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Determination of Lead in Soil and Plants and Risk Assessment of its Effects among Preschool Children in Daycare Center in Manila, Philippines

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Abstract. Adverse health effects caused by heavy metal toxicity, particularly lead, commonly manifest in children due to their higher absorption rate and frequent exposure from play areas such as school grounds. The aim of this study is to: (1) determine lead levels in soil and plant samples and compare to US EPA acceptable limits; and (2) assess health risk by determining if an association exists between the occurrence of physical and neurological symptoms of lead poisoning among the pre-school children in Manila (exposed group) and pre-school children in Bataan (unexposed group). Using flame absorption spectroscopy, it was found that lead levels in plant species and soil samples ranged from 0.11-0.16 ppm and 1.12-2.59, respectively. These were still within the limits set by US EPA at 300 ppm (plants) and 400 ppm (soil). However, if accidentally ingested, the amount absorbed would exceed serum safe level of 10 mcg/dl, leading to possible toxicity. On the other hand, the cross-sectional survey component of this study revealed a positive association existing between the exposure to the playground, and both physical (OR=1.60) and neurological symptoms (OR=1.38) of lead poisoning, indicating the odds of manifesting lead toxicity through physical and neurological symptoms is higher in children in Manila than in Bataan. However, the mean scores of physical and neurological toxidromes of exposed group versus the unexposed group were found to be insignificant with p-values p=0.3573 and p=0.4126, respectively, using two-tailed t-test.

Keywords: Lead, Playground, Toxidromes, Pre-school children

1. Introduction

1.1. Background

Children's activities mainly revolve around learning, exploration and play. Most commonly, it is in school playgrounds that children have longer contact time having to spend greater time in school facilities than in their homes. The U.S. Environmental Protection Agency of the United States estimates that more than 20% of normal children eat around a teaspoon of soil on several occasions[1]. Most children also gnaw on walls or furniture painted with old lead-based pain. Their susceptibility to inhalation of air pollutants is said to be more pronounced in outdoor urban areas, risking them to several health hazards such as toxic chemicals, harmful bacteria and parasites, among others.

Compared with heavy metal poisoning, bacterial and parasitical infections have more distinct signs and symptoms like bloody diarrhea, which can prompt parents for early treatment. Heavy metal intoxication, meanwhile, is an uncommon diagnosis causing irreversible damage[2] mainly due to their rapidly developing system that even brief exposures to heavy metals may affect their developmental processes, which can further lead to learning disabilities3. In addition, children have higher rates of absorption which hastens their capacity for lead bioaccumulation. It is then important to protect young lives by ensuring that their environment for daily activities is safe from heavy metal toxicants, such as lead. The aim of this study, therefore, is to determine lead levels in soil and plant samples collected from a daycare center in Taft, Manila, and compare the values to US Environmental Protection Agency's acceptable limits. Also, another objective is to assess health risk by determining if an association exists between the occurrence of physical and neurological symptoms of lead poisoning among the pre-school children in the same daycare center (exposed group) vis-a-vis pre-school children in Bataan (unexposed group).

1.2. Objective

The general objective of the study is to determine the safety of the pre-school playground (found in Manila) from heavy metal contaminants found in the soil and plants situated in the area. Specifically, the study aims to quantify lead in soil and plants found in the playground area using AAS, compare the levels of such heavy metal to the standards set by U.S. EPA, and determine if there is a significant difference in the symptoms experienced between preschool students classified as exposed and unexposed using survey.

1.3. Scope

For the purposes of this study, only soil and plant samples were used. Detection of lead limits is dependent on the detection limit of the equipment used, the Flame Atomic Absorption Spectroscopy, that is, 0.1 mg/L. In terms of the survey, there is an inevitable introduction of selection bias due to the convenience sampling that occurred. It must also be noted that causality cannot be established between the toxidromes and lead levels, since this study did not measure the baseline health status of children and also since other confounding factors such as house living environment were not assessed. Besides, causality will require biological laboratory testing which is also beyond the scope of this study. Information bias due to inability to validate the survey tool also limits the generalizability of the study.

1.4. Significance

Play is an important part of a child's life. It is where they learn to be cognizant of their environment and develop their social skills. Play can happen almost everywhere but among other places, playgrounds are one of the children's favourite places for recreation. However, such places are not free from environmental toxicants, particularly, heavy metals. Determining the presence and level of such contaminants in a pre-school playground will allow better safety parameters to be established to protect the children from acute or chronic exposure and thus protecting them from developing diseases related to exposures from heavy metals.

2. Methodology

2.1. Research Design

This study employed a descriptive non-experimental quantitative research design wherein the amount of lead contaminating the soil and plant sample from the playground was determined. The time frame of sampling was on the second week of January 2012. The treatment of the specimens was conducted in the Toxicology Laboratory of College of Pharmacy, University of the Philippines Manila, while the analysis of lead content was performed using Flame Atomic Absorption Spectroscopy, at the Institute of Chemistry, University of the Philippines Diliman.

To supplement the result of quantitative determination of lead levels, a risk assessment survey was done. This is to assess the association of the incidence of adverse effects of lead to the exposure of children playing in the playground in a daycare center in Taft Avenue, Manila City. The survey for the control group was conducted in an elementary school in Abucay, Bataan. The study was conducted from January to March 2012 and it was collected using a self-administered questionnaire and interview.

2.2. Instrumentation

For lead determination, Perkin-Elmer Atomic Absorption Spectrometer from the Institute of Chemistry, University of the Philippines Diliman was used. The questionnaire was formulated in English with corresponding Filipino translation, according to the list of common physical and neurological symptoms adapted from WHO Childhood Lead Poisoning booklet[4].

2.3. Sampling Plan

For the quantitative analysis of lead, 5 samples of soil and 4 samples for plant were obtained from areas near the bench, pots, grass, entrance and bars in the grounds of the daycare center. It must be noted that plant samples obtained were of different species. For the risk assessment, the sample population for the cross-sectional survey were obtained by convenience sampling with 27 students for the exposed group and 30 students for the control group.

2.4. Procedure

Approximately 5 g of leaf and soil samples were collected from the same height of plants and depth of soil, respectively. Samples were dried for 24 hours at 80C, and homogenized using mortar and pestle. 2 grams of powdered sample were weighed and macerated using 40 ml nitric-hydrochloric acid solution for 7 days. They were then digested for 2 hours at 200C, prior to filtration. Finally, each was diluted to a 20 ml solution using deionized water. Lead content was analyzed using Flame Atomic Absorption Spectroscopy.

Data collection for the risk assessment survey was conducted on the first week of March. Consent of participants' corresponding guardians was sought, and the questionnaires were given and then collected at a later time. The questionnaire revolved around the determination of incidence and severity of symptoms related to possible lead intoxication in the play area of the subjects.

2.5. Data Analysis

Results of AAS test were already expressed in parts per million (ppm); hence, no further computation was done. Data was compared with the set lead soil and plant levels of US EPA.

For the risk assessment, demographic characteristics of the subjects were summarized. Symptoms that have been experienced by the children of exposed and unexposed groups were converted to toxidrome scores. T-test of toxidrome scores of the exposed versus the unexposed group was performed. The association between exposure and the incidence of the non-specific toxic symptoms was determined by calculating the odds-ratio and relative risk.

3. Results and Discussion

Based on the AAS results, the lead concentrations in the samples are way below the acceptable limit of lead in soil which is 400ppm, and in plants, 300ppm. As seen in table 1, the highest concentration of Lead from soil is 2.59ppm and the least is 1.12ppm. The soil with the highest concentration (S8) was taken from the entrance where all of the children and adults enter. The least amount was from the pot beside the trees that is a located near the playing area of the kids. The large concentration of lead can be attributed to the relative proximity to the parking lot, as well as the street of Taft, Avenue where there are vehicles.

Table 1: Lead concentrations of different soil samples

Sample Code	Lead, ppm
S3	1.29
S6	1.12
S7	1.89
S8	2.59

Comparing the lead concentration of soil in the playground and that of the other areas of the school like the entrance, it can be seen from the figure below that the playing area has relatively lower concentrations. This is a good indication that the children playing in the said area may be safe from lead intoxication.

Plant samples collected around the vicinity were taken and analyzed using AAS and the result is shown in figure 1. All the plant samples did not exceed the lead limit of 300 ppm. But comparing the lead levels among plant samples, P3 has the highest concentration of 0.16ppm located near the playground area. P1 is located at the entrance, P6 is near the monkey bars of the playground and P7, P3 and P2 were collected in a relatively close proximity in the area.

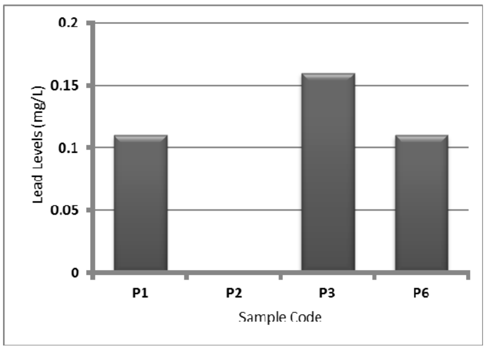

Fig. 1: Graph of lead levels in different plant samples

Note that lead levels in the plant samples are lower than that in soil. Although plants can serve as biomonitors of lead (or other heavy metal pollutant) through bioaccumulation and adsorption, they vary in their capacity to do so. Furthermore, certain variables were not controlled, specifically, type and age of plant, hence, yielding varying values of lead levels. What can be surmised from this data is that lead is accumulating in the grounds of the daycare center.

For the risk assessment, the exposed group were composed of more male (59%, n=11) than female (41%, n=16) respondents with a mean age of 5. Since the lead levels were tested only in selected areas of the playground, only those who regularly play are included in the exposed group. On the other hand, for the control group, more females (60%, n=18) than males (40%, n=12) with a mean age of 6, were surveyed.

Table 2: Prevalence and Mean Scores of Toxidrome among Exposed and Unexposed

	%prevalence	%mean score	SD
Exposed *(n=27)*			
Physical Toxidrome *(n=11)*	40.74	25.93	28.99
Neurological Toxidrome *(n=11)*	40.74	30.86	30.56
Unexposed *(n=30)*			
Physical Toxidrome *(n=9)*	30.00	33.33	31.03
Neurological Toxidrome *(n=10)*	33.33	37.78	32.44

Toxidromes are clinical syndromes that are essential for the successful recognition of poisoning patterns. A number of common physical and neurological signs and symptoms associated with chronic lead poisoning were adapted from WHO Childhood Lead Poisoning booklet, each item being rated as one point. Severity of symptoms was used in the designation of children who are positive for physical and neurological toxidromes. Those with at least two scores ($\geq$50%) were included. Mean percent of positive physical and neurological toxidrome scores were computed. The higher the score relative to the number of items, the more intoxicated the person is with the lead. It can be seen that control group has higher %mean score because more students experienced one symptom each from the physical and neurological part.

In the exposed group, respondents 6 and 14 are said to experience the most physical (100%) and neurological (100%) toxidromes of lead toxicity, respectively. The most common physical symptom is constipation from unknown reasons while the neurological symptom that scored the most is difficulty in concentrating in class. These symptoms, however, cannot be directly associated with lead toxicity since there are other factors that can be considered as possible causes of these. The mean scores of physical and neurological toxidromes of the exposed group versus the unexposed were found to be insignificant with p-values p=0.3573 and p=0.4126, respectively, using two-tailed t-test.

In order to express how the exposure to lead in playground is associated to the occurrence of non-specific symptoms, odds-ratio for the association between the exposure and the prevalence of the symptoms of the different toxicants were computed and summarized in table below.

A positive association was found between the exposure in playground, and both physical (OR=1.60) and neurological symptoms (OR=1.38) of lead poisoning. This means that the odds of manifesting physical and neurological toxidromes is higher in children in Manila than in Bataan group.

Table 3: Projected Lead Levels When Ingested

Location	Lead mcg/L	Projected Blood Levels
S1	129	64.5
S2	112	56
S3	189	94.5
S4	259	129.5
S5	11	5.5
P1	-	-
P2	16	8
P3	11	5.5
P4	11	5.5

Projected blood lead levels when ingested were also computed. There is a risk of ingestion of soil since amongst exposed group, four children play in bare soil. All computed blood lead levels exceeded the acceptable amount set by US EPA[5], 10mcg/dL. This is alarming since even though the lead soil levels are below limit, its ingestion can possibly lead to toxicity.

The sample size of unexposed group is too small to produce a significant difference between scores and between groups. There are also possible confounders that can affect the results such as the current health status of the subjects. Recall bias of the guardian/child can also affect the result of the study.

4. Conclusion and Recommendation

Based on the results of the study, the levels of lead were below limits, however, the projected blood levels are high thus continuous monitoring must be done and certain precautionary measures must be conducted in order to prevent possible ingestion of soil containing lead.

Although the association between exposure and presence of toxidromes are all positive, causality cannot be made since baseline health status of subjects which could affect the results of the study were not assessed. Moreover, the toxidromes identified are not specific for lead toxicity, further supported by the very low levels of lead in soil and plants found in the playground area.

Since there was no suitable tool available for this study, a survey form was made by researchers; thus, the validity has not been established. Validation of the survey instrument must be done to ensure the accuracy of the study. This however can serve as pilot study of the instrument used.

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