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Potential lead hazards in pre-1978 childcare facilities in Southern Nevada

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Abstract: Communities continue to find lead in buildings and manufactured goods, placing children at risk for negative health effects. This study sought to determine the presence or absence of traditional and non-traditional lead hazards in the total population of pre-1978 licensed childcare facilities in Clark County, Nevada ($N = 94$) through lead risk assessments. Analysis suggests that the pre-1978 structures in Clark County Nevada, USA do not follow national trends pertaining to the prevalence of lead-based paint, dust, and soil. Of the 94 facilities assessed: 30 (31.9%) contained lead-based paint, 41 (43.6%) contained leaded tile, 9 (9.5%) had dust exceeding EPA clearance standards, and 7 (7.4%) facilities had playground equipment test positive for lead. These results confirm the need for continued monitoring of traditional and non-traditional sources of lead to prevent unnecessary lead exposure in childcare facilities.

Subjects: Environment & Health; Environmental Health & Safety; Children and Youth; Community Health; Environmental health

Keywords: lead hazards; childcare facilities; lead risk assessment

1. Introduction

Human activities are the primary cause of adverse environmental and human health impacts caused by lead (Bellinger, 2004; Kessler, 1995). Environmental levels of lead remain on the rise due to

ABOUT THE AUTHORS

The authors' research focus is on childhood lead poisoning prevention and the impact of the built environment on human health. Gerstenberger, PhD, founded the Nevada Healthy Homes Partnership and has multiple collaborative grants with key community partners such as the Southern Nevada Health District, City of Henderson, City of Las Vegas, and the Nevada State Health Division. The authors have worked to identify and reduce lead and healthy homes hazards throughout Southern Nevada supported by grants from agencies such as the Centers for Disease Control and Prevention, US Department of Housing and Urban Development, and the Environmental Protection Agency.

PUBLIC INTEREST STATEMENT

Communities continue to find lead in buildings and manufactured goods, placing children at risk for negative health effects. This study sought to determine the presence or absence of traditional and non-traditional lead hazards in the total population of pre-1978 licensed childcare facilities in Clark County, Nevada ($N = 94$) through lead risk assessments. Analysis suggests that the pre-1978 structures in Clark County Nevada, USA do not follow national trends pertaining to the prevalence of lead-based paint, dust, and soil. Of the 94 facilities assessed: 30 (31.9%) contained lead-based paint, 41 (43.6%) contained leaded tile, 9 (9.5%) had dust exceeding EPA clearance standards, and 7 (7.4%) facilities had playground equipment test positive for lead. These results confirm the need for continued monitoring of traditional and non-traditional sources of lead to prevent unnecessary lead exposure in childcare facilities.

continued use in applications ranging from common household items to industrial applications. Lead can be found not only in traditional sources (paint, dust, soil, and water), but also in non-traditional sources like ceramic tile, plastic products, vinyl blinds, metal, jewelry, home remedies, and artificial turf (Gorospe & Gerstenberger, 2008; Jacobs et al., 2002; Maas, Patch, Morgan, & Pandolfo, 2005).

However, there are no beneficial uses for lead in the human body and it is especially toxic to children under the age of six years old (Lanphear, Dietrich, Auinger, & Cox, 2000). Reduced cognitive functioning, poor academic achievement, and behavioral issues are just a few of the well documented adverse effects of childhood lead poisoning (Needleman, 1980). The Centers for Disease Control and Prevention (CDC) estimates that there are at least 500,000 children under the age of six with blood lead levels above 5 μg/dL, the blood lead reference level for public health action (Lead, 2017). Therefore, it is extremely important to identify and limit childhood exposure to lead.

In 2006, the Southern Nevada Health District (SNHD) received a Childhood Lead Poisoning Prevention Program (CLPPP) grant from the CDC. A key aspect of the program was primary prevention aimed at determining what lead hazards existed in the community and how to abate them before children could become lead poisoned. The SNHD in partnership with the University of Nevada, Las Vegas (UNLV) implemented a lead hazard risk assessment program for all pre-1978, health-permitted childcare facilities located in Clark County, Nevada. This project focused on locating and identifying potential and actual lead hazards in childcare facilities. Limited research of lead in childcare facilities existed in the literature at the time of this project in 2008.

Weismann, Dusdieker, Cherryholmes, Hausler, & Dungy (1995) evaluated the amount of lead levels in six university affiliated day cares in 1995. Five of the centers were built before 1940 and the last was built in 1959. Their results showed that all had elevated lead-based paint levels; two had elevated window sill lead dust levels, and one had elevated window well lead dust levels (Weismann et al., 1995). Elevated water lead levels were also found in one facility, as were elevated soil levels of lead (Weismann et al., 1995). However, none of the facilities had elevated floor lead dust levels (Weismann et al., 1995). The Weisman et al. findings proved that lead could be found in day care facilities after the ban of residential lead-based paint in 1978.

Viverette et al. (1996) also conducted a study of four day care centers in New Orleans in 1996. They assessed public and private centers in both the inner city and outer city locations. Surprisingly, the inner city private center had more severe lead hazards than the in public center (Viverette et al., 1996). This was due to the differences in conditions and ground cover of the two facilities. The public day care had lower lead contamination because it had no bare soil and newer high quality play equipment, despite both being located in high vehicle traffic areas. Viverette et al. (1996) concluded that lead dust contamination had less to do with location of the day care center and was related more to the condition of the equipment and soil (Viverette et al., 1996).

The Department of Defense also conducted a study in 2002 of playground equipment to determine if any lead hazard risks were present (Belfit, Nix, & Graham, 2002). Belfit et al. found that 37% of US Department of Defense playground equipment exceeded the lead dust on residential floors standard, 40 μg/ft^2, set by the US Environmental Protection Agency (US EPA) (Belfit et al., 2002). Findings by both Viverette et al. and Belfit et al. demonstrated a need to test playground equipment at childcare facilities to ensure the safety of children's outdoor environments regardless of location.

Additional studies have been completed after the SNHD and UNLV project in 2008. Greenway and Gerstenberger (2010) documented that leaded toys existed at seven of the ten day care facilities they tested in Clark County, Nevada in 2010. Leaded day care toys (Sanders, Stolz, & Chacon-Baker,

2013) were also discovered in 12% of the overall toys tested in seven Southern New England facilities in 2013. Lead in drinking water above US EPA standard of 20 ppb (ppb) was also reported in 28% of first draw water samples in schools (Barn & Kosatsky, 2011) in Ontario, Canada in 2011 and 3.6% of first draw water samples from five South Central Kansas preschools and primary schools (Massey & Steele, 2012) in 2012. All of these studies confirm the continued need to monitor potential lead sources in childcare facilities.

Given the fact that dust, water, soil and playground equipment have been shown to contain to elevated lead levels in playgrounds and child care facilities, an investigation of all pre-1978 licensed childcare facilities was initiated. The purpose of this study was identify any possible sources of lead in facilities that posed a hazard to children, and suggest appropriate actions that need to be taken to attenuate or eliminate these lead hazards.

2. Methods

The SNHD is the regulating agency in charge of ensuring a safe, clean environment for children who are cared for in a group setting such as a Family Care Home (FCH), Group Care Home (GCH), and Commercial Childcare Center (CCC) in Clark County, NV. Childcare facilities are classified based on the maximum number of children that may attend each facility. A FCH may serve up to six children at one time and typically operates out of the caregivers private residence. Similarly, a GCH is permitted to care for up to twelve children at one time and; GCHs also typically operate out of the caregivers private residence. For the purpose of this study FCHs and GCHs were grouped into one category as they both typically operate out of private residences. Childcare Centers are permitted to care for twelve or more children and generally operate in a commercial center, large church or school facility. However, a few CCCs were found to operate out of converted private residences. Childcare facilities on whole are prohibited from operating out of a condominium or an apartment.

The SNHD issues permits to all FCHs, GCHs and CCCs that hold a business license in Clark County. At the time of the study, SNHD issued and regulated permits for over 600 childcare facilities, built both pre- and post-1978.

2.1. Selection of childcare facilities

Childcare facilities constructed in or before 1978 were selected to be tested for lead hazards. The SNHD maintains the addresses and owner information of the permitted childcare facilities in an internal database. The age of construction of each facility was determined by cross checking the SNHD address on file with the year of construction recorded on the Clark County Assessor's website (http://www.clarkcountynv.gov/assessor/Pages/RecordSearch.aspx). There were 94 permitted childcare facilities that were constructed in or pre-1978.

It is possible that new permits were added or deleted from the SNHD master list of childcare facilities during the course of the study. So all active pre-1978 childcare facilities on file at the SNHD as of January 31, 2009 were included. It was possible that unpermitted childcare facilities in Clark County were being run out of private residences operating as family care homes or group care homes without proper health permits or business licenses. These unpermitted facilities were not included in this study as they could not be accounted for.

All childcare facilities permitted by the SNHD received a letter from an inspector informing them of the SNHD Childcare Facility Lead Risk Assessment Program. Each center was informed that mandatory lead testing was to be performed at all childcare facilities constructed in or pre-1978. The Childcare Lead Risk Assessment Notice Letter also contained information on a voluntary toy risk assessment program offered by fellow graduate students at the University of Nevada, Las Vegas. SNHD inspectors focused on delivering the letters to all pre-1978 childcare facilities in their assigned districts. Districts were determined by zip codes to ensure accurate tracking of notice deliveries. The SNHD required letters to be delivered at least two weeks prior to a phone call that was placed to schedule an appointment for an on-site visit.

An excel spreadsheet was created for all of the scheduled lead risk assessments. The spreadsheet contained information on the childcare facility name, the lead case number (SNHD-CC-XXX), address, the SNHD permit number, the Clark County parcel number, the year of construction, the delivery date of the Childcare Lead Risk Assessment Notice Letter, the date of lead risk assessment, and if lead was present, where it was located.

2.2. Lead risk assessments

Upon arrival at a facility, the lead risk assessment team explained the lead risk assessment procedure to the facility operator and asked if there were any questions. An operator was either the facility's manager facility/homeowner or person in charge at the time of the inspection. The operators of the FCHs and GCHs were given the option to have their entire facility (house) screened for lead. If that offer was declined, it was noted in the final report and only the childcare areas (kitchen, bathrooms, outdoor play areas, and rooms that were utilized by the children) were screened, as those were the only areas permitted by the SNHD. Once all necessary paperwork was completed, the lead risk assessment began.

EPA-certified Lead Risk Assessors from the SNHD and UNLV completed inspections. Lead Risk Assessors used one of two Niton XLp300A series X-ray Fluorescence (XRF) analyzers to complete lead risk assessments in accordance with EPA and US Department of Housing and Urban Development (HUD) guidelines (U.S. Department of Housing & Urban Development, 1995). A minimum of three calibration readings were taken and recorded prior to the lead risk assessment, at the end, and every four hour interval the assessment lasted. Calibrations were taken using the National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) nominal 1.0 mg/cm^2 paint film. The XRFs were used to test interior and exterior painted surfaces and structures for lead-based paint concentrations. A lead concentration of greater than or equal to 1.0 mg/cm^2 is identified as the threshold for a lead-based paint hazard by the EPA/HUD guidelines (U.S. Department of Housing & Urban Development, 1995). All XRF readings were recorded and photographs taken of lead positive surfaces or structures. A diagram of each facility was also created at the beginning of each risk assessment; rooms labeled "No Access" denoted non-childcare areas of FCH and GCH private dwellings.

2.3. Soil samples

Composite soil samples were collected in accordance with EPA/HUD guidelines using either the straight drip line or X formation technique for play areas, dependent on the location of bare soil (U.S. Department of Housing & Urban Development, 1995). Soil samples were taken by an EPA-certified Lead Risk Assessor using a soil corer to remove the top half inch of bare soil and collecting it in non-sterilized polyethylene 50 mL sample tubes. All soil samples were recorded and sample tubes labeled with location taken, date, and case number. Soil samples were collected from all facilities unless no bare soil was present at a facility; sandbox soil samples were also taken if present. Samples were to sent to a National Lead Laboratory Accreditation Program (NLLAP)—accredited laboratory for analysis via Graphite Furnace Atomic Absorption Spectroscopy (GFAAS) or Inductively Coupled Plasma Mass Spectrometer (ICP/MS). Samples did not require refrigeration and were stored in plastic bags labeled by case number at SNHD until several sets of samples were collected, and sent to the NLLAP-accredited laboratory. The longest hold time was approximately two weeks between sample collection and mailing.

2.4. Water samples

The facility operator or employee collected water samples from their respective childcare facilities. An EPA quick reference guide to the Lead and Copper Rule for schools and childcare facilities was provided to each facility along with directions for water sampling (U.S. Environmental Protection Agency, 1992). The SNHD inspector explained water collection directions and emphasized water must be undisturbed in the pipes for 6–8 h before the sample could be taken. SNHD also provided a one liter plastic sample bottle labeled with a case number, and a collection form to record the time and date of last water use, time and date of water collection, and signature of facility employee collecting the sample to each facility. The SNHD inspector retrieved the collected water sample from the facilities after they were completed. All water samples were sent to an NLLAP-accredited laboratory for analysis using GFAAS. Samples did not require refrigeration and the one liter plastic bottles labeled by case number were stored at SNHD until several sets of samples were collected, and sent to the NLLAP-accredited laboratory. The longest hold time was approximately two weeks between sample collection and mailing.

2.5. Dust wipe samples

HUD/EPA and American Society for Testing and Materials (ASTM) dust technician standards (American Society for Testing & Materials International, 2003) for collecting dust samples version ASTM E1728. EPA-certified Lead Risk Assessors collected dust wipes using Ghost Wipes (Environmental Express, Mt. Pleasant, SC), non-sterilized polyethylene 50 mL sample tubes, and pre-formed plastic templates measuring 0.5 ft^2 for floors and 0.25 ft^2 for window sills (BTS Laboratories, Richmond, VA). Dust wipe samples were recorded on a sampling form indicating date, case number, location of sample, and dimensions of the sample area. All sample tubes were labeled in the same manner and stored in a collection bag labeled by case number and date. A chain of custody form was completed with this information for each sample before sent for analysis.

A minimum of two dust wipe samples were collected from the entryway and play area of each facility. These samples could be taken from floors, window sills, or other areas children frequented throughout the childcare facility. Additional dust samples were collected from areas testing positive for lead via XRF at the discretion of the Lead Risk Assessor. All dust wipe samples were sent to a NLLAP-accredited laboratory for analysis using GFAAS or ICP/MS. Samples did not require refrigeration and were stored in the collection bags labeled by case number at SNHD until several sets of samples were collected, and sent to the NLLAP-accredited laboratory. The longest hold time was approximately two weeks between sample collection and mailing.

2.6. Playground equipment samples

Large pieces of anchored playground equipment were tested with the XRF. When a piece of equipment revealed a lead concentration above 1.0 mg/cm^2 standard for paint as determined by the XRF, a dust sample was also collected of that area. The dust samples were sent to a NLLAP-accredited laboratory for analysis using GFAAS or ICP/MS. Samples did not require refrigeration and were stored in the collection bags labeled by case number at SNHD until several sets of samples were collected, and sent to the NLLAP-accredited laboratory. The longest hold time was approximately two weeks between sample collection and mailing.

2.7. Lead standards

The EPA and HUD have standards (EPA, 2000) for lead in dust, soil, and water (Table 1). This study utilized the standards for floors and window sills because window troughs are difficult to test, as the window units in Las Vegas, Nevada vary from the traditional windows with large troughs used in the Midwest and on the East Coast and instead are narrow and traditionally made of vinyl or metal, not

Table 1. Lead clearance standards set by the United States Environmental Protection Agency (EPA) and Department of Housing and Urban Development (HUD)

Sample type	Standards
XRF analysis	• 1 mg/cm^2
Dust samples	• Interior floors (carpeted and uncarpeted) = 40 g/ft^2 • Interior window sills = 250 $\mu g/ft^2$ • Window troughs = 400 ug/ft^2
Soil samples	• Bare play area = 400 ppm • Bare soil in non-play areas = 1,200 ppm • Abatement required = 5,000 ppm
Water samples	• 15 ug/L or 15 ppb or 0.015 mg/L

Source: U.S. Department of Housing and Urban Development (1995).

wood. Playground equipment was held to the standard of 40 µg/ft^2 for floors to be considered positive for this study.

2.8. Risk assessment reports
A final risk assessment report was provided to each childcare facility participating in this study. The report explained the condition of the components tested and if they were an imminent lead risk hazard. It also provided a detailed description of the lead hazards found on the premises, and noted the required course of action to remediate, contain, or abate the lead hazards that were present.

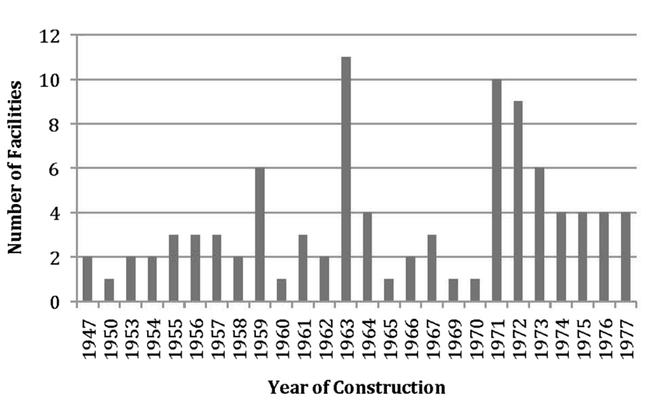
2.9. Data analysis
SPSS version 17.0 for Windows® was used to perform the statistical analyses for this project. Those analyses included the Mann–Whitney U Test, Pearson's Correlation, Linear Regression, a one way ANOVA, descriptive analyses, and an Independent T-test between two groups. All statistical tests ran had non significant results. Therefore, for the purpose of this study, the results will be reported using descriptive statistics.

2.10. Quality control measures
Quality control measures were used for both the collection of XRF data and in the collection of dust samples. A blank dust sample was submitted with each batch of samples collected from a facility. Blanks were submitted to capture the background lead dust concentrations in the air and ensure that samples were not contaminated from improper dust wipes or contaminated gloves. The laboratory utilized for this project followed in house quality assurance and control procedures approved by NLLAP.

3. Results
Lead risk assessments were performed on all 94 childcare facilities in Clark County, NV, built before 1978 holding active permits with the SNHD at the time of the study. There were 41 Family Care Homes, 4 Group Care Homes, and 49 Commercial Childcare Facilities assessed. Figure 1 illustrates the profile of the childcare facilities assessed by frequency of the year of construction. A total of 11,465 XRF readings, 91 soil samples, 93 water samples, and 424 dust samples were collected. XRF readings collected from non-structural items (i.e. garden hoses, garden pots) were excluded, as the focus of this study was structural components not non-structural items; these types of items were not consistently tested.

3.1. Descriptive statistics
A simple linear regression failed to find a correlation between the age of the dwelling or facility and the number of lead hazards; the number of samples available that exceeded clearance standards limited the analysis. Therefore, this section will present only the descriptive statistics.

Figure 1. The number of Pre-1978 permitted childcare facilities in Clark County, NV by year of construction.



3.2. Lead in paint and tile

Of the 94 facilities assessed, 30 (31.9%) contained lead-based paint. A positive reading for lead-based paint on the XRF is defined as a result greater than 1.0 mg/cm^2. A total of 9,076 total paint readings were taken; including quality control repeat readings. Of those, there were 194 (2.1%) lead-positive readings, excluding quality control readings. Values were determined to be paint readings by reviewing the substrate, component, color and notes that were recorded on the Excel spreadsheets and field forms. Lead in tile was also recorded during assessments. A total of 41 facilities (44%) contained lead-positive tile using the positive XRF lead-based paint definition. An independent T-test also found no statistical significance between the mean hazards for lead-based paint and leaded tile.

3.3. Lead in soil

A total of 91 soil samples were collected from the 64 facilities that had bare soil on the property. The range in the number of soil samples collected from the facilities was zero to eight samples; based on risk assessor discretion and the number of playgrounds or bare soil areas present. None of the samples collected exceeded the EPA's clearance standard of 400 ppm lead in soil for child play areas. The mean lead concentration for the 91 soil samples collected was 35.89 ppm, and the standard deviation (SD) was 40.77 ppm. The lead soil concentrations ranged from below the level of detection (LOD) less than 7–160 ppm. Soil concentrations of lead below the LOD were adjusted to 3.5 ppm to account for variations in laboratory detection limits. A total of 12 (12.7%) childcare facilities had soil lead concentrations equal or greater than 40 ppm, but none exceeded the clearance standard (400 ppm) for child play areas (Figure 2).

3.4. Lead in water

A total of 93 water samples were collected for the study. One facility did not have a water sample collected as it was remodeled in early 2000. None of the drinking water samples collected exceeded the EPA's Action Limit of 15 ppb lead in water. Five facilities (5.3%) had a detectable concentration of lead in the water ranging from 6–11 ppb (Figure 3). The remaining facilities had water concentrations below LOD of less than 5 ppb. Water samples below LOD were adjusted to 2.5 ppb to account for variations in laboratory detection limits.

3.5. Lead in dust

A total of 424 dust samples were collected from the childcare facilities, 323 (76%) of these samples were collected from interior floors and 101 (24%) samples were collected from window sills. The number of samples collected per facility ranged from two (study design minimum) to eighteen samples. The maximum number of samples collected was not established as each facility differed in square footage and number of lead hazards present; creating a need to collect a varied number of samples per facility.

Figure 2. Soil lead concentration levels in parts per million (ppm) from Pre-1978 Clark County, NV permitted childcare facilities with bare soil.

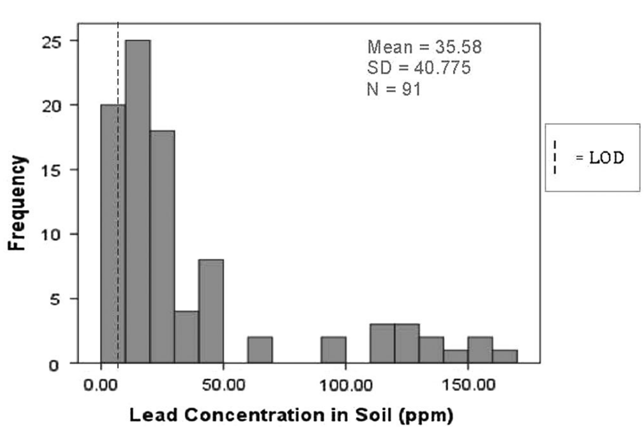
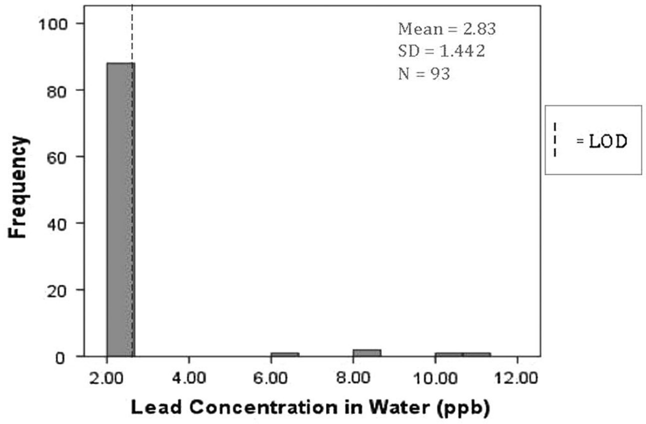


Figure 3. Lead concentration in water in parts per billion (ppb) from Pre-1978 Clark County, NV permitted childcare facilities.

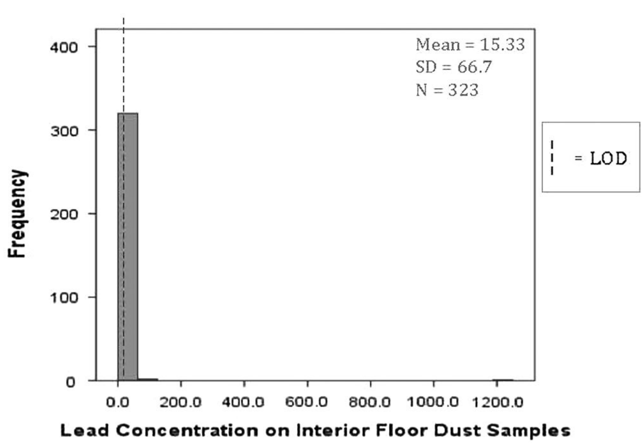


The dust samples with lead concentrations below the LOD (floors 20 μg/ft², windowsills 40 μg/ft²) were adjusted to half of the limit of detection, 10 μg/ft² for the floors and 20 μg/ft² for the window sills to account for variations in laboratory detection limits. Eleven (3.4%) floor dust samples were over the EPA clearance standard of 40 μg/ft² for interior floors, and 2 (1.9%) window sill samples exceeded the EPA clearance standard of 250 μg/ft² for window sills. The range of lead dust concentrations for interior floor samples was below LOD to 1200 μg/ft² with a mean of 15.33 μg/ft², SD = 66.76 μg/ft² (Figure 4). The range of lead dust concentration for window sills was below LOD to 740 μg/ft² with a mean of 42.48 μg/ft², SD = 96.32 μg/ft² (Figure 5).

3.6. Lead in playground equipment

A total of 50 childcare facilities had playground equipment that was tested for lead content using XRF techniques. Of the 50 facilities, a total of 98 individual pieces of playground equipment were tested resulting in 394 XRF readings. A total of 7 (7%) pieces of playground equipment were found to contain lead concentrations greater than 1 mg/cm² using the XRF. The substrates of these structures were categorized as metal or plastics. Positive readings were on 30.4% of painted metal and on 69.6% of plastics playground equipment. The range of positive lead concentrations was from 1.0 to 7.7 mg/cm², with a mean of 2.02 mg/cm². Pieces of playground equipment found to contain elevated lead levels had a dust wipe sample taken to see if lead was bioavailable via dust from the equipment. Dust samples collected from playground equipment were included in the floor dust analysis.

Figure 4. Lead concentration on interior floor dust samples in micrograms per foot squared (μg/ft²) from Pre-1978 Clark County, NV permitted childcare facilities.



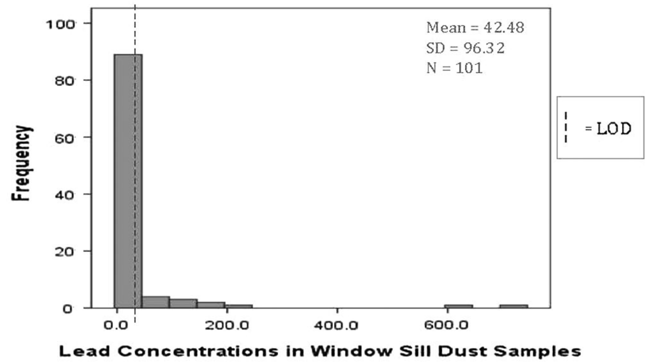


Figure 5. Lead concentration in window sill dust samples in micrograms per foot squared (μg/ft²) from Pre-1978 Clark County, NV permitted childcare facilities.

4. Discussion

There are many factors that contribute to the presence of lead hazards in a childcare facility. Studies have shown a direct correlation between the age of the dwelling or facility, and the number of lead hazards (Jacobs et al., 2002; Levin et al., 2008). This study was statistically unable to duplicate those results. However, descriptive statistics revealed that of the 94 facilities assessed for this study, 30 (31.9%) contained lead-based paint, 41 (43.6%) contained leaded tile, 9 (9.5%) had dust exceeding EPA clearance standards, and 7 (7.4%) facilities had positive playground equipment using the paint standard of greater than 1.0 mg/cm². None of the facilities contained lead concentrations in soil over clearance standards or had lead concentrations exceeding the Action Limit set for lead in water (U.S. Department of Housing & Urban Development, 1995; U.S. Environmental Protection Agency, 1992).

Most lead hazards occur due to the natural aging process of paints and substrates. When paints and substrates are not properly maintained, it can result in deteriorating paint that chips and flakes creating elevated lead concentrations in surrounding dust and soils (Jacobs et al., 2002). Fortunately, lead concentrations in soil do not appear to be the major route of exposure in the childcare facilities assessed in this study. Most of the soil samples collected correlated with the national background of lead levels (Agency for Toxic Substances & Disease Registry, 2007) of less than 10 to 30 ppm. This may be attributed to limited lead industries within urban areas of Clark County, NV and the newer housing stock built post-1978. However, a recent lead hazard control and healthy homes program in Henderson, NV reported 58 of 75 (77.3%) pre-1978 homes had lead-based paint identified during a lead inspection and risk assessment (Rufin, 2015). This finding is important for the FCHs and GCHs that are operated out of private residences. Despite having a smaller pre-1978 housing stock than other East Coast communities, the lead program in Henderson, NV still found a high percentage of lead-based paint that could potentially create lead hazards for children.

Most of the lead-based paint indentified in the study was found in good condition. This typically reduces the amount of lead dust produced. However, lead dust can result from alternative sources than paint. Environmental, take home, or non-traditional sources of lead can produce dust (Gorospe & Gerstenberger, 2008; Jacobs et al., 2002; Levin et al., 2008). One facility assessed did not have any lead-based paint present, but had an interior floor dust wipe with a lead concentration of 50 μg/ft², which is above the 40 μg/ft² clearance standard (U.S. Department of Housing & Urban Development, 1995). This sample was collected at the front entrance under a rubber welcome mat. Lead is used in a variety of consumer goods, including vinyl and polyvinyl chloride (Levin et al., 2008). Therefore, it is possible that the welcome mat itself was creating the lead dust above the clearance standard. Another facility had a positive interior floor sample with a lead concentration of 1,200 μg/ft². This sample was collected from a painted threshold that was found in deteriorated condition. SNHD mandated that this component be abated from the facility since it was a lead hazard. A set of mini-blinds located in the window sill also had lead dust above the clearance level (U.S. Department of Housing & Urban Development, 1995) of 250 μg/ft². The mini-blind dust wipe contained 600 μg/ft² and was removed by mandate of SNHD as well.

Playground equipment was also tested for lead due to increased awareness of lead in children's toys (Belfit et al., 2002; Greenway & Gerstenberger, 2010; Viverette et al., 1996; Weismann et al., 1995). It has been demonstrated that large playground structures contain lead in the paints and plastics to aid in color maintenance and integrity in extreme outdoor environments (Belfit et al., 2002; Greenway & Gerstenberger, 2010; Sanders et al., 2013; Viverette et al., 1996). Playground equipment assessed in this study contained both plastic and metal components. Seven of 94 (7.4%) large playground structures were found to have positive lead levels. Of the positive XRF readings, 30.4% were from painted metal, and 69.6% were from plastic components. Although only a few structures contained lead, dust wipes taken from a set of stairs on a slide contained 740 $\mu g/ft^2$ of lead dust. This result warrants further investigation and monitoring of playground equipment to prevent children from being exposed to lead dust that is bioavailable.

Clark County, NV is known for its extreme heat and intense summers. These factors could contribute to the breakdown of substrates or painted materials causing the release of leaded dust when lead is present in play equipment. The potential for this has already been considered for lead in artificial turf (Van Ulirsch et al., 2010). With the wear and tear, the outdoor playground equipment may produce leaded dust that could expose children. Furthermore, if proper hand washing techniques are not utilized after play, children could be further exposing themselves. Since Health Departments have jurisdiction over school and childcare facilities, they may want to implement annual screening of playground equipment for post-1978 facilities and upon addition of new equipment for leaded structures. All playground structures should be assessed using a Plastics XRF Analyzer using the lead in plastic standard of 600 ppm, and dust wiped to determine the bioavailability of lead to prevent future exposures (Ban of lead-containing paint & certain consumer products bearing lead-containing paint, 2001).

Another commonly found non-traditional source of lead in the childcare facilities was tile. The analysis determined that 43.6% of facilities had leaded tile, while only 31.9% of facilities had lead-based paint. While leaded tile was in a higher percentage of facilities than leaded paint, the US Consumer Product Safety Commission currently does not consider tile or ceramic glaze to fall under restrictions on the use of lead-based paint and products containing lead-based paint (Ban of lead-containing paint & certain consumer products bearing lead-containing paint, 2001). Jacobs et al. (2002) have already expressed their concern for leaded tile calling for further study to determine if it could be a source of lead exposure for children. A full investigation of the potential for tile to contribute to a lead dust hazard should be completed, especially during remediation and replacement efforts.

An additional unique non-traditional lead hazard was also discovered during the course of the study. Several childcare facility murals were painted using artists' paints. This would not be so interesting if artist's paints were included in the lead-based paint ban, however they were not (Ban of lead-containing paint & certain consumer products bearing lead-containing paint, 2001). These murals were a popular decoration in childcare facilities assessed in this study, and many were created using commercial paints. However, some of the positive lead-based paints identified during risk assessments were on murals created by artists' paints. SNHD recommended that childcare facilities ensure that the paint they use is of commercial grade that adheres to the standard (Ban of lead-containing paint & certain consumer products bearing lead-containing paint, 2001) set for lead in paints (600 ppm). Careful planning and education of employees can ensure that these paints are not used in facilities where children are present.

Lead was also a popular substrate used in plumbing before a 1,968 ban (Bryant, 2004). However, this was not a complete ban; lead was still permitted in certain plumbing materials up to specific allowable concentrations and did not address service lines containing lead and copper previously installed (Bryant, 2004). This is important because some childcare facilities, or even residential dwellings, may have leaded solder or lead service lines present post-1968 that contain lead. Without proper treatment applications by local water authorities, there is the risk of lead leaching into the water (Pieper, Tang, & Edwards, 2017). In Clark County, NV, the Southern Nevada Water Authority applies the treatment technique required to control for lead leaching and all of the water samples taken from childcare facilities were below the Action Limit of 15 ppb lead in water (U.S. Environmental Protection Agency, 1992). Only 5 of the 93 water samples collected during the study had lead concentrations above the laboratory's detection limit of 5 ppb. These samples ranged from 6 to 11 ppb of lead in water. However, the water crisis in Flint, Michigan is a prime example of how lead can leach into the water service lines when appropriate controls are negated (Pieper et al., 2017). Therefore, local authorities should not disregard the necessary chemical controls and potential lead hazard that may be located in water service lines.

4.1. Study limitations

The sample size (*N* = 94) for this study maybe considered small. However, this was the entire population of pre-1978 childcare facilities permitted as of January, 2009 in Clark County, NV. Since that time, new facilities operating out of pre-1978 structures have opened for business and have been assessed by the SNHD, but these facilities were not included here. This study was not able to account for childcare facilities operating without a required SNHD permit.

Each FCH or GCH that was assessed was given the option to have the entire facility/residential dwelling screened or only the child occupied areas. As per the SNHD health permit, only the areas that the children access are regulated by SHND. Therefore, the inspectors did not have the authority to assess the entire facility/dwelling without the owner's permission. Commercial childcare centers did not have this option because their structure was not a private residence. A few FCH and GCH operators chose to have their entire facility/dwelling screened, but most denied the offer. This is considered a limitation because additional lead hazards may have gone unscreened in alternative areas of the facility/dwelling. Although the child occupied areas are approved by SNHD, it is possible that children still enter these unapproved areas. A majority of the facilities tested were also constructed post-1950 when lead concentrations in paint were voluntarily being reduced by the industry (Mushak & Crocetti, 1990). These are all factors that could influence the amount of hazards identified per facility.

A total of six EPA Certified Lead Risk Assessors contributed to completing this study. Multiple inspectors completed the risk assessments, although they were all trained consistently the possibility of inter-rater reliability issues arise. Outdoor play equipment was one aspect of the assessment that varied by risk assessor. All risk assessors did not complete a follow-up dust wipe after identifying a positive XRF reading. This limits the ability to determine if the lead in the playground equipment is creating an actual lead dust hazard to the children.

It is also possible that additional pieces of playground equipment were positive based on the 600 ppm standard for lead in consumer products because the study team did not have access to an XRF Plastics Analyzer that could produce results in ppm (Ban of lead-containing paint & certain consumer products bearing lead-containing paint, 2001). Therefore, it is possible that the XRF readings below 1.0 mg/cm^2 could be above the 600 ppm standard since there is no conversion formula. It is recommended that future studies utilize a Plastics XRF Analyzer for testing lead concentration of playground equipment, followed by dust wipe sampling to determine the bioavailability of lead.

5. Conclusion

Overall, lead concentrations in soil, dust, water, and paint were very low and infrequent in the pre-1978 childcare facilities tested in Clark County, Nevada. Although this severely limits the discussion of the lead sources, more importantly it is excellent news for the residents of Clark County. Lead concentrations exceeding existing standards were certainly found in childcare facilities, but often were in isolated areas that could quickly and easily be removed or stabilized. Annual monitoring of traditional and non-traditional lead sources should be completed to ensure these facilities provide a safe environment for children. This allows us to take preventative measures instead of using children as bioindicators to find the lead sources.

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