduced health outcomes with lead being one such outcome (Cory-Slechta, Virgolini, Thiruchelsum, & Bauter, 2004). Poverty itself can cause be a chronic, salient, and uncontrollable source of stress (Dilworth-Barth & Moore, 2006). Gump et al. (2009) examined how blood lead levels were an environmental mechanism that contributed to the association between socioeconomic status and psychological dysregulation. Gump et al. (2009) longitudinal study examined the link between blood lead levels and cortisol levels following acute level stress based on SES. The study suggested how lead is more commonly associated with low SES and how it can inversely affect other responses, like psychophysiological responses. Living in poverty or being of low SES status is associated with negative outcomes, and can make the effects of lead even more detrimental.

Along with children who live in poverty, foreign-born children are more likely to have lead exposure and high blood lead levels because of less stringent environmental policy laws restricting lead in their previous home country. The United States began its campaign of enforcing strict policies on lead around the 1970s when research indicated that this metal posed a serious threat to the population. However, can still be found in abundance in other parts of the world. Tehranifar et al. (2008) examined if foreign-birth place or residence is associated with an increased risk of lead poisoning. This study conducted a matched case-control study among children from New York City, who were matched on age, residential area, and date of test. The ages ranged from one year to 18 years old. The experimental or case group was defined in the study as children with blood lead levels 15 ug/dl and 19 ug/dl and the control was defined as any level less than 5 ug/dl. showed that foreign residence and time since foreign residence had a higher incidence of lead compared to children born in the United State with no history of living in a foreign residence. Foreign-born children were five times more likely to have elevated blood lead levels. This is consistent with literature on the high amount of lead exposure in foreign-countries compared to the United States.

Screening and Prevention

Overall childhood blood lead levels have decreased due to public health interventions reducing the amount of lead in the environment. However, lead can still be found in the environment because of industrialization (Centers for Disease Control, 1991). Data from the late

1960s and early 1970s indicated that 20-45% of children had blood lead levels above 40 ug/dl, which was reduced to 15 ug/dl by 1980 (Olympio, Gonclaves, Gunther, & Bechara, 2009). In 1991, the Centers for Disease Control (CDC) and American Academy of Pediatrics (AAP) recommended that all children have their blood lead concentration measured at one and two years of age. The recommendation was based on the high amounts of lead exposure still experienced in the country, about 1 in 11 children have a blood lead concentration over 10 ug/dl (Committee on Environmental Health, 2005). With proactive public health interventions, the prevalence of lead has decreased and cases above blood lead concentrations 10 ug/dl decreased. In 1997, the CDC and AAP only recommended that children with the greatest chance of exposure or most susceptible be screened for lead (Committee on Environmental Health, 2005). According to the guidelines children considered at risk are those who lived in older housing built before 1978, those who came into close contact with a sibling or friend with elevated blood lead levels, or those who lived or visited an older structure or house that contained damaged, deteriorated or re-modeled lead-paint surfaces (Committee on Environmental Health, 2005).

In 2005, it was mandated that all children enrolled in Medicaid be screened for lead at the ages of one and two. If children do not receive a lead test at these ages, then at 36-72 months a lead screening was recommended (Wendogrovitz & Brown, 2009). The preferred method of screening children is through a blood lead test due to its accuracy (Centers for Disease Control). Most children enrolled in Medicaid have elevated blood lead levels as they often are from low socio-economic families, however most have not been screened for lead (Committee on Environmental Health, 2005). This is problematic because these children receiving Medicaid have the highest risk to be exposed to lead and have elevated blood levels. Because of this concern, the CDC recommended that health officials update blood lead screening procedures for

Medicaid children, improve the rates of screening among these children determined at risk for lead exposure, and design updated surveillance and evaluation strategies (Wendogrovitz & Brown, 2009). Another problem facing public health officials centers on how to screen and identify children not on Medicaid but still at risk for lead exposure due to environmental factors such as living in older housing or being in contact with lead exposed children. Each state has different lead requirements, but a common mandate is to screen children at one year (Centers of Disease Control, 1991).

Lead poisoning is entirely preventable as the causes, sources, and prevention methods are well established through research. The fact that children are still being exposed to this harmful neurotoxin is surprising given the wealth of information about lead's negative effects. Preventing lead exposure is the most important strategy for eliminating potential low-level effects (Committee on Environmental Health, 2005; Needleman, 2004). The goal of eliminated lead exposure was incorporated in the Healthy People 2010 for the United States, which is a subset of the overall goal to reduce health disparities among different parts of society that occur based on race, ethnicity, and socioeconomic status (Wengrovitz & Brown, 2009). This federal strategy focused on primary prevention and was aimed at housing. The strategy is a grant-funded program administered by the Department of Housing and Urban Development (HUD) that aimed to remediate housing to make houses that are lead-safe for children (Committee on Environmental Health, 2005).

Prevention techniques are crucial for reducing lead accumulation in the blood stream and eliminating potential contact with sources of lead. Lead is difficult to treat and totally eliminate from the blood stream. Low concentration of lead can be especially problematic because the effects are often 'asymptomatic', indicating that the child might go undiagnosed or untreated.

The effects of lead are irreversible once damage to the brain or central nervous system occurs there are ways to reverse the harmful effects. Once cognitive impairments occur or neuropsychological effects are established, no intervention for reducing lead will negative these determents. When blood lead levels greater than 45 ug/dl occur medical management is needed. Chelation therapy or a succimer, an oral chelating agent, is used to lower the amount of lead in the blood (Centers for Disease Control, 1991; Committee on Environmental Health, 2005).

According to the CDC because 10 ug/dl is the safe threshold, prevention and intervention should aim at reducing the child's blood lead level to the safe threshold level and below (Center for Disease Control, 1991). Levels at or below 10 ug/dl should have interventions that focus on community prevention activities. Blood levels between 10-14 ug/dl are in a border zone as described by the CDC, and this zone often is not the focus of an intervention. As explained by the CDC, this is because levels in this range often can not be tested by blood tests accurately, so the levels can be lower and that effective interventions have not been identified (Centers for Disease Control, 1991). Children with at or above 15 ug/dl should receive individual case management that includes nutritional and educational interventions as well as more frequent screenings. Children at or above 20 ug/dl should have a medical evaluation and environmental investigation done to locate the source of lead exposure (Centers for Disease Control, 1991). Levels above 45 ug/dl require chelation therapy for significant reductions of lead in the blood (Centers of Disease Control, 1991). Once lead is in the brain, no intervention can negate its effects. Chelation therapy can work to reduce the amount of lead especially in the blood stream, but not for complete removal (Lidsky & Schneider, 2003). Primary prevention is the most effective goal for eliminating potential harmful effects posed by low-level amounts of lead.

Lead Exposure on Social Skill Development

Much is known about the effect of low-level amounts of lead on cognitive deficits and behavioral disorders, like ADHD. However limited research has focused on the impact of lead on social skill development, which is another critical component of school achievement and academic competence. The current study explores the association of blood lead concentration on social skill development behavior in Head Start children. The development of social skills is important for adapting to the school environment and interacting with peers. It is estimated that 15% of elementary school students have difficulties with peer relationships and this social rejection continues throughout childhood resulting in negative outcomes. These negative outcomes may result in delinquency and maladjustment into adulthood (Whiteside, McCarthy, & Miller, 2007). Poor social skills left untreated are persistent throughout development and are associated with poor classroom performance and harmful psychopathology (Gresham & Elliot, 1990). Developing social skills, defined at socially acceptable learned behaviors, is essential for interacting effectively with others to avoid undesirable responses for others (3).

CHAPTER 3

METHOD

Participants

Data were collected on a sample of 2,165 children and families who had been enrolled and utilized Head Start services before entering kindergarten. Participants were selected from the National Head Start/ Public School Early Childhood Transition Demonstration Study, which took placed from 1991-1999. Although the study took place over 10 years ago, lead is still a relevant concern as children continue to be exposed to lead in their environment. The multi-site study featured a total of 10,392 participants randomly selected from 31 sites across the United States. The purpose of the National Head Start/ Public School Early Childhood Transition Demonstration Study was for Head Start agencies and local education agencies/public schools to work together to develop and implement programs for low-income families to facilitate successful transitions between preschool into public schools. The 31 sites were funded through a competitive grant and were required to implement Head Start-type supports for kindergarten through third grade for a randomly selected group of Head Start graduates. Children enrolled in the treatment group continued to receive Head Start support services through the third grade, while children in the control group experienced a traditional elementary school curriculum. A non-Head Start control group was also added to the study, but participants from that group are not included in the current study. Each of the 31 sites employed a random selection procedure to assign their participants. Evaluations were conducted at each site from kindergarten to third grade to determine the impact of the program on children, families, communities and schools as children transitioned from Head Start to public school.

The national study used a variety of measures: family interviews, assessment of children, standardized ratings of individual children, classrooms, and schools, direct observations of classrooms, reports by principals, review of student records, and collection of community-level data from public information sources. The current study focused on the family interview and teacher report for obtaining the data necessary to complete the research questions. In the fall and spring of the kindergarten year, families were given a comprehensive family interview measure to complete incorporating health questions and questions about their children's social skills. Data from teachers that completed assessments of children in the spring of the kindergarten year are used in this study.

The current study focused on the four items pertaining to lead in the survey assessment of children's health and safety. While the initial data file had many more participants, participants were eliminated if they were missing data from this measure, as lead was the variable of focus. Parents who indicated that their children had been tested for lead poisoning and whose results were positive for elevated levels of lead during fall of kindergarten were selected for participation in the study as the high lead exposure group. All other children who had been tested but were not found to have been exposed to lead comprised the comparison group. After controlling for the variable of having been tested for lead, the current study had a sample of 2,165 participants. Children with lead poisoning comprised 9.3% of the overall sample (n = 201), whereas children who were not identified with lead poisoning accounted for 90.7% of the sample (n = 1964). The overall sample was comprised of 1115 males and 1029 females. There was no significant difference found between gender and identification with lead poisoning ($\chi^2(1) = 2.45$,

p = .12). The ethnic distribution for the overall sample was 41.2% Black/ African American, 37.0 % White/Caucasian, 12.0% Hispanic/ Latino, 1.0% American Indian/ Native American, 0.9% Asian or Pacific Islander, and 8.0% other. No significant difference was found between ethnicity and lead poisoning ($\chi^2(5) = 6.01$, $p = .31$). The most frequently occurring education level of the family member who completed the interview and indicated whether the child had been diagnosed with lead poisoning was a high school graduate or GED completer (33.2%), followed by those who had not yet completed high school but had a minimum of a ninth grade education (29.2%). Some college experience, but no formal degree was noted by 22.9%, while 8.1% had completed a college education. Almost 6% of the family member who completed the interview had less than an eighth grade education. The primary language spoken at home was English (89.8%), along with Spanish (5.8%) and other (4.4%).

Interview respondents were asked to describe their child's overall health. On a scale ranging from poor to excellent, a statistically significant difference was found between children who had been identified with lead poisoning and those who had not ($\chi^2(4) = 23.63$, $p = .00$). Specifically, more children with lead poisoning were rated as having fair health. In addition, on a question centered on whether or not the child was less healthy than other children, more children with lead poisoning had parents who indicated that this was definitely true for their child ($\chi^2(4) = 17.48$, $p = .002$). Because lead poisoning is often associated with the diagnosis of ADHD, two questions on whether or not the child had been diagnosed with ADHD were examined. There were no statistically significant differences in the frequency of children who had been diagnosed with ADHD with regard to also being diagnosed with lead poisoning. Family members filled out this question and not physicians, and it could be that children in the study had not yet been tested for this behavioral disorder. As the children were starting kindergarten at the time of the interview, it could be that the children were too young to obtain a diagnosis. In addition, children with lead poisoning were not rated by their parents as having been seen for emotional or mental problems, or taking behavior controlling drugs in any greater frequency than those without lead poisoning. On a formal diagnosis of anemia, 31% of children with lead poisoning were also diagnosed with anemia while only 22.6% of children who were not diagnosed with lead poisoning had anemia ($\chi^2(1) = 5.34$, $p = .02$). No statistically significant difference were found between children with and without lead poisoning on number of days absent from school or presence of an individualized education plan for special education services

Research Question

To explore the effect of lead exposure on social skill development at kindergarten and through third grade, one main research question was examined in this study. Previous empirical studies indicate that lead has an effect on intelligence and behavior, with no research on lead's influence on social skill development. The research question examined in this study was:

1.) How do former Head Start children with lead exposure compare to former Head Start children who have not been exposed to lead in their social skill development?

Measures

Data were collected from children's families during fall and spring of kindergarten and in the spring of each year from first grade through third grade. In the fall of kindergarten, families were given a comprehensive family interview in which the data for the current study along with the sample was drawn. The Social Skills Rating System (SSRS; Gresham and Elliot, 1990), one of the standard assessment methods for determining social skills, were completed by families and teachers to measure the child's social skills.

This study utilized the parent and teacher rating scales in the assessment of the child's social skill behavior. In the fall of kindergarten and the spring of each year from kindergarten through third grade, the SSRS measured only social skills and academic competence. However, in the spring of second and third grade the SRSS forms for parents and teachers also included the measure of Problem Behavior. The SSRS is a pencil-and-paper assessment including three forms for parent, teacher and student report forms (Whiteside, McCarthy, & Miller, 2007). It is a norm-based assessment measuring social behaviors, problem behaviors, and academic competence often used by school psychologists for children having difficulties in school settings (Clyde-Diperna & Volpe, 2005). This assessment is effective in providing a multi-rater measurement, which encompasses student social behavior affecting teacher-student relations, peer acceptance, and academic performance (Gresham & Elliott, 1990). The SSRS focuses on pro-social behaviors and includes a brief measure of potential problem behaviors and academic competence as these factors may have an effect on social skills. Potential problem behaviors may interfere with the performance of acquisition of social skills, and academic competence because poor academic performance and social behavior problems are associated (Gresham & Elliot, 1990).

Each rating scale measures common core behaviors from the sub-domains of assertion, cooperation, and self-control (Gresham & Elliot, 1990). Some rating scales have extra components, for example the SSRS-Parent scale has an extra measure of responsibility and the SSRS-Student scale has an extra measure of empathy. There are five subscales that have the acronym of CARES: Cooperation, Assertion, Responsibility, Empathy, and Self-Control (Gresham & Elliot, 1990). Each subscale assesses different pro-social behavior. The Cooperation subscale measures behaviors like sharing materials, complying with rules and distractions, and helping others. Assertion examines initiation behaviors such as asking others for information, introducing oneself, and responding to others actions. Responsibility measures behaviors that reflect the ability to communicate with adults and regard for property and work. Empathy measures behaviors that show concern and respect for other's viewpoints and feelings. The last subscale, Self-Control, measures behaviors that emerge when in a situation dealing with conflict, that includes how the child responds to teasing, and situations with no conflict, like taking turns or compromising with others (Gresham & Elliot, 1990). Each subscale is rated in two ways, by frequency of behavior that reflects "how often" of occurrence. The three answers are never, sometimes or very often. The second rating is of importance, assessed by parents, teachers, and older students. Importance is conceptualized differently regarding rater; teachers rate by the importance of each behavior for success in the classroom, parents rate by how important for their child's overall development, and older students in grades 7-12 rate each behavior with their view on its importance to their relationships with others (Gresham & Elliot, 1990). The measure can be completed in about 25 minutes (Gresham & Elliot, 1990). Only the how often rating is used in the current study.

Van der Oord, et. al. (2004) examined social skills in children with Attention Deficit Hyperactivity Disorder using the SSRS. The authors were interested in assessing the psychometric properties of the parent, teacher, and student version of the SRSS on children with ADHD. This study was conducting in the Netherlands using 362 school children, including 288 boys and 64 girls between the ages of 8 and 12 years old. The children were divided into groups based on ADHD subgroups; 112 had the combined subtype, nine children with the inattentive subtype, and two children with the hyperactive/ impulsive subtype (Van der Oord et al., 2004). There was also a comparison group of non-ADHD children. All of the SSRS measures were translated into Dutch and administered to parents, teachers, and students. Results found support for the factor structure of the SSRS-T for both ADHD and non-ADHD groups. The subscales of cooperation, self-control and assertion had internal consistencies and were supported by both the ADHD and non-ADHD groups. The subscale factor of responsibility was not supported in both groups. ADHD children were consistently found to have greater social skill deficits compared to the non-ADHD group as rated by parents, teachers, and themselves.

Data Collection

Data from the comprehensive family interview was collected in the fall of kindergarten and then collected again spring of kindergarten until the end of third grade. Data from the SSRS was collected from teachers in the spring of the kindergarten year and then collected again each spring until the end of third grade. The Problem Behavior measure was only collected during third grade.

Data Analysis

Data were accessed from the National Head Start/Public School Transition Demonstration restricted-use database. Participants were selected based on parental response to a question focused on whether or not the child had tested positive for lead poisoning. Frequency counts and Chi-Square analyses were conducted to examine the demographics of the participants. The major analysis strategy used to address the research question in the current study was an analysis of variance (ANOVA) through repeated measures.

CHAPTER 4

RESULTS

This chapter summarizes the findings from the analyses examining differences between former Head Start children who had been diagnosed with lead poisoning and those who did not have that diagnosis. Analyses presented below are arranged in sequential order by grade level beginning in kindergarten and ending in third grade. In each grade, data from families is presented first followed by data from teachers. Data were collected in the spring of each grade.

Kindergarten Data

Families completed the Social Skills Rating System (SSRS) in the spring of the kindergarten year. Data for cooperation, assertiveness, responsibility, self-control, and an overall social skills score were collected. Parents responded to how often their child engaged in a given behavior. Data were coded on three-point scale (0 = never, 1 = sometimes, 2 = very often). Subscales scores were calculated according the SSRS manual. Data for these measures are displayed in Table 1. On all subscales, children who had the diagnosis of lead poisoning were rated less positively by their parents than children who did not have the diagnosis. Each of these analyses was statistically significant.

Teachers completed the SSRS or each child in the study in the spring of the child's kindergarten year. Teachers provided ratings on individual questions, which centered on children's academic competence in relation to other children in the child's classroom. Three individual items were completed that focused on the child's overall competence, intellectual functioning, and overall behavior. On all three items, children with lead poisoning were rated lower than their peers who did not have lead poisoning. These data are displayed in Table 2. Teachers also completed a number of other items that were part of five subscales that included social skills, academic competence, cooperation, assertion, and self-control. These data are displayed in Table 3. On social skills, academic competence, cooperation, and assertion statistically significant differences were found between those children diagnosed with lead poisoning and those who did not have that diagnosis. For self-control, no significant difference was found. Self-control items focused on a child's appropriate response to social situation. The lack of difference between the two groups may be the result of the focus in kindergarten classrooms on positive behaviors and greater tolerance for children negotiating relationships with one another.

Repeated Measures Kindergarten to Grade 1

Children were rated by their families on the SSRS in the spring of first grade. Repeated measures analysis of variance was conducted between ratings in kindergarten and first grade. On the family rating of children's cooperation, a group effect was found where children with lead poisoning scored significantly lower than their peers without such exposure ($F(1, 1591) = 15.27$, $p = .00$). No time or interaction effect was found. Family ratings of assertion between kindergarten and first grade indicated significant time, interaction, and group effects. On family ratings of self-control, an effect was found for group ($F(1, 1579) = 17.28$, $p = .00$,). Family ratings of responsibility indicated both a time effect where children displayed greater responsibility across time ($F(1, 1580) = 50.87$, $p = .00$, $\eta^2 \geq .03$) and a group effect where children with lead poisoning had lower ratings than their non-poisoned peers ($F(1, 1580) = 17.37$, $p = .00$). Regarding overall social skills, a time and a group effect were found where social skills improved over time. Children who had been identified with lead poisoning had lower overall scores when compared to their non-exposed peers. Data for these analyses are displayed in Table 4.

Teachers completed ratings of children on the SSRS in the spring of both the kindergarten and first grade year. On the subscale of cooperation, a time and a group effect was found. The two groups of children improved in the ratings of cooperation from kindergarten to first grade, but the significant difference between the two groups with children who were exposed to lead scoring more poorly. On assertion, teachers rated children who had lead poisoning less favorably than their non-lead poisoned peers (F(1, 1350 = 5.14, $p \geq .02$). A time effect was found on teacher's ratings of children self-control (F(1, 1350 = 6.19, $p \geq .01$). On overall social skills, a group effect was found ($F(1, 1365) = 3.99$, $p \leq .05$). Ratings of children's academic competence did not produce any significant effects. Data for these analyses are displayed in Table 5.

Repeated Measures Kindergarten to Grade 2

On five of the six subscales in the SSRS rated by families from kindergarten to the end of second grade, significant time effects and between subjects effects were found. On cooperation, families overall rated their child more positively over time ($F(1, 1335) = 3.99$, $p \leq .02$). In examining family ratings between children with lead poisoning and those without, parents rated children who did not have lead poisoning more positively than those parents whose children had lead poisoning ($F(1, 1335) = 12.61$, $p = .00$). For assertion, responsibility, self-control, and overall rating of social skills, parents rated their children more positively as they moved from kindergarten to second grade. In all subscale analyses, children with lead poisoning were rated lower on these social skills dimensions than those children who did not have lead poisoning. Families also provided ratings on children's externalizing, internalizing, hyperactivity, and problem behaviors. Only one significant difference was found between family ratings of children with and without lead poisoning. This difference was found on the externalizing behaviors subscale ($F(1, 1529) = 4.88$, $p \leq .03$). The means, standard deviations, and repeated measures analyses are displayed in Tables 6 and Table 7.

Teachers completed ratings for children on the SSRS during their kindergarten, first, and second grade years. Only one difference was noted in teacher ratings on the nine subscales of the SSRS. That difference found in the cooperation subscale over time ($F(1, 1298) = 3.51$, $p = .03$) was rated less positively for children as they moved through their beginning years of school. A between subjects was also found for cooperation where the children with lead poisoning were rated lower than their peers without lead poisoning ($F(1, 1529) = 7.54$, $p \leq .01$). The means, standard deviations, and repeated measures analyses are displayed in Tables 8 and Table 9.

Repeated Measures Kindergarten to Grade Three

On the six subscales completed by families from kindergarten to third grade, all six of the subscales reported significant time effects and between subjects effects. Two of the subscales also reported significant interactions between time and group. For the subscale of cooperation, a group effect was found between children with lead poisoning and those without in that those with lead poisoning were rated lower than their non-lead poisoning peers ($F(1,1160) = 7.98$, $p \leq .01$). For cooperation, a time effect which indicated that the children's scores improved over time with the exception of the grade three data for non-lead poisoned children ($F(1,1160) = 5.27$, $p \geq .00$). Again on cooperation, an interaction was found between time and group ($F(1,1160) = 3.75$, $p \geq .01$). Analyses from the subscale of assertiveness revealed that ratings increased for all across time as they moved from kindergarten to third grade with the exception of the children without lead-poisoning in grade three ($F(1,1156) = 6.35$, $p = .00$). A group effect on the assertiveness measure was found where children with lead poisoning were rated lower when compared to their peers without lead-poisoning ($F(1, 1156) = 8.28$, $p \geq .00$). On responsibility, children's scores increased indicating a time effect ($F(1, 1137) = 60.87$, $p = .00$, $\eta^2 \leq .14$) with a between subjects effect where children with lead poisoning had lower ratings than their peers ($F(1, 1137) = 17.09$, $p=.00$). On responsibility, no interaction was found. On ratings of self-control, family ratings of children increased over time ($F(1, 1153) = 9.82$, $p = .00$) with a between subjects effect where children with lead poisoning had lower scores compared to their peers ($F(1, 1153) = 8.98$, $p \geq .00$). Over time, the Family Social Skills Standard Scores increase suggesting a time effect ($F(1, 1117) = 26.62$, $p = .00$, $\eta^2 = .05$). Children with lead poisoning were rated less positively than their peers ($F(1, 1117) = 9.38$, $p \geq .00$). Finally, on family overall ratings of social skills, an interaction was found between time and group ($F(1, 1117) = 2.63$, $p \leq .05$). These data are displayed in Table 10. Parents also completed ratings on children's externalizing, internalizing, hyperactivity, and overall problem behaviors on the SSRS in third grade. Only one significant effect was found on the scale of hyperactivity ($F(1, 1331) = 4.42$, $p \leq .04$). Data for these analyses are displayed in Table 11.

Teachers rated children from kindergarten to third grade on measures of cooperation, assertion, self-control, social skills, and academic competence. The sample size decreased drastically in the third grade with data available for only 861 children (771 non-lead, 90 lead). Only two effects were found in the area of cooperation. These effects were a time effect ($F(1, 859) = 2.65$, $p \leq .05$, $\eta^2 = .85$). Children who had been exposed to lead had cooperation scores that increased over time, while children who did not have lead-poisoning had scores that rose through first grade and then fell at second and third grade. A between subjects effect was found ($F(1, 859) = 5.62$, $p \leq .02$). Teachers also completed ratings on children's externalizing, internalizing, hyperactivity, and problem behaviors. No statistically significant differences were found. These data are displayed in Tables 12 and 13.

CHAPTER 5

DISCUSSION

Based on ratings provided by families and teachers, Head Start children with lead poisoning were consistently rated as having poorer social skills compared to Head Start children without lead poisoning. These differences were found on social skills measures of cooperation, assertiveness, responsibility, self-control, and an overall social skills standard score along with measures of overall academic competence, intellectual functioning, and overall classroom behavior. These findings suggest that lead poisoning, especially in the early formative years of development, contributes to diminished social skills. The study replicates prior findings that children with lead poisoning have reduced intelligence due to cognitive deficits as found through lower ratings of overall academic competence and intellectual functioning. The link between behavior and lead was also found as children with lead poisoning in the current study had lower ratings on the measure of overall classroom behavior. As previous research on lead has not focused on social skills, these findings provide useful information about the detrimental effects of lead on the domain of social skill development.

Social skills ratings improved over time for children with lead poisoning and children without lead poisoning. As children progress from kindergarten through third grade, social skills ratings increased as indicated by higher ratings by families and teachers. Although ratings increased for both groups, children with lead poisoning were found to have lower ratings compared with peers. This indicates that although there is improvement over time, children with lead poisoning still have overall poorer social skills compared to their peers without lead poisoning. A possible reason for the improved ratings for both groups could reflect maturity as children develop and learn the appropriate ways to act. In kindergarten through third grade, for the subscale of cooperation, the effect size for time was .85 indicating a strong relationship and the highest effect size found in the study. Independent ratings from two sources, families and teachers, provided ratings that were consistent across measures. The uniformity of ratings suggests that the scores for each child were reliable for assessing their overall social skills. As families and teachers likely did not influence each other's ratings and assumes independence, these data suggest greater confidence in the ratings of social skills.

As one of the most researched environmental neurotoxins, the harmful effects of lead have been established in the domains of cognitive deficits and behavior (Children's Environmental Health Project, 2000). In the past, lead was commonly found in sources such as paint or gasoline. The general public was exposed to high amounts of lead. After research emerged establishing the harmful effects of lead, especially on young children, public health campaigns took a proactive approach in reducing the amount in the environment (Children's Environmental Health Project, 2000).. Based on previous research on lead, lead has been indicated in effecting the brain, behavior, causing health complications and even death. Most research on lead have focused its studies on how lead contributes to diminished capacity in the domain of intelligence (Canfield, Gendle & Cory-Slechta, 2004) and behavior (Chiodo, Jacobson, & Jacobson, 2004), with current studies centering on the effects of low-lead levels. These findings are important for explaining how lead exposure at a young age hinders academic achievement. These findings also suggest another risk factor for children living in poverty; as in today's society this group is more likely to be exposed to lead due to housing (Lindsky & Schneider, 2003). Scarcely any research has focused on the lead's effects on social skills. The current study attempted to explore the domain of social skills. Social skill development is important for children's functioning in the classroom, and poor social skills can be another risk factor for underachievement in the classroom.

As the findings of the study indicate, children with lead poisoning have poorer social skills compared to children without lead poisoning. Social skills are yet another domain that is affected by lead exposure, highlighting the harmful consequences of this neurotoxin on children. This also suggests yet another aspect of how lead contributes to lower academic achievement and lowered ability in the classroom. In the study, children with lead poisoning were rated lower by teachers on measures of academic competence and intellectual functioning while also receiving lower ratings of social skill ratings by both families and teachers. Social skills are an important aspect of interacting with others and forming positive relationships. Children with lower social skills often have more conflict with peers, teachers, and families, which can often impact performance in the classroom. (Gresham & Elliot, 1990). These findings are important in understanding how harmful lead can be for children and establishing diminished social skills as yet another risk factor of this neurotoxin.

The implication of this study suggests the removal of lead from the environment, the need for early lead screening, and the necessity for early intervention for children identified with exposure to lead. Public health campaigns should focus on the removal of all lead from the environment. Previous efforts made by public health campaigns have proven successful for reducing the amount of lead exposure; however with the emergence of recent findings, lead removal from the environment should still be an important focus as children are still being affected. Although the amount of lead has been greatly reduced since the turn of the century, it can still be found in the environment and in other countries with less stringent regulations. As the main source of exposure for children living in poverty, the removal of lead from subsidized housing built before 1975 should be a prominent focus. Subsidized housing units are more likely to experience dilapidated conditions and less likely to be screened for lead by health officials. Unfortunately, these units are not screened regularly and children come into contact with lead from paint chips, dust or in soil. Public health officials need to be more proactive in screening these housing units and removing possible sources of exposure.

Early screening of children to identify those with lead poisoning should be a central focus of health officials. Even though Medicaid regulates that children should be screened at one and two years of age, often times children's families do not follow these guidelines. Also screening at older ages should be required as the effects of lead interfere with normal growth of the brain. As literature established, harmful effects pose the most risk for young children in the formative stages of development. Early detection will help negate lead's harmful effects on the child through removal of lead from the house and interventions. Screening will allow the identification of children that are at risk for negative developmental outcomes posed by lead. Another implication is the importance of early intervention for children that are identified through screening as having elevated blood lead levels. As the current study and previous research established, one of the biggest risk factors of lead is the negative effect on academic achievement. Outcomes that include reduced intelligence, behavioral problems in the classroom, and poor social skills contribute to lower school performance. Providing early intervention for children with elevated blood lead levels will contribute to better performance in the classroom. This is essential for helping with academic achievement, especially for children living in poverty who often have many other risk factors.

There were some limitations of the current study. One limitation was that only ratings from the families were provided for indication of lead poisoning. No medical records or actual blood lead level amounts were given. This would have been informative as research suggests that low-lead levels contribute to serious risks for children and the effects on social skills at various levels could have been examined. There was no information that indicated the level or amount of lead in the child's system, only that the child had tested and was treated for lead poisoning before kindergarten. As this is one of the first studies to examine the link between lead poisoning and social skills, there are many different ways to extend this research. Future research should focus on examining different blood lead levels to better understand the effects on social skills. As this study did not have information regarding the amount of lead in the child's system, it would provide a better understanding. Especially examining the effects at low levels, which is a central focus of current research focusing on intelligence. Future research should also examine the effects on social skills throughout adulthood to better the stability of effects. It would also be informative to examine relationships as social skills are useful for navigating relationships.

Based on ongoing research, lead still poses a significant threat and exposure can produce developmental deficits in young children. There is a common assumption among the general public that lead is not a significant concern as it was in the past decades. Public health campaigns should focus on educating the public about sources of lead exposure and the results from current research studies about the harmful effects of this neurotoxin. Parents, especially should be aware of sources of lead exposure that can be found in their own homes and the detrimental effects on young children's development. Lead continues to be found in the environment and poses a significant risk on young children's development.

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Table 1

Results of ANOVA of Social Skills Ratings in Kindergarten Reported by Parents on the SSRS[1]

Variable		*N*	*M*	*SD*	*F*	*P*
Cooperation	Lead	196	10.99	3.61	14.76	.00
	No Lead	1914	12.01	3.55		
Assertiveness	Lead	195	14.52	3.07	15.17	.00
	No Lead	1912	15.37	2.88		
Responsibility	Lead	196	11.29	3.18	16.88	.00
	No Lead	1902	12.24	3.06		
Self-Control	Lead	195	10.62	3.11	14.78	.00
	No Lead	1912	11.58	3.34		
Social Skills Standard	Lead	187	85.52	14.31	27.11	.00
Score	No Lead	1846	91.54	15.14		

[1] Not all data sum to 2,165 because of missing data.

Table 2
Results of ANOVA of Children's Academic Competence Items as Reported by Kindergarten Teachers on the SSRS[1]

Variable		*N*	*M*	*SD*	*F*
Overall Academic	Lead	181	2.80	1.25	11.25*
Competence	No Lead	1723	3.12	1.23	
Intellectual Functioning	Lead	180	2.99	1.17	7.66**
	No Lead	1715	3.25	1.19	
Overall Classroom	Lead	181	3.18	1.30	6.60**
Behavior	No Lead	1719	3.44	1.29	

[1] Not all data sum to 2,165 because of missing data.
*p = .00; **p = .01.

Table 3.
Results of ANOVA of Social Skills Ratings Reported by Kindergarten Teachers on the SSRS[1]

Variable		*N*	*M*	*SD*	*F*	
Social Skills Standard	Lead	175	96.91	15.91	5.29	.02
Score	No Lead	1688	99.86	16.15		
Academic Competence	Lead	176	87.55	15.29	7.85	.01
Standard Score	No Lead	1690	91.00	15.57		
Cooperation Scale	Lead	176	13.49	4.71	7.20	.01
Score	No Lead	1691	14.48	4.62		
Assertion Scale Score	Lead	176	11.69	4.50	5.66	.02
	No Lead	1692	12.57	4.65		
Self-Control Scale	Lead	179	13.37	4.59	2.30	.13
Score	No Lead	1681	13.91	4.56		

[1] Not all data sum to 2,165 because of missing data.

Table 4. Family Ratings on the SSRS, Kindergarten to First Grade.

Scale	Time 1		Time 2		F_T p η^2	F_{TxG} p η^2	F_G p η^2
Family	*M*	*SD*	*M*	*SD*			
Cooperation							
LP	10.68	3.69	11.18	3.98	3.52	1.92	15.27
NLP	11.98	3.60	12.06	3.66	NS	NS	.00
					.00	.00	.01
Assertion							
LP	14.55	3.18	15.38	2.87	16.31	4.59	6.34
NLP	15.39	2.89	15.64	3.00	.00	.03	.01
					.01	.00	.00
Self-Control							
LP	10.45	3.21	10.67	3.20	2.78	.02	17.28
NLP	11.51	3.33	11.77	3.49	.10	.90	.00
					.00	.00	.01
Responsibility							
LP	11.10	3.35	12.19	3.07	50.87	.63	17.37
NLP	12.19	3.06	13.06	3.17	.00	.43	.00
					.03	.00	.01
Social Skills							
LP	85.49	15.07	89.63	15.21	25.44	1.97	15.95
NLP	91.33	15.15	93.67	16.30	.00	.16	.00
					.02	.00	.01

Time 1= Kindergarten, Time 2= First Grade, LP= Lead Poisoning, NLP= No Lead-Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher)

Table 5. Teacher Ratings on the SSRS, Kindergarten to First Grade.

Scale	Time 1		Time 2		F_T p η^2	F_{TxG} p η^2	F_G p η^2
Teacher	*M*	*SD*	*M*	*SD*			
Cooperation							
LP	13.70	4.68	12.64	5.48	14.19	1.13	8.46
NLP	14.56	4.54	13.97	4.94	.00	.29	.00
					.01	.00	.01
Assertion							
LP	11.63	4.52	11.71	4.37	.00	.15	5.14
NLP	12.49	4.67	12.39	4.43	.96	.70	.02
					.00	.00	.00
Self-Control							
LP	13.54	4.68	12.90	5.10	6.19	.22	2.33
NLP	13.99	4.55	13.55	4.66	.01	.64	.13
					.01	.00	.00
Social Skills							
LP	97.02	15.41	95.90	18.10	2.57	.05	3.99
NLP	99.72	16.10	98.24	16.56	.11	.83	.05
					.00	.00	.00
Academic Competence							
LP	89.36	15.14	89.32	16.09	.00	.00	.78
NLP	90.55	15.73	90.57	15.50	.99	.96	.38
					.00	.00	.00

Time 1= Kindergarten, Time 2= First Grade, LP= Lead Poisoning, NLP= No Lead-Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher)

Table 6. Family Ratings on the SSRS, Kindergarten to Second Grade.

	Time 1		Time 2		Time 3		F_T p η^2	F_{TxG} p η^2	F_G p η^2
	M	*SD*	*M*	*SD*	*M*	*SD*			
Cooperation							3.99	1.40	12.611
LP	10.58	3.70	11.23	4.02	11.25	3.88	.02	.02	.00
NLP	11.91	3.52	12.03	3.59	12.15	3.73	.01	.25	.01
Assertion							7.738	.54	7.46
LP	14.73	3.19	15.25	3.00	15.27	3.27	.00	.59	.01
NLP	15.41	2.89	15.70	2.97	15.98	2.93	.01	.00	.01
Responsibility							45.33	.08	16.88
LP	11.11	3.34	12.14	3.10	12.55	3.32	.00	.93	.00
NLP	12.12	3.01	13.08	3.15	13.59	3.15	.06	.00	.01
Self-Control							7.70	1.42	9.45
LP	10.39	3.24	10.78	3.30	11.31	3.32	.00	.24	.00
NLP	11.42	3.34	11.74	3.47	11.83	3.52	.01	.00	.01
Social Skills							22.23	.69	10.92
LP	85.77	15.00	89.94	15.51	91.37	17.25	.00	.50	.00
NLP	91.06	15.05	93.69	16.20	95.28	16.46	.03	.00	.01
Academic Competence							.57	1.04	.35
LP	88.77	14.84	89.56	16.52	90.64	15.13	.56	.35	.55
NLP	90.66	15.65	90.57	15.34	90.38	14.82	.00	.00	.00

Time 1= Kindergarten, Time 2 = First Grade, Time 3=Second Grade, LP= Lead Poisoning, NLP= no Lead Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher).

Table 7.
Results of ANOVA of Family Ratings of Children's Externalizing, Internalizing, Hyperactivity, and Problem Behaviors on the SSRS in Second Grade

Variable		*N*	*M*	*SD*	*F* *p*
Externalizing Behaviors	Lead	147	4.88	2.38	4.88
	No Lead	1383	4.38	2.64	.03
Internalizing Behaviors	Lead	147	4.22	2.29	.32
	No Lead	1387	4.10	2.36	.57
Hyperactivity	Lead	145	4.97	2.66	1.32
	No Lead	1385	4.70	2.68	.25
Problem Behaviors	Lead	145	104.91	14.35	1.98
	No Lead	1381	103.95	14.29	.16

[1] Not all analyses total to the number of children enrolled in the study. These missing data not completed by families or the child was lost to the study.

Table 8. Teacher Ratings on the SSRS, Kindergarten to Second Grade.

	Time 1		Time 2		Time 3		F_T p η^2	F_{TxG} p η^2	F_G p η^2
	M	*SD*	*M*	*SD*	*M*	*SD*			
Cooperation							3.51	.81	7.54
LP	13.44	4.73	12.83	5.43	13.20	5.01	.03	.44	.01
NLP	14.70	4.40	14.14	4.94	13.92	4.90	.01	.00	.01
Assertion							1.82	2.21	1.23
LP	11.71	4.58	11.74	4.48	12.62	4.51	.16	.11	.27
NLP	12.50	4.66	12.37	4.48	12.39	4.46	.00	.00	.00
Self-Control							1.87	.69	1.53
LP	13.44	4.56	12.87	5.21	13.31	4.87	.15	.50	.22
NLP	13.96	4.57	13.61	4.67	13.49	4.83	.00	.00	.00
Social Skills							.37	1.46	1.76
LP	96.73	15.71	96.57	18.49	98.05	17.44	.69	.23	.18
NLP	99.93	15.87	98.62	16.69	98.19	17.15	.00	.00	.00
Academic Competence							.57	1.04	.35
LP	88.77	14.84	89.56	16.53	90.64	15.13	.56	.35	.55
NLP	90.66	15.65	90.57	15.34	90.38	14.82	.00	.00	.00

Time 1= Kindergarten, Time 2= First Grade, Time 3=Second Grade, LP= Lead Poisoning, NLP= No Lead-Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher)

Table 9

Results of ANOVA of Teacher Ratings of Children's Externalizing, Internalizing, Hyperactivity, and Problems Behaviors on the SSRS in Second Grade

Variable		*N*	*M*	*SD*	*F* *p*
Externalizing Behaviors	Lead	130	4.03	3.67	3.09
	No Lead	1169	3.46	3.48	.08
Internalizing Behaviors	Lead	129	3.78	2.94	.65
	No Lead	1165	3.56	2.79	.42
Hyperactivity	Lead	128	5.12	3.77	2.12
	No Lead	1165	4.63	3.55	.15
Problem Behaviors	Lead	127	108.35	16.67	1.91
	No Lead	1137	106.32	15.63	.17

[1] Not all analyses total to the number of children enrolled in the study. These missing data not completed by teachers or the child was lost to the study.

Table 10. Family Ratings on the SSRS, Kindergarten to Third Grade.

	Time 1		Time 2		Time 3		Time 4		F_T p η^2	F_{TxG} p η^2	F_G p η^2
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cooperation									5.27	3.75	7.98
LP	10.43	3.69	11.20	3.96	11.35	3.88	11.78	3.76	.00	.01	.01
NLP	11.90	3.51	12.04	3.61	12.16	3.70	11.98	5.60	.01	.01	.01
Assertion									6.35	.59	8.28
LP	14.62	3.19	15.17	2.92	15.20	3.26	15.43	3.24	.00	.62	.00
NLP	15.44	2.91	15.71	2.97	15.99	2.97	15.97	2.91	.02	.00	.01
Responsibility									60.87	2.09	17.09
LP	10.84	3.31	12.05	3.20	12.41	3.20	13.43	3.09	.00	.10	.00
NLP	12.09	2.99	13.13	3.14	13.62	3.17	13.99	2.99	.14	.01	.02
Self-Control									9.82	1.85	8.98
LP	10.09	3.16	10.72	3.35	11.17	3.30	11.46	3.58	.00	.14	.00
NLP	11.38	3.34	11.74	3.50	11.78	3.51	11.97	3.54	.03	.01	.01
Social Skills	84.13	14.12	89.35	15.49	91.08	16.79	93.58	17.39	26.62	2.63	9.78
LP	90.81	15.05	93.65	16.22	95.16	16.49	95.64	15.99	.00	.05	.00
NLP									.05	.01	.01

Time 1= Kindergarten, Time 2= First Grade, Time 3=Second Grade, Time 4=Third Grade LP= Lead Poisoning, NLP= No Lead-Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher)

Table 11
Results of ANOVA of Family Ratings of Children's Externalizing, Internalizing,
Results of ANOVA of Family Ratings of Children's Externalizing, Internalizing, Hyperactivity, and Problems Behaviors on the SSRS[1] in Third Grade

Variable		*N*	*M*	*SD*	*F* *P*
Externalizing Behaviors	Lead	139	4.37	2.52	.62
	No Lead	1331	4.18	2.62	.43
Internalizing Behaviors	Lead	139	4.10	2.35	.14
	No Lead	1338	4.02	2.31	.71
Hyperactivity	Lead	139	4.52	2.64	4.42
	No Lead	1331	5.02	2.68	.04
Problem Behaviors	Lead	138	103.54	13.90	1.28
	No Lead	1323	102.11	14.20	.26

[1] Not all analyses total to the number of children enrolled in the study. These missing data not completed by families or the child was lost to the study.

Table 12. Teacher Ratings on the SSRS, Kindergarten to Third Grade.

	Time 1		Time 2		Time 3		Time 4		F_T *p* η^2	F_{TxG} *p* η^2	F_G *p* η^2
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*			
Cooperation									2.65	.26	5.62
LP	13.48	4.86	13.07	5.43	13.16	5.17	12.91	4.72	.05	.85	.02
NLP	14.66	4.44	14.25	4.89	14.03	4.86	13.69	4.99	.85	.00	.01
Assertion									1.60	.83	.26
LP	11.92	4.30	11.98	4.39	12.71	4.56	11.85	4.47	.19	.48	.61
NLP	12.41	4.61	12.38	4.52	12.38	4.52	12.05	4.38	.01	.00	.00
Self-Control									1.80	.31	.38
LP	13.64	4.60	13.30	5.40	13.57	4.93	12.96	5.07	.15	.82	.54
NLP	13.93	4.63	13.67	4.66	13.54	4.88	13.37	4.86	.01	.01	.00
Social Skills									1.54	.66	.83
LP	96.82	15.66	97.60	18.98	98.45	17.82	95.98	15.47	.20	.58	.36
NLP	99.54	16.02	98.82	16.86	98.42	17.34	97.31	17.00	.01	.00	.00
Academic Competence									1.32	.93	.24
LP	88.96	14.43	89.51	15.78	91.00	14.98	88.47	13.35	.27	.43	.62
NLP	90.16	15.49	90.37	15.46	90.38	14.93	90.17	15.35	.01	.00	.00

Time 1= Kindergarten, Time 2= First Grade, Time 3=Second Grade, Time 4=Third Grade LP= Lead Poisoning, NLP= No Lead-Poisoning, η^2 values: small effect (.01-.05), medium (.06-.14), large effect (.15 and higher)

Table 13
Results of ANOVA of Teacher Ratings of Children's Externalizing, Internalizing, Hyperactivity, and Problems Behaviors on the SSRS[1] in Third Grade

Variable		*N*	*M*	*SD*	*F* *P*
Externalizing Behaviors	Lead	125	3.65	3.66	.26
	No Lead	1084	3.48	3.45	.61
Internalizing Behaviors	Lead	123	3.73	2.76	.31
	No Lead	1084	3.59	2.68	.58
Hyperactivity	Lead	123	4.77	3.62	.83
	No Lead	1085	4.47	3.50	.36
Problem Behaviors	Lead	121	107.30	15.66	.56
	No Lead	1061	106.20	15.27	.46

[1] Not all analyses total to the number of children enrolled in the study. These missing data not completed by families or the child