5-2009

An Evaluation of plastic toys for lead contamination in day care centers in the Las Vegas valley

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AN EVALUATION OF PLASTIC TOYS FOR LEAD CONTAMINATION IN DAY CARE CENTERS IN THE LAS VEGAS VALLEY

by

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Bachelor of Science
University of Bakersfield California
1986

A thesis submitted in partial fulfillment
of the requirements for the

Master of Public Health Degree
Department of Environmental and Occupational Health
School of Community Health Sciences
Division of Health Sciences

Graduate College
University of Nevada, Las Vegas
May 2009

Thesis Approval
The Graduate College
University of Nevada, Las Vegas

March 6, 2009

The Thesis prepared by

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Entitled

AN EVALUATION OF PLASTIC TOYS FOR LEAD CONTAMINATION IN DAY CARE CENTERS IN THE LAS VEGAS VALLEY

is approved in partial fulfillment of the requirements for the degree of

Master of Public Health

[redacted]

Examination Committee Chair

[redacted]

Dean of the Graduate College

[redacted]

Examination Committee Member

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Examination Committee Member

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Graduate College Faculty Representative

1017-53

ABSTRACT

An Evaluation of Plastic Toys for Lead Contamination in Day Care Center in the Las Vegas Valley

by

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The harmful effect of childhood exposure to environmental lead continues to be a major health concern. This study examined lead contamination within the plastic of children's toys. It was also hypothesized that the use of lead as a stabilizer would result in higher incidents of elevated lead ($\geq$ 600 ppm) in polyvinyl chloride plastics (PVC) than non-PVC plastics. It was also hypothesized that, due to the use lead chromate, yellow toys would have higher incidents of elevated lead ($\geq$ 600 ppm) than toys of other colors. Toy samples were limited to those found in day care centers in Las Vegas, Nevada. Ten day care centers were visited and approximately 50 toy samples were taken from each center. Of the 535 toys tested, 29 contained lead in excess of 600 parts per million (ppm). Of those 29, 20 were PVC and 17 were yellow. Both of the two hypotheses were strongly supported by the data. In addition to examining lead contamination, the presence of other heavy metals was observed. It was found that when lead was elevated, there was a high probability ($P = 0.72$) of the presence of elevated concentrations ($\geq$ 100 ppm) of

the other heavy metals cadmium, arsenic and chromium. To better understand childhood exposure risks from lead and other heavy metals additional research is needed.

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ACKNOWLEDGEMENTS

The effort of researching and writing a work such as a thesis is collaborative. I wish to thank all those that provided their support and assistance. Principally, I'd like to thank Dr. Shawn Gerstenberger. As chair of my thesis committee, he greatly assisted in the development of my thesis topic, protocols and methodology. He also generously provided financial support for the training and certifications needed, such as EPA Risk Assessor and XRF Certification. His assistance was also invaluable in the completion of legal matters, including IRB Review, CITI Certification, and non-liability agreements. I'd also like to thank my committee member, Dr. Linda Stetzenbach. It was under her tutelage that my knowledge and skills for writing a professional paper were enhanced. In this area her skills are unequaled. It will take years of practice to implement all that I've learned from her. I'd like to thank Dr. Chad Cross, the statistician of my committee. I greatly appreciate his patience as he explained the statistics needed for my thesis. It would have been impossible for me to move forward without his assistance. Dr. Ronald Smith, my fourth committee member, was my outside advocate. In addition to being a voice of support, he is also a long time friend and role model, and someone I've appreciated and admired for years.

In addition to my committee members, there are a few more individuals I wish to acknowledge. First, I'd like to thank Mark Bergtholdt and Karla Shoup of the Southern Nevada Health District. Without their assistance, this project would not have been possible. It was through their efforts that I received the day care center volunteers. Next, there is Laura Stupi of Thermo Fisher. She and other members of this company trained me on the use of different models Niton XRFs. They also freely and generously lent multiple XRFs to the UNLV laboratory of Environmental Studies. It was one of these XRFs that I used to sample the toys within day care centers. I'd like to thank Ashley Phipps; a friend and companion master's student. She is expert in the use of laboratory equipment. Without her help with the XRF, Microwave Digester and Graphite Furnace, there would have been gaping holes in my research. I'll always appreciate the time she gave me from her busy schedule. I'd also like to thank Dave Broderson who provided hours from his busy schedule to discuss statistical procedures, and edit drafts of my thesis. His generosity was above and beyond expectations. Finally, I'd like to thank my friends and family who each provided support in their own way; from editing versions of my thesis, to words of encouragement, they were always ready to provide assistance.

CHAPTER 1

INTRODUCTION

Lead is a neurotoxin and carcinogen. It can damage the nervous system, reproductive organs, cardiovascular system, liver, immune system and the kidneys (Gidlow, 2004). Some of the harmful health effects of lead are cumulative and irreversible (Needleman et al., 1991). Despite its potential for harm, lead has enough desirable properties that it has been sought and used throughout history. This use has often placed a burden on the global environment. Most of the lead found in soil and dust is a result of human activity. Lead is considered one of the first anthropogenic environmental pollutants (Aberg et al., 1999). Two significant sources of the lead in dust and soil in this country originated in lead-based paint and leaded gasoline (Mielke et al., 1998a). Exposure to lead comes with a financial cost as well as a cost to health.

The federal standard for childhood lead poisoning is 10 micrograms per deciliter (μg/dL) (ATSDR, 2007a, 2007b). In 2002 a low estimate for U.S. health care costs for childhood lead poisoning was 43.4 billion dollars; more than 2% of all U.S. health care costs (Landrigan et al., 2002). Within the years 1997-2006, the number of children with elevated blood lead levels (> 10 μg/dL) reported to the Centers for Disease Control and Prevention (CDC) was 763,306. This number under represents of the actual burden because not all states reported, and not all eligible children were tested (CDC, 2007).

Although lead exposure poses a risk to humans in general (Shilu Tong et al., 2000), children are at greater risk (Fels et al., 1998; Markowitz et al., 2000). A child can absorb up to 50% of lead that enters the body (Wisconsin, 2000) in comparison to an adult's 5-10% (Mahaffey, 1977). A child's metabolic rate is higher than that of an adult's rate. This includes a rapid respiration, which in turn increases exposure to any air pollutant (Bearer, 1994). A crawling infant may disturb soil or dust that is contaminated with lead. This lead may enter the body through respiration or ingestion when a dust-covered hand is placed into the mouth (Mielke et al., 1998b).

The dangers of exposure to lead were widely known at the turn of the twentieth century, but it was not until recent decades that U.S. regulations reflected these dangers (Needleman, 1992b). In consideration of the severe threats to health caused by lead exposure, and after many decades of delay, lead-based paint in the United States with a lead content in excess of 600 ppm was banned for use in products marketed to children (USCPSC, 1996, 2001). As more children's products, especially toys containing lead-based paints and plastic are imported from countries that do not follow the same standards as the US, the effect of this ban diminished and the need for additional regulations was needed. On August 14, 2008, *H.R. 4040: Consumer Product Improvement Act of 2008* was signed by President George W. Bush. This act expanded protection to children by defining any children's product that contained more lead than the limit established by the act (600 ppm), as a banned hazardous substance. This study will focus on lead contaminated toys in day care centers, but to fully appreciate the hazards that lead poses to human and environmental health it is valuable to know the historical use of lead and its contamination of the global ecology. The following literature review first discusses the effects of lead on health. This is followed by the history of the use and misuse of lead. Due to its extreme persistence in the environment, and the role humans have played in the accumulation of that lead, the discussion begins with ancient history and ends in the modern era. In the discussion concerning the present day, the two greatest sources of environmental lead are mentioned – lead based paint and leaded gasoline. The literature review closes with information on toys and day care centers.

CHAPTER 2

REVIEW OF RELATED LITERATURE

The Effects of Lead on Human Health

Lead is highly toxic to humans. It is presently recognized “as the single most significant environmental health threat to American children” (Mott, 1997). It can enter the body through ingestion, inhalation of lead containing dust, and under some circumstances, through the skin. Once in the body, it can enter and affect any cell type (Markowitz, 2000). Of particular concern is exposure to the nervous system. Lead can pass through the blood brain barrier and cause damage to the central nervous system. The symptoms are decreased cognitive performance in both learning and memory (Stewart et al., 2007). Children are of greatest vulnerability (Finkelstein et al., 1998). Lead exposure can create impairments in growth and development physically, mentally and emotionally. Lead exposure can cause anemia, kidney damage, hypertension, immune system damage, behavioral changes, it can also be a cofactor in cancer (Goyer, 1990). Recent research suggests that there may be no safe minimum lead blood level (Stringer et al., 2001).

Over the last few decades the maximum acceptable concentration of blood lead has been a moving target. Prior to 1970, the CDC defined this maximum as 60μg/dL. In 1985 the concentration was lowered to 30μg/dL. In 1991 it was dropped even further to 25μg/dL. Today the standard is set at 10μg/dL. Many medical experts believe that even this is too high and should be lowered to 5μg/dL (ATSDR, 2007b).

Cognition

Lead is a neurotoxin (Gidlow, 2004). The American Academy of Pediatrics estimates that 25% of children with lead poisoning will have permanent brain damage, and 82% will suffer recurrent seizures and mental retardation (Damstra, 1977). In a 2007 Michigan study, blood samples were taken from 7-year old children (n=506). These samples were tested for lead with a graphite furnace atomic absorption spectrometer. Using regression analysis to control for prenatal drug use, alcohol, tobacco and other potential confounding factors, the researchers identified a negative relationship between blood lead concentration and IQ. There was an inverse correlation between blood lead concentration and skills in math, reading, verbal and response times. There was an increase in hyperactivity, behavioral problems, and poor attention (Chiodo et al., 2007). In that same year, research carried out at the National Institute of Health with 780 children as study participants, found similar results (Chen et al., 2007).

The question arises, "What are the long term effects of lead toxicity?" During the period 2000-2006, 1140 randomly chosen Baltimore residents, aged between 50 and 70, participated in a study on the long term effects of lead exposure. Over the seven year study period, each participant was given a battery of cognitive tests. They were each tested three times with an average of 14 months between visits. During these visits lead concentrations were tested in both their tibia and blood. The results indicated that not only were the effects of lead toxicity persistent, they were possibly progressive (Stewart et al., 2007).

Immune System

Lead is a developmental immunotoxicant. One of its prominent effects is to weaken the immune system by shifting the body's balance of type 1 T-helper cell responses to type 2 T-helper cell responses. This change compromises the immune system function causing the individual to be more vulnerable to various diseases (Dietert et al., 2004).

Kidneys

In Katowice, Poland in 1995, a research team attempted to establish the effects of lead on kidney function. Sixty-two children living in proximity of lead-producing factories, and 50 children with no known exposure to lead were selected for the study. The exposed children's blood lead levels averaged 13.3 ± 6.2 ug/dL and the control group children averaged 3.3 ± 1.3 ug/dL. The exposed group was found to have an abnormally high frequency of glomerular damage as well as decreased distal tubular function (Fels et al., 1998).

Reproduction

Lead is known to cause adverse affects in human reproduction. In the male it can damage sperm numbers, motility, chromosomes, and functionality resulting in infertility. It can also cause prostate damage and impotence (Baranski, 1993). Some of the adverse affects in the female are infertility, miscarriage, hypertension and premature delivery (Winder, 1993).

The History of Lead Use

Lead is a heavy, gray metal. It is easily malleable, resists corrosion, is easy to mine, has a low melting point and combines well with other metals to make alloys (Bray, 1979). In part, because of these useful properties, lead has been widely used throughout recorded history. Many of these uses have proved detrimental to human and environmental health. Analysis of Iceland ice cores show signs of atmospheric lead pollution that date back earlier than 2000 B.C. (Renberg et al., 2000). There was a peak during the Greek-Roman period around 0 A.D. and another that began at the time of the European industrial revolution (Renberg et al., 2000). Lead pollution found in some soils of Europe is more than 1000 times higher than natural levels (Renberg et al., 2000).

Archeological digs and historical records provide information on uses of lead in ancient societies. Lead was used as both an eye salve and cosmetic in Egypt as far back as 6000 years ago (Needleman, 1992a). A 1981 article in the American Journal of Archeology examines the extensive use of lead pipes in the Roman aqueducts. It was so customary for Roman pipe makers to use lead that they were known as "lead men" or "plombiers", from which we derive the word plumber (Hodge, 1981). Not only did they use lead pipes to transport their water, it was also used in dishes and cooking utensils. The ancient Romans brewed grape juice syrup in lead pots. This syrup was used to sweeten foods and wine. During the brewing process, such a high quantity of lead leached into the liquid that one teaspoonful was more than sufficient to cause chronic lead poisoning (Nadakavukaren, 2006). The use of lead was so extensive that the fall of the Roman Empire can be linked to lead poisoning (Volesky, 1990).

After the fall of the Roman Empire a decline in the mining, smelting and use of lead lasted for hundreds of years. Between the years 1000-1200 A.D. there was a surge in mining and metallurgy. Swedish peat core samples show a spike in atmospheric lead during this period (Bränvall et al., 2001). The Black Death again brought a decline in lead mining that lasted until the 15^{th} century (Bränvall et al., 2001). Resulting from advances in mining and metallurgy, there was a steady rise in lead production and pollution beginning in the sixteenth century and peaking at the beginning of the nineteenth century. The end goal of much of the mining was the extraction of the precious metal silver. Lead was considered a nuisance and as much as possible was converted into smoke (Nriagu, 1998).

Lead poisoning was a major cause of morbidity and mortality during the industrial revolution (Gidlow, 2004). The development of firearms at the end of the fifteenth century spurred mining industries in search of iron, copper and lead. As mining operations expanded, so did the health ailments of miners. In 1473 a German physician, Ulrich Ellenbog wrote a treatise, *On the Poisonous Wicked Fumes and Smokes,* in which he discussed toxicity from heavy metal fumes. Over the next few centuries, numerous articles and books were published throughout the European countries. They addressed "lung sickness" and other diseases experienced by miners, caused by heavy metal toxicity (Abrams, 2001).

The harmful effects of lead on human health have been known for thousands of years (Hodge, 1981; Volesky, 1990) yet during that same period the burden of lead pollution on the global environment has increased by millions of tons (Nriagu, 1990). Apparently, knowledge isn't always followed by wisdom. Modern uses of lead continue to pollute the environment and put humans in danger of exposure. The sources of exposure span the spectrum from an inadvertent breath of dust contaminated with lead from aging paint or leaded gasoline to the direct, purposeful ingestion of lead as an herbal remedy. Lead can be found in lead glazed pottery, lead shot, lead sinkers, cosmetics, children's jewelry and even candy. There are many sources of lead in modern society, three will be discussed here: leaded gasoline, lead-based paint and lead contaminated toys.

Leaded Gasoline

Tetraethyl lead (TEL) has been used in gas as an octane booster since the early 1920s (Gibbs, 1997). In May of 1925 there was public outcry about the outbreak of severe lead poisoning in occupational workers of the TEL industry. The use of lead additives in gasoline was temporarily halted. The U.S. Surgeon General appointed an expert panel to make a public statement on the safety of the use of lead additives. In June of 1926, after worker protection practices had been instituted, the ban was lifted (Nriagu, 1990).

Prior to the use of TEL, other gasoline additives were studied. During the early 1920s numerous chemicals were investigated for antiknock properties. One of these chemicals was an ethanol-gasoline mixture named synthol. Due to ethanol's high octane rating, this mixture was found to have similar antiknock properties as TEL. Research was discontinued in 1925 when it was discovered that synthol would increase gas mileage, thus decreasing dependency on petroleum products. TEL did not increase gas mileage so was used as the additive of choice (Nadim et al., 2001). For the next 70 years, TEL entered the atmosphere through its use in automobiles. At its peak, leaded gas was the source of 200,000 tons of annual atmospheric lead pollution in the United States (USEPA, 1996). The atmospheric lead falls as a dust and accumulates in the soil (Mielke, 1994). Between 1926 and 1985 it is estimated that the use of leaded gasoline added a cumulative 7 million tons of lead residue into the atmosphere (Nriagu, 1990). The US EPA considers these residues and those of lead-based paint, to be the primary source of blood lead levels in children (Mielke et al., 1998a). According to a 1991

National Health And Nutrition Examination Survey (NHANES), 8.9% of American children ages 1-5 have blood lead levels in excess of 10 μg/dL (Brody et al., 1994).

Lead-Based Paint

In 1892, Turner and Lockhart of the Children's Hospital of Brisbane, Australia, examined a dozen children with chronic lead poisoning. By 1897 another 76 cases were studied. The source of the lead exposure remained a mystery for almost 12 years. In 1904 Gibson published, "A Plea for Painted Railings and Painted Walls of Rooms as the Source of Lead Poisoning". In this paper he suggested that lead paint was the source exposure, but he was ridiculed in the scientific community. It wasn't until 1920, after hundreds of children had been diagnosed and treated for lead poisoning that the Australian Medical Congress passed legislation banning the use of leaded paint. Subsequently, numerous papers were published on the subject. However, the legislation and papers were viewed with indifference in the United States (Needleman, 1992b). The U.S. Department of Health and Human Services acknowledged the findings, but legislation was still decades away (Rabin, 1989). By the early 1920s it was widely recognized that severe lead poisoning had become common in children. In the 1930s lead-based paint in the homes was identified as the source (Rabin, 1989). By the late 1950s over 6,000 cases of lead-based paint poisoning had been reported in Baltimore, Boston, New York and Chicago. In 1970 childhood cases were estimated at 12,000-16,000, with 200 deaths and up to 50%, of the those that did not die, were left mentally retarded (Jacobs, 1995). If those examinations had been based on today's blood lead level standards, incident frequency would have been tabulated much higher, as the federal standard definition for lead poisoning until the 1950s was a blood lead level of 80ug/dL in comparison to 10ug/dL today (Packard, 2004).

Evidence mounted that lead based paint posed a hazard to human health, especially that of children. Many countries acted and either banned or placed severe restrictions on the production and use of leaded paint. In the United States, The Lead Industries Association (LIA), a trade group representing lead pigment manufacturers, spent enormous resources to counteract information on the dangers of lead-based paint to children (Markowitz et al., 2000). They created an aggressive marketing campaign, using images of children in their advertisements, to convince especially the public health community, hospitals, and schools to use lead-based paint wherever children reside (Markowitz et al., 2000). The campaign was very successful and 50 years passed before lead-based indoor paint was banned in the United States in 1971. In 1978 the CPSC extended this ban to include lead-based paint in all consumer products (Freudenberg et al., 1987).

It has been 30 years since the banning of lead-based paint in this country, but the danger of exposure continues. First, as the paint ages, leaded particles of dust enter the air and settle into the soil. Second, an increasing percentage of consumer products are imported, especially toys (Schmidt, 2008) and not all countries abide by the same standards as the United States. Imported toys, at times, contain lead-based paint and plastics (Gregory et al., November 18, 2007; Schmidt, 2008).

Toys

In 1972 the United States Congress passed the Consumer Protection Safety Act. As part of this act, the CPSC was created. The purpose of this commission is to protect consumers from hazardous products (Congress, 1972). For the last three decades the CPSC has examined consumer products, banned certain unsafe practices and recalled hazardous items (USCPSC, 1996). Not all countries follow the same strict consumer product standards as the United States. Throughout 2007 a number of reports on tainted imports were reported in the news. *USA Today* provided information on pet food, imported from China, tainted with melamine, a toxic substance that causes kidney failure (Manning et al., February 18, 2007). *The New York Times* reported on toothpaste containing diethylene glycol (Bogdanich, June 2, 2007). These and other similar reports created a public outcry. The safety of consumer products, especially those marketed to children, were given greater scrutiny (Schmidt, 2008).

In recent years, the percentage of toy imports has been increasing. As of December 2007, 87% of toys sold in this country were imported; 74% of these were imported from China (Schmidt, 2008). The increase in the percentage of toys imported into this country reverses some of the progress made toward childhood safety, especially from lead contamination. A recent deluge of recalls of consumer lead contaminated toys has brought the dangers of lead pollution into the public eye. On December 5, 2007 a Michigan based Ecology Center submitted a press release. This release published the results of 1,268 popular toys tested for heavy metals. They found 35% to contain high concentrations of lead. Dollar store animal figurines tested at 6,700 ppm. A Hannah Montana Pop Star Card pack tested at 3,056 ppm and Circo baby shoes contained 1,700 ppm lead (Shriberg, 2007). Anything above 600 ppm is considered a hazard and will evoke a recall (USCPSC, 2001).

In a 2006 study at the University of Ashland, Ohio 139 items of imported children's toy jewelry were tested for lead. Almost half of the items were heavily leaded, some as high as 80% by weight. Sixty percent of the samples tested for leachability exceeded CPSC guidelines for accessible lead (Weidenhamer et al., 2007). In 2003, 150 million pieces of inexpensive toy jewelry were recalled. The jewelry was sold nationwide in vending machines found in shopping malls and grocery stores. Approximately 50% of the items tested contained dangerous concentrations of lead (Sheth et al., 2004). Table 1, shown below, provides a few examples of recalled toys.

Table1. A sample list of toys recalled in 2007, by the CPSC, due to high concentrations of lead (USCPSC, 2008b).

Manufacturer	N	Description	Substrate	Origin
Amscan Inc.	43,000	Ugly Teeth	Paint	China
Family Dollar Store	142,000	Halloween Pails	Paint	China
Jo-Ann Craft Stores	97,000	Toy Gardening Tools	Paint	China
Fischer Price	38,000	Diego Toy Boat	Paint	China
Dollar Tree Stores	198,000	Children's Jewelry	Metal	China
WeGlow Intl.	110,000	Children's Jewelry	Metal	China

Based on recall counts compiled by the CPSC, the number of lead contaminated toys recalled in 2007 was in the millions. There were a total of one hundred and twelve recalls, due to lead hazard, during that year. In December alone, this amounted to 977,860 individual toys recalled (USCPSC, 2008b). Most of the lead contaminated toys entering this country are imported from China (Weidenhamer et al., 2007). Note the first item in Table 1, "Ugly Teeth". These are meant to be put into a child's mouth. However, they contain high concentrations of lead in the paint.

Upon learning that millions of toys were recalled due to lead contamination, the question arises, “Why is lead being used in the production of toys?” Lead and other heavy metals are used as a stabilizer and softener in plastics (Kruszewska, 1996). Pigments containing heavy metals are often used in plastics to increase the vibrancy of colors (Lardinois et al., 1995). Lead is most frequently used in yellow and red pigments (Gregory et al., November 18, 2007). Lead chromates are used for pigments that range from greenish-yellow to yellowish-red. The mid-shade yellows are pure lead chromate (Robert, 1994). In a Connecticut study, polyethylene bags, used to wrap bread, candy and other food products, were cut into pieces based on color of pigment. The highest concentrations of lead were found on bags with yellow and orange as the predominant colors. Lead concentrations were found as high as 23,000 ppm (Hankin et al., 1974).

Day Care Centers

In a 1995 study by the Department of Pediatrics at the University of Iowa, 6 day care centers were examined for risk factors to lead exposure. Elevated concentrations of lead ($\geq 1 \mu g/cm^2$) were found in the wall paint of all the centers. Windowsill dust contained as high as 18 $\mu g/cm^2$ lead and soil as much as 1,100 μg/kg lead (Weismann et al., 1995). The source of lead in the windowsill dust may have been from window miniblinds. In 1996 the CPSC concluded that imported miniblinds from China, Taiwan, Mexico and Indonesia presented a lead poisoning hazard to children. As the blinds age, lead leaches from the vinyl and deposits as dust on the surface (Juberg et al., 1997). The presence of miniblinds is ubiquitous in day care centers. They present a risk, but more research is needed to quantify that risk (Gilbert-Barness et al., 1998; West, 1998).

A void exists in the knowledge base of child safety in day care centers, regarding lead exposure from plastic toys. Although articles were found on childhood lead exposure in day cares for paint, dust, soil, and miniblinds (Bradman et al., 2001; Viverette et al., 1996; West, 1998), after extensive searches in peer reviewed journals, to date not a single article was found on lead contaminated toys in day care centers. Articles were found on lead within toys and childhood exposure (Schmidt, 2008; Shriberg, 2007; Weidenhamer et al., 2007), but none mentioned day care center toys. Publications are lacking for the two topics combined (i.e., lead content in toys within day care centers). The research from this thesis will assist in filling the existing gap.

CHAPTER 3

QUESTIONS, OBJECTIVES, AND HYPOTHESES

Questions

• Will toys with elevated lead (≥ 600 ppm) be found in day care centers?

• Are there visual cues that can assist day care center personnel in the identification of lead contamination within toys?

• Is the type of plastic from which the toy is produced associated with elevated lead (≥ 600 ppm)?

• Is the color of plastic from which the toy is produced associated with elevated lead (≥ 600 ppm)?

• When elevated lead (≥ 600 ppm) is found, does the lead reside in the surface dust in addition to the substrate?

Objectives

• Identify toys, in day care centers, that contain elevated lead (≥ 600 ppm).

• Identify the toy substrate Polyvinyl Chloride (PVC) versus non-PVC with the higher frequency of toys with elevated lead (≥ 600 ppm).

• Test for a relationship between toy color and frequency of toys with elevated lead (≥ 600 ppm).

Hypotheses

Hypothesis One: Frequency of elevated lead ($\geq$ 600 ppm) content: PVC versus non-PVC plastics.

Lead is used to stabilize PVC plastic products (Kruszewska, 1996). Little information is publicly available on lead content in non-PVC plastic, but what little information is available raised the expectation that non-PVC plastic rarely contains lead.

- Ho: High lead concentrations ($\geq$ 600 ppm) will be found with equal frequency in PVC and non-PVC plastics of toys tested in day care centers.

- Ha: High lead concentrations ($\geq$ 600 ppm) will be found at greater frequency in PVC versus non-PVC plastics of toys tested in day care centers.

Hypothesis Two: Frequency of elevated lead ($\geq$ 600 ppm) content by color of plastic toy.

The yellow pigment, lead chromate is used in plastics to increase the vibrancy of colors (Lardinois et al., 1995). Recent research has found that yellow plastics more frequently contain high concentrations of lead than other colors (Gregory et al., November 18, 2007; Hankin et al., 1974). This thesis research was designed to confirm these findings, and determine if they apply to plastic toys.

- Ho: High concentrations of lead ($\geq$ 600 ppm) will be found in equal frequency between yellow plastic toys and plastic toys of other colors.

- Ha: High concentrations of lead ($\geq$ 600 ppm) will be found with greater frequency in yellow plastic toys than in plastic toys of other colors.

CHAPTER 4

METHODOLOGY AND DATA DESCRIPTION

Data Collection

Prior to any collection of data, or testing for lead within toys, information on sample sizes and toy availability was needed. A power analysis could not be performed to determine the best sample size. To perform a power analysis, random sampling is needed. There are 569 licensed day care centers in the Las Vegas valley. A random selection of these centers would have been preferable, but was not possible. The selection of toys and day care centers was opportunistic. Though more than 200 day care centers were asked to participate in this project, it was difficult to acquire the needed volunteers.

To determine what comprised a representative sample of toys, prior to sampling, two day care centers were visited. A visual assessment was made of the type, quantity, and color of toys present. At both day care centers, almost all plastic toys resided within plastic bins, with each bin containing a single toy type. For the purpose of this study, toys were grouped into four categories. The first category included simple repetitive shapes. These shapes included link blocks, animal shapes, alphabetic and numeric shapes, and various geometric shapes such as cubes, rectangles, and pyramids. The majority of these toys were colored yellow, blue, green, and red. The second toy category consisted of realistic animals. The toy animals included cows, horses, lions, and other animals typically found on a farm or in the zoo. Dinosaurs were included within the animal group.

The colors were mostly brown, gray and green. A third category consisted of plastic food. Fruits, vegetables, bread, pizza, fried eggs and hamburgers were included in this category. The fourth category was defined as miscellaneous. This category included plastic cars, planes, dolls, and dishes.

These preliminary day care center visits were authorized and accompanied by a staff member of the Southern Nevada Health District. The staff person stated that the toys were representative of all day care centers within the valley. Time constraints did not permit a count of all the toys, nor would a count have been valuable for this experiment. Although the toys were typical, the size of day care centers varied. For this reason, sampling was based on a visual assessment of the toys in each day care center. Ten to 15 toys were tested from each of the four toy categories. A minimum of 50 toys were tested at each center.

To avoid skewing the results of this study, selection of toys at each day care center, were made prior to testing. Under no instance was a particular toy type over or under sampled based on lead content. Lead concentrations were measured with a portable x-ray fluorescence (XRF) device (Niton Thermo Fisher, Billerica, MA; model XLt 797 2W). The toys were tested in Bulk Plastic mode for the duration of 10 seconds. The Niton XRF manual recommends testing for the duration of 60 seconds. To determine if the 10 second duration was sufficient, the plastic lead standard (1000 ppm) for XRF calibration was used. Lead concentration, within the standard, was measured 10 times, each for the duration of 10 seconds. An ANOVA was performed on the means of the sample errors. The means did not significantly differ ($p = 0.357$), and were within the bounds suggested by Niton (±10%). This research examined three broad categories of lead concentration: 1) non-detectable (< 10 ppm), 2) moderate (10-599 ppm) and 3) elevated (≥ 600 ppm). The 10 second duration XRF test time may not be appropriate for experiments that require different conditions.

To maintain a visual link between XRF results and the toy, every tested toy was identified and photographed. The identification contains a code number for the day care, the accession number of the XRF test, the toy color, and a brief description of the toy. This information is included in the compiled data. If a toy was found to exceed the CPSC guidelines for lead (≥ 600 ppm; USCPSC, 2008), the area of the toy that had been tested by the XRF was wiped of surface dust (10 passes of a 15cm x 15cm Ghostwipe; Environmental Express, Mt. Pleasant, SC). The same area of the toy was retested with the XRF to determine if the lead had been within the dust or the plastic. If the lead concentration remained above 600 ppm, the toy was placed into a plastic bag and removed from the day care center for future disposal, or additional testing. Toys with elevated lead were found in seven day care centers. After all the XRF data from all 10 day care centers were gathered, one toy with elevated lead (≥ 600 ppm) was removed from each day care center for additional testing. The seven toys were individually, and thoroughly, swabbed of surface dust with a Ghostwipe. The toys were of various sizes and shapes, therefore no set number of wipes could be performed on each of the toys. This did not compromise the value of this step of the experiment as only the presence or absence of lead was examined. Each of the wipes was placed into an individual plastic cylinder and covered with 10mL of nitric acid (pH = 0.17). This was followed by microwave digestion (PerkinElmer, Multiwave 3000; Shelton, CT). The microwave cycle was five minutes warm up, eight minutes at peak heat and 90 minutes cool down. After the completion of the microwave cycle, 100μL of the resulting effluent was pipetted into a sterile vial. This was diluted with 50mL of de-ionized water. A portion of each of the 10 diluted samples, one from each toy, was placed into a graphite furnace (PerkinElmer, AAnalyst600; Shelton, CT) and measured for lead concentration by atomic absorption spectroscopy. Of the seven samples, three contained a detectable concentration of lead (≥ 0.3 ppb). To determine if the lead originated from the toy substrate, or was contaminated from a lead source within the day care, a follow-up experiment was performed.

To perform this follow-up experiment, it was necessary to acquire certain information - toys with non-detectable lead (< 10 ppm), and similar toys from the same facility with elevated lead (≥ 600 ppm). A measurement of the toy surface areas was needed, so an easily measurable shape was preferable. Toys of a rectangular shape were chosen. Toys from one day care center met these conditions. At the day care center of interest, there were medium sized linking blocks with non-detectable (< 10 ppm) and elevated lead (≥ 600 ppm). Prior to the visit, two US EPA certified lead inspectors performed a risk assessment of the facility. All tests of paint, dust, soil and water at the facility were negative – no lead hazards were present. Following the risk assessment, six toys, with elevated lead (≥ 600 ppm), and six without detectable lead (< 10 ppm), were wiped with a Ghostwipe. All 12 toys were non-PVC medium sized linking blocks each with a surface area of $126cm^2$ (12cm x 3cm x 3.5cm). Each of four sides of each block was given eight passes with the Ghostwipe, for a total of 40 passes per block. A new Ghostwipe was used for each toy. Each of the wipes was folded four times and placed into a unique, labeled, sterile vial.

The wipes were later removed from the vials and each was placed into a plastic XRF sample container. Using Thin Sample Mode, each Ghostwipe was tested for the presence of lead. The duration of each XRF test was 30 seconds. The wipes were subsequently dissolved in nitric acid, microwave digested, and examined with atomic absorption spectroscopy following the same procedures described above.

CHAPTER 5

STUDY RESULTS

Measurements and Statistics

Measurements of heavy metal concentrations were taken using the XRF with three principal objectives in mind: 1) Discover if there were any visual cues to assist day care center personnel to locate lead contaminated toys without the need of an XRF. 2) Determine if toys constructed of PVC plastic had a greater frequency of elevated lead (≥ 600 ppm) than non-PVC plastic toys, and 3) Determine if yellow plastic toys had a greater frequency of elevated lead (≥ 600 ppm) than non-yellow plastic toys. Although lead was the metal of principal interest, data for concentrations of cadmium, arsenic, and chromium, were also measured.

Approximately 50 toys from each of 10 day care centers were tested, for a total of 535 samples. Of the 535 toys tested, 29 (5.4%) were found with elevated lead (≥ 600 ppm). The lead concentrations ranged from 621 – 8081 ppm, with an overall average of 2019 ± 329 ppm. The following is a description of the data for samples with elevated lead (Table 2).

Table 2. *Statistics for plastic toy samples with elevated lead (≥ 600 ppm**).

							Skewness		Kurtosis	
	N	Min	Max	Mean	STD	S.E.	Statistic	S.E.	Statistic	S.E.
Samples	29	621	8018	2019	1774	329	2.37	0.43	5.50	0.85

*Excludes all data for toys with < 600 ppm lead. **Parts per million.

Frequencies

The frequencies of toys with elevated lead were not distributed normally, rather the curve is leptokurtic and skewed to the left displaying that the majority of toys with elevated lead fall below the mean (Figure 1).

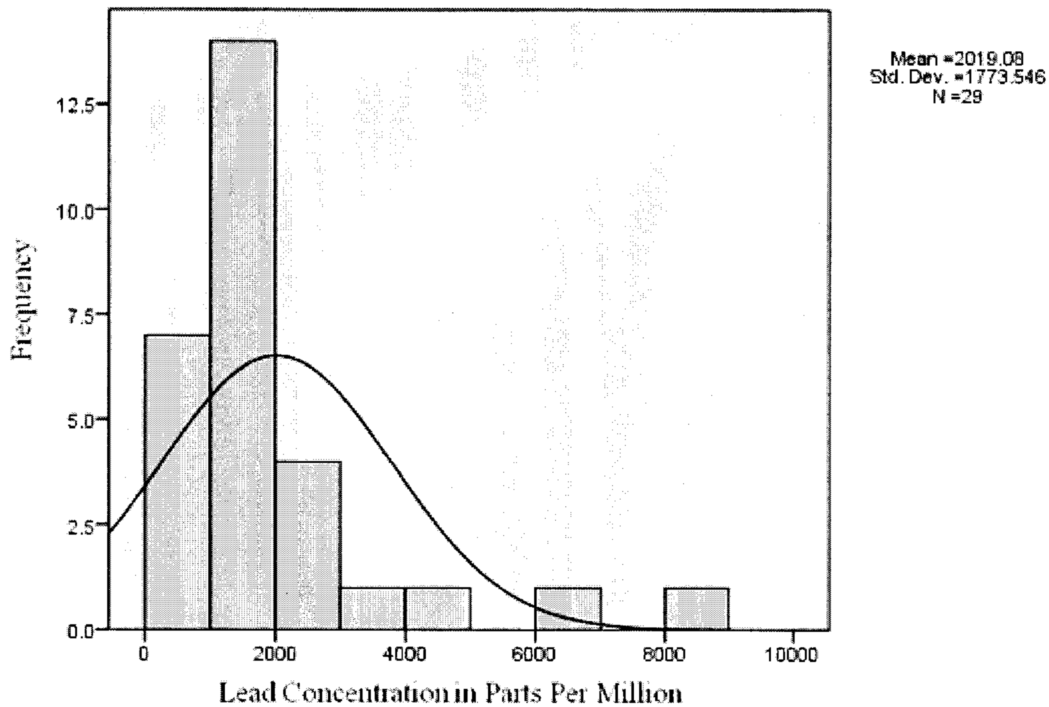

Figure 1. Lead concentration by frequency of samples with elevated lead (≥ 600 ppm).

Of the 10 day care centers visited, toys with moderate lead (10-599 ppm) were found in seven of the day care centers, and toys with elevated lead (≥ 600 ppm) were found in seven of the day care centers (Table 3).

Table 3. Frequencies of toys tested for lead at day care centers by three categories - undetectable (< 10 ppm*), moderate (10-599 ppm) and elevated lead (≥ 600 ppm).

Day Care Code	N	(< 10 ppm)	(10-599 ppm)	(≥ 600 ppm)
(01)	56	51	5	0
(02)	54	52	2	0
(03)	51	39	5	7
(04)	50	50	0	0
(05)	46	35	5	6
(06)	50	47	2	1
(07)	51	50	0	1
(08)	60	59	0	1
(09)	58	48	3	7
(10)	59	44	9	6
Total	535	475	31	29

* parts per million

PVC

Of the 535 samples, 145 (27.1%) were PVC plastic, while the remaining 390 (72.9%) were non-PVC plastic. The mean lead concentration for PVC toys was 325 ppm (±89); for non-PVC, the mean was 89 ppm (±13). When the test on average lead concentration was limited to toys with elevated lead (≥ 600 ppm), the means were 2,189 ppm (±471) and 1,642 ppm (±162) respectively.

A chi-square test for independence was performed to determine if there was a relationship between PVC and an elevated lead concentration. All expected values for this analysis were greater than five, which satisfies the assumption of the chi-square test. The Pearson Chi-square value for PVC toys with elevated lead was 27.2 ($p < 0.01$). There were 20 observed PVC toys and eight expected toys with elevated lead (Table 4).

Table 4. Comparisons of observed versus expected frequencies for plastic type - undetectable (< 10 ppm*), moderate (10-599 ppm) and elevated lead (≥ 600 ppm).

Lead Concentration	N	non-PVC Observed	non-PVC Expected	PVC Observed	PVC Expected
(< 10 ppm)	475	365	346	110	129
(10-599 ppm)	31	16	23	15	8
(≥ 600 ppm)	29	9	21	20	8
Total	535	390	390	145	145

* parts per million

With the two degrees of freedom, used in this test, and $p < 0.01$, a Pearson Chi-Square value of 9.21 is needed to demonstrate significance. The value calculated for this test is almost three times the value needed. Null hypothesis one is rejected. PVC is not independent of elevated lead (≥ 600 ppm). There is a strong relationship between the PVC as a substrate and lead concentrations.

Color

Of the 535 toys, 115 (21.5%) were yellow, while the remaining 420 (78.5%) were non-yellow. The mean lead concentration for yellow toys was 216 ppm (±53); for non-yellow, the mean was 94 ppm (±30). When the test on average lead concentration was limited to toys with elevated lead (≥ 600 ppm), the means were 1,440 ppm (±156) and 2,839 ppm (±716) respectively.

A chi-square test for independence was performed. A chi-square test for independence was performed to determine if there was a relationship between yellow plastic and an elevated lead concentration. All expected values for this analysis were greater than five, which satisfies the assumption of the chi-square test. The Pearson Chi-square value for yellow toys with elevated lead was 25.0 ($p < 0.01$). There were 17 observed yellow toys and six expected toys with elevated lead (Table 5).

Table 5. Comparisons of observed versus expected frequencies for color - undetectable (< 10 ppm*), moderate (10-599 ppm) and elevated lead (≥ 600 ppm).

Lead		non-Yellow		Yellow	
Concentration	N	Observed	Expected	Observed	Expected
(< 10 ppm)	475	378	373	97	102
(10-599 ppm)	31	30	24	1	7
(≥ 600 ppm)	29	12	23	17	6
Total	535	420	420	115	115

* parts per million

This is almost three times the value needed to support significance ($p < 0.01$). Null hypothesis two is rejected. Yellow is not independent of elevated lead (≥ 600 ppm). There is a strong relationship between the yellow plastic and lead concentrations.

<u>Other Heavy Metals</u>

The percentage of toys with cadmium (2.3%), arsenic (0.0%) and chromium (0.0%) was low for toys with undetectable lead. When toys contained elevated lead, other heavy metals were frequently present. These included: cadmium (34.5%), arsenic (31.0%) and chromium (38.0%) were frequently present (Table 6).

Table 6. Heavy metal concentrations*, substrate and color for toys with elevated ($\geq$ 600 ppm) lead.

Description	Lead	Cadmium	Arsenic	Chromium	PVC	Yellow
Yellow Squash	621	647	0	0	Yes	Yes
Yellow Pear	692	359	0	0	Yes	Yes
Yellow Banana	780	264	0	0	Yes	Yes
Green Lime	930	0	0	0	Yes	No
Yellow Pear	931	312	0	0	Yes	Yes
Yellow Plum	955	430	0	0	Yes	Yes
Yellow Banana	992	0	0	0	Yes	Yes
Yellow Lemon	1016	381	0	0	Yes	Yes
Red Link Block	1041	0	0	772	Yes	No
Red Stack Ring	1056	0	169	560	No	No
Orange Truck	1074	0	100	512	No	No
Yellow-Cucumber	1148	0	0	0	Yes	Yes
Green Apple	1196	0	0	0	Yes	No
Yellow Lemon	1265	479	0	0	Yes	Yes
Orange-LinkBlock	1351	0	161	524	No	No
Yellow Latch	1503	0	93	442	No	Yes
Yellow-LinkBlock	1621	0	153	611	No	Yes
Brown Lion	1742	135	0	0	Yes	No
Yellow-GiantBlock	1805	0	205	537	No	Yes
Yellow-LinkBlock	1807	0	117	823	No	Yes
Yellow-LinkBlock	1927	0	231	577	No	Yes
Yellow-Triceratops	2069	0	0	0	Yes	Yes
Bell Pepper	2529	0	0	689	Yes	No
Yellow-Truck	2637	0	193	891	No	Yes
Yellow Dinosaur	2712	0	0	0	Yes	Yes
Green Pear	3244	0	0	0	Yes	No
Brown T-Rex	4945	720	0	0	Yes	No
Purple Dino	6945	145	0	0	Yes	No
Brown Stegosaurus	8018	0	0	0	Yes	No

* Concentrations are displayed in parts per million by weight.

CHAPTER 6

DISCUSSION

The research for this thesis explored the following four questions. 1) Do toys at day care centers, constructed of PVC plastic, have a higher frequency of elevated lead ($\geq$ 600 ppm) concentration than non-PVC toys? 2) Do toys at day care centers, constructed of yellow plastic, have a higher frequency of elevated lead ($\geq$ 600 ppm) concentration than non-yellow toys? 3) Are there other heavy metals present with higher frequency in toys with elevated lead ($\geq$ 600 ppm) than in toys with non-detectable lead (< 10 ppm)? 4) Are there any visual cues that can assist the consumer and day care center personnel in the identification of toys with elevated lead ($\geq$ 600 ppm)?

Lead Concentrations in PVC Plastic

This study commenced and was nearly completed prior to the passage of the Consumer Product Safety Improvement Act of 2008 (CPSIA), which sets new minimum standards for the definition of elevated lead. In 2010 the standard will be reduced to 300 ppm, and reduced further in 2012 to100 ppm. The findings of this study demonstrated a statistically significant ($p < 0.01$) association between PVC and concentrations of lead above the minimum standards in effect at the time samples were taken and analyzed. The percentage of toys having elevated concentrations of lead in PVC was six times greater than non-PVC (Table 4). Under regulations prior to the passage of CPSIA, 20 of the PVC toys tested fell within the definition of elevated lead (≥ 600 ppm). Under the new standard, which will be effective in early 2010, 24 of the PVC samples tested in this project would fail to meet the new safety limits of 300 ppm. If the standard of 2012 were to be applied to the samples in this study, the number of toys with elevated lead would increase by more than 50%, to 31.

In light of the findings in this study and proposed changes in the regulations, it would be preferable to buy toys that are constructed of non-PVC plastics. To avoid purchasing such toys, it would be necessary to be able identify the materials from which toys are made. However, an observation of the population of toys from which the samples were taken produced no visual distinction between PVC and non-PVC plastics. Currently identification methods require the use of sophisticated and expensive equipment. A possible solution would be to label the toy's packaging, using methods similar to the ingredients label found on food items. Although toy labeling is present on packaging, current standards include only the country of manufacture. The CPSIA has addressed this limitation to some degree. In early 2010, labeling will be required to include additional information, such as date of production, batch number, or other identifying characteristics (USCPSC, 2008a). However, this is still inadequate in that the notification of the presence of PVC in the toy is not included.

An inspection of the toys using PVC suggests that the lead may not be necessary as a stabilizer in their construction. There was no apparent visual or tactile difference between PVC toys with elevated lead and PVC toys with undetectable lead. This suggests that, in the hundreds of toys tested, the presence of lead as a stabilizer did not demonstrate an impact on the deterioration of the plastic. The reason for this could be that almost all toys tested in this study were found indoors, and were not directly exposed to the ultraviolet light (UV) of the sun. Even if the UV light does cause an accelerated deterioration of unleaded PVC plastic, this would be a better option than placing a child at risk of exposure to lead. It is recommended that toy producers consider avoiding the use of lead altogether as a stabilizer in toy construction.

Concentrations in Yellow Plastic

Lead chromate is used as a yellow coloring in plastic (Lardinois et al., 1995). There was a statistically significant ($p < 0.01$) association between yellow toys and elevated lead ($\geq$ 600 ppm), as compared to toys of other colors. Seventeen yellow toys tested in this study contained elevated lead. With one exception, all of the yellow toys tested either had elevated lead, or no detectable lead (< 10 ppm). The one exception had 308 ppm of lead. This finding supports the value of the enactment of the CPSIA, and the stricter regulations contained therein, as the toy with 308 ppm would have been included among the list of unsafe toys.

Within the day care centers from where the samples were taken, thousands of yellow toys were noted. Most of these were simple repetitive shapes identified as “category one” toys in the methodology section. Other than medium sized link blocks produced by one manufacturer, none of the other “category one” toys were found with detectable lead.

There was no noticeable visual difference in the color quality or vibrancy of the yellow toys with elevated lead and the yellow toys with non-detectable lead. In light of this, it seems unnecessary to use lead chromate as a color enhancer in yellow toys. It is recommended that toy manufacturers discontinue this practice. It is possible that lead chromate was not the cause of elevated concentrations of lead among the samples. It was not within the design of this experiment to directly detect lead chromate, lead within some of the yellow toys could have been placed there as a stabilizer rather than a color enhancer. As noted earlier, a significant association was found between yellow toys and elevated lead; however, this does not assure a causal relationship. Of the 17 yellow toys with elevated lead, 11 were constructed of PVC plastic. This finding strengthens the point of avoiding toys constructed from PVC, but it does not address a course of action regarding non-PVC toys that have higher concentrations of lead.

The enactment of the CPSIA will decrease the allowable lead within all consumer products, especially those marketed to children. With the understanding of the health impact of lead on children, those decreases will not be soon enough. Based on this study, there is little reason for a manufacturer to continue adding lead to toys whether it would be to foster stabilization or to enhance color. These practices could be discontinued today. With no noticeable visual differences between toys with lead and those without, it is believed the marketing of toys would not be harmed by avoiding manufacturing methods requiring the use of lead. It is believed that just the opposite would be true if a toy's packaging were labeled "lead free". Notably, most toys already are free from detectable lead therefore the removal of lead, from the remaining few, should have little impact on production costs.

Visual Cues

In light of the absence of any visual or tactile distinction between PVC plastic and non-PVC plastic, without the use of a portable x-ray fluorescence device (XRF), day care center personnel are not able to distinguish between the plastics of which toys are constructed. Consequently, it is not possible for consumers to use PVC as a visual cue to identify potential lead contamination.

Yellow versus non-yellow clearly is visually distinguishable, but color alone does not provide sufficient evidence for lead contamination. When toy characteristics were used in conjunction with color, valuable visual cues were discovered. Medium sized (typically 2cm x 3cm x 3.5cm) link blocks were found in three of the 10 day care centers visited. These same link blocks were found at a fourth day care center, but the center withdrew from the study. Consequently, the samples tested at that center were not included in the data. Of the blocks sampled, 100% of the yellow blocks had very high concentrations of lead (1,000 – 2,500 ppm). To further explore this observation, approximately 20 additional yellow blocks were tested. Although the data were not shown in this study, all 20 contained high concentrations of lead. This evidence is strong enough to suggest that the presence of these yellow blocks can be used as a visual cue to potential lead contamination. It would be advisable that consumers and day care center personnel discard these blocks to remove the risk of exposure. It should be noted that although similar in shape to Lego blocks, yellow blocks are larger and not produced by the Lego Company. No Lego blocks tested contained detectable lead.

Of the 17 yellow plastic fruits/vegetables tested, nine (53%) contained high lead concentrations. There were also a couple of pieces of fruit that had a surface color of green or brown that was covering yellow plastic. Some of these contained moderate lead concentrations (10-599 ppm). This percentage is high enough to warrant concern, and it is recommended that, until more stringent lead standards are implemented, yellow plastic fruit be discarded from day care centers. No other visual cues were discovered.

Migration of Lead and Destabilization of Plastic

As plastic ages, it degrades. Heat, ultraviolet light and acidic conditions can accelerate this process (Scheirs, 2003). As plastic degrades, heavy metals contained within can migrate to the surface and deposit within dust (Christensen, 1998; Juberg et al., 1997). One of the efforts of this study was to determine if lead was migrating from the toys, and in turn becoming accessible to children. The findings indicate that when the possibility of cross contamination was minimized, lead was not detected within the dust of toys with elevated lead (≥ 600 ppm). A much larger study is needed, but if the results of this experiment hold true, there is minimal danger of lead exposure from a child handling plastic toys that contain elevated lead. However, this study only explored the production of dust on toys. It does not provide information on the dangers of chewing, or swallowing plastic toys with elevated lead. Additional research is needed.

Other Heavy Metals

The heavy metal concentrations of cadmium, arsenic, and chromium were tabulated in all XRF tests. Although presently there are no national standards for concentrations that invoke a recall for these metals, some consumer groups define ≥ 100 ppm as high, and suggest a voluntary recall (HealthyToys, 2008). According to the Agency for Toxic

Substances and Disease Registry (ATSDR, 2009), all three of these metals pose potential health risks. With the exception of lead, the Consumer Product Safety Improvement Act of 2008 (CPSIA), does not mention any standards for heavy metals within consumer products. This may be is a serious shortcoming of the act.

The combination of lead with cadmium, arsenic and chromium has a synergistic effect causing an amount of neurological damage in excess of the amount that would be caused by any of these metals individually (Roney et al., 2004). These metals were frequently present in toys with elevated lead (Table 6). They were not present within toys with lead concentrations below 600 ppm. This finding suggests that heavy metal contamination in general can be avoided if manufacturing procedures which use lead are abandoned. As the standard for elevated lead is reduced, in 2010, and again in 2012, these heavy metals might not be placed into any newly constructed toys. In the meantime, labels can help foster safety for children by providing information on heavy metal content. Food labels include calories and percentage of calories by sugar, carbohydrates and fat. Toy labels could include parts per million of each of these heavy metals, or at least what is contained in each of the products added to the toy.

Study Limitations and Future Research

Due to time constraints, it was not possible to test all the toys within the 10 day care centers visited. This was a concern for certain toy types. Examples are plastic fruits and animals, especially dinosaurs. It was discovered that in a bin of these toy categories, all but one or two may have a tested below 10 ppm. For the occasional toy with elevated lead ($\geq$ 600 ppm), there were no distinguishing visual characteristics that would suggest a difference in lead content. For these types of toys, it would have been beneficial to test all toys present.

As part of this study, an experiment was performed to test the migration of lead from the plastic to the surface of toys. Although, no migration of lead was discovered, the experiment was too small to test multiple conditions. The toys tested were found indoors. It is recommended that a future study be conducted to test for the migration of lead under various environmental conditions. A future experiment could place toys under ultraviolet light, various temperatures, and other environmental conditions. At regular intervals, plastic could be checked for deterioration and lead migration.

When obtaining volunteers, each day care center was informed that, if toys with elevated lead were found, parents would need to be notified. One day care center participating in the study backed out of the project once toys with elevated lead were discovered. The samples from this center were not included in the data of this study. This exclusion may have resulted in an underestimate of toys > 600 ppm.

Finally, this study was limited to toys found in day care centers in the Las Vegas valley. Due to the small number of centers tested, and that day care center selection was not random, it is unknown if the 10 Las Vegas day cares used are representative of the typical center. If a national study were performed, the number of day care centers to select from would be large enough that sampling could be randomized. A large random sample would decrease the chance of bias and provide a more accurate and complete picture of toys in day care centers.

Summary

Exposure to lead is a risk factor directly related to the health of children (Bearer, 1994). It has been known for many years that children are being exposed to lead from deteriorating paint, dust, soil and water (Mielke et al., 1998a) and now, possibly toys. Imported toys contaminated with leaded plastic, have recently been of increasing concern (Schmidt, 2008). Day care centers are a central location for the gathering and care of children. These centers often contain numerous toys available to the children. After an extensive search of peer review journals using the keywords (lead, contamination, day care, and children), hundreds of articles were found, but none contained information linking lead and plastic toys in day care centers. An aim of this research was to provide data to fill this knowledge gap and to examine lead exposure risks to children in day care centers.

This study attempted to resolve the two hypotheses: 1) there is an association between PVC and elevated lead ($\geq$ 600 ppm), and 2) there is an association between yellow plastic and elevated lead. This research confirmed that there is a strong association in both cases.

In addition to the resolution of the two hypotheses, one of the purposes of this study was to find visual characteristics of toys from which day care personnel and the consumer could estimate the chance of lead contamination. These cues were found. Within the toys, a high percentage of the yellow plastic fruit (53%) and medium sized yellow link blocks (100%) contained elevated lead. This information is of value to day care center personnel and the consumer when selecting toys. .

Another aspect of this study was to find the concentrations of other heavy metals such as cadmium, arsenic, and chromium, within toys. It was discovered that when elevated lead was present, one or more of these other heavy metals were also present in more than one third of the samples. When lead concentrations were moderate (10-599 ppm) or non-detectable (< 10 ppm), these other heavy metals were often not present.

Conclusion

This research was a preliminary step in examining lead exposure risks to children from playing with plastic toys. The findings indicate that lead is contained in toys above 600 ppm. Toys made with PVC are more likely to contain elevated concentrations of lead (≥ 600 ppm). In light of existing research describing the risk and types of injury to children who are exposed to lead, the findings from this study are compelling. Consumers should avoid toys made from PVC. Additionally, they should consider purchasing yellow toys only from manufactures with a good safety record. This information can be found on the Consumer Product Safety Commission website.

Research is not performed in a vacuum. A purpose of research is to discover knowledge that can assist change. This change can be in the private sector through the modification of manufacturing processes, or in the public sector through policy. The Consumer Product Safety Improvement Act (CPSIA) of 2008 (USCPSC, 2008a) is an example of research influencing policy. This act creates more stringent standards for lead contamination. It also requires more detailed labels on consumer products, including date of production and batch number. The policy changes contained within this act are encouraging, but the findings in this study suggest that these changes are inadequate. More stringent standards for other heavy metals are needed. Labeling should mention materials from which plastic toys and other consumer products are made. Specifically, labeling should include parts per million of heavy metals as well as plastic type.

The efforts of this research began with the aim of discovering potential childhood lead exposure risks. This study was concluded during the creation of a new political environment in which children's health is given greater consideration and protection. Future studies will be working within this new political environment, but despite the regulations to make future products safer, millions of contaminated products on the market now, will not quickly disappear.

Continued research is needed to increase our understanding on potential lead exposures and gather knowledge to influence the development of policies and procedures to minimize risks to children. Given the speed at which technology changes, a replication of this study in two or three year is warranted. It is recommended that future research continue to explore the potential exposure risks to lead, and gain information to be used to protect children from these risks.

APPENDIX

GENERAL RELEASE OF LIABILITY (FACILITY)

This General Release of Liability (this "**Release**") is made and entered into this _____day of________________________, 2008 by _______________________________________ ("**Owner**") in favor of the Board of Regents of the Nevada System of Higher Education, on behalf of the University of Nevada, Las Vegas, School of Public Health ("**UNLV**").

Definitions

XRF means an x-ray fluorescence analyzer used to measure sample composition, especially for the detection of heavy metals. It performs its function by projecting and subsequently analyzing a reflected beam of x-rays.

ppm means parts per million.

Operator means each person performing tests on toys.

Preliminary Statements

WHEREAS, Owner is the operator of the daycare facility located at __________________ ____________ __________________ (the "**Facility**");

WHEREAS, in exchange for this Release, UNLV will test toys and toy accessories in collaboration with the Southern Nevada Health District at the Facility for lead and other heavy metals, and provide information to Owner as to the heavy metal content of each toy;

WHEREAS, metal, painted surfaces and/or plastics will be tested for lead (Pb) content via hand held XRF; if the lead content of the paint or plastic of a toy equals or exceeds 600 ppm (the current federal standard), the toy will be set aside and Owner, or its duly appointed representative, will be notified that said toy exceeds the current federal standards;

WHEREAS, testing will occur at the Facility, except that under conditions of excessive volume, or need for additional laboratory testing, toys will be relocated to the UNLV laboratory of environmental studies and returned after testing; and

WHEREAS, statistics will be compiled on the data gathered and the results may be published. However, the identity of the Facility and Owner will be held confidential in all circumstances, including in the published results.

NOW THEREFORE, in consideration of the foregoing and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Owner agrees as follows:

Release

1. Owner is aware that testing for hazardous materials involves risks, dangers and hazards, both to the Operator, the surrounding environment and other persons within proximity, including release of a limited quantity of x-rays upon testing with an XRF and exposure to persons within proximity of the XRF.

2. Owner agrees that no persons, except for the Operator(s), will be in proximity to the XRF during testing. If testing under these circumstances is impossible or impractical, Owner shall request the toys and/or toy accessories be removed from the Facility and tested in the UNLV laboratory.

3. Owner agrees that UNLV is not responsible for the cost or replacement of any toy, accessory or other article or item damaged or displaced during testing.

4. Some toys, due to irregular shapes and sizes, may not be tested in UNLV's sole discretion.

5. Owner hereby does release, acquit and forever discharge the UNLV, and its employees, officers, agents, representatives, insurers, successors and assigns, from any and all actions, suits, losses, claims, damages, expenses, judgments and executions, whether known or unknown, liquidated or unliquidated, fixed, contingent, direct or indirect (including pain and suffering, punitive damages, death, dismemberment, disability, physical or mental illness or the loss or destruction of the personal property of Owner) arising out of testing of toys, toy accessories and/or other articles or items within the Facility and/or out of Owner's action or inaction based upon the information contained in the testing results.

6. UNLV will notify Owner if the lead content of any toy equals or exceeds the current federal standard. In such an event, the Owner agrees to cooperate with UNLV to mutually inform the parents of each child at the Facility of such test results. Facility agrees to indemnify, defend and hold harmless UNLV, and its employees, officers, agents, representatives, insurers, successors and assigns, from any and all actions, suits, losses, claims, damages, expenses, judgments and executions arising out of the test results and/or any failure to inform a parent of a child at the Facility regarding the test results.

7. Owner acknowledges that the testing is voluntary and that this Release is made freely,

voluntarily, and under no compulsion.

I have read, understand and agree to all terms and provisions of this Release.

Authorized Signature	**Date**
Print Name	**Title**

Facility Name	
Address	
City State Zip	
Phone	
Fax	
Owner Name	
Phone	

Dear Parent (guardian),

Due to our concern from the recent news reports of lead found in many imported toys, we were pleased to have the opportunity to participate in a voluntary program to have our toys tested. This opportunity to have toys tested for lead is being offered to many of the day care centers in the Las Vegas Valley. This program is a cooperative effort of members of the School of Public Health of the University of Nevada Las Vegas and the Southern Nevada Health District. On __________ a sample of our toys were tested. The results have been made available to us and it is our pleasure to forward the findings to you.

The process for testing toys went as follows: 50 toys were chosen as a representative sample. A balance of toy shape, size, color and type were the criteria used. If a toy is tested and found to have lead, for the sake of thoroughness, other similar toys were added to the initial 50. The vast majority of toys tested at our center contained no detectable levels of lead. The few toys that were found to have elevated levels of lead* were removed from the premises. It should be noted that none of these toys had parts that could be swallowed.

If you are concerned about toys in your own household, or would like additional information on lead and toys, the U.S. Consumer Product Safety Commission posts these types of data at: http://www.cpsc.gov/

In our ongoing efforts to maintain a setting that is conducive to the health and well being of your child, we will continue to take every measure available to create and maintain a safe and nurturing environment.

* Lead is often used as a softener and color enhancer in plastic. The federal standard for maximum allowable lead within toys is 600 parts per million (ppm). Toys found to exceed this standard were removed from the premises.

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Thesis Title: An Evaluation of Plastic Toys for Lead Contamination in Day Care Centers in the Las Vegas Valley

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