

# Lead Exposure, IQ, Neurological Effect, and Behavioral Problems in Children Six Years And Under

Anna Adhiambo Odipo<sup>1</sup>, Francie McNeil, RN, BSN<sup>2</sup>, Sandy Houser<sup>1</sup>, and Barbara J. Jackson, (Ph.D.)<sup>2</sup>

<sup>1</sup>Munroe- Meyer Institute at the University of Nebraska Medical Center; <sup>2</sup>University Medical Associates at the University of Nebraska Medical Center

Munroe-Meyer Institute



## Abstract

Medical studies show that lead exposure is associated with neurological effect, low IQ, behavioral and developmental impairment in children six ages and under. The purpose of the study was to determine the association between elevated blood lead concentrations in children six years and under, and how their immediate environment influences their blood lead levels (EBLL). Data were collected from 170 one-to-six-year-old subjects at the University of Nebraska Medical Center Pediatric Clinic between January and March 2005. The samples were collected by capillary method, followed by venous puncture. Results showed that of the 170 samples tested, 42 were eliminated from the study for various reasons. Out of the 128 tested, 43 had elevated blood lead levels (EBLL) and all subjects reside in EPA designated lead site in Omaha.

## Introduction

The Centers for Disease Control and Prevention 2000 (CDC) reported that a significant number of children ages six and under were still being poisoned by lead each year. The vast majority this lead poisoning takes place in low income, minority urban neighborhoods within older homes and residences built prior to 1978.

In Nebraska, according to the Health and Human Services Department, Douglas County, with the highest number of children six years and under (47,885), the highest percentage (46%) of older homes and residences built prior to 1978, and the highest levels of lead poisoning in children compared to the state.

## Sources

- Between 1870 and 1997, the ASARCO facility conducted lead refining operations in Douglas County in downtown Omaha, encompassing zip codes, 68102, 68105, 68107, 68108, 68110, 68111 and 68131 which were designated Environmental Protection Agency's (EPA) Priority area for clean up in 1999.
- Gould, Inc. which operated a lead battery recycling plant and a secondary lead smelter in the area but closed down in 1982.
- The third source and the most important in this study was lead-based paint used in older homes and residences built before 1978 in Omaha. Based on these three major sources of Lead in Omaha, in 1999, EPA designated Douglas County in Omaha as a priority site for clean up. Eleven zip codes surrounding down town Omaha, including the seven priority zip codes for EPA were designated for study to establish the association between elevated blood lead levels and lead based paint in children six years and under who reside in homes and residences built prior to 1978 in Omaha.

## Target Zip Codes

The 11 target zip codes from which the samples were collected (included the EPA designated lead site area in Omaha) were, 68102, 68104, 68105, 68106, 68107, 68108, 68110, 68111, 68112, 68131, and 68132. The surrounding zip codes to downtown Omaha which were included in the study for possible lead poisoning included, 68114, 68116, 68117, 68118, 68122, 68124, 68127, 68130, 68135, 68137, 68142, 68144, 68152, 68154 and 68164.

## The Purpose of the Study

To determine the association between elevated blood lead concentrations in children six years and under, and how their immediate environment in which they grow up influences their elevated blood lead levels (EBLL), neurological effect, behavioral and developmental impairment.

## Symptoms

The short term consequences of prolonged exposure to lead result in anorexia which is the earliest symptom in toddlers, followed by persistent vomiting, irritability, unwillingness to play, convulsion, and coma. The long term serious symptoms include, peripheral nerve weakness, damage to the brain, and retarded physical development, which may cause behavioral and learning problems.

Table 1: Shows the Priority of Elevated Blood Lead Levels in Children Six Years and Under

| Priority Category | EBLL mg/dl       | Neurological Effect                     | Other Effects                               |
|-------------------|------------------|---|---|
| First Priority    | 80-100           | Encephalopathy                          | Behavior and Development Impairment         |
| Second Priority   | 70-79            | Peripheral neuropathy                   |   |
| Third Priority    | 30-69            | Slowed nerve conduction Velocity        | Behavior and development impairment         |
| Fourth Priority   | 21-25            | Lower IQ, slower reaction time          | Impaired vitamin D metabolism               |
| Fifth Priority    | 15 - 20<br>10-15 | Deficits in neurobehavioral development | Reduced gestational age and weight at birth |

Source: Childhood Lead Poisoning Prevention Program, Omaha, 1999-2000

## Methods

### Sample size:

Data were collected at the University of Nebraska Medical Center Pediatrics Clinic on 170 one - to- six- year- old children who attended immunization clinic between January and March of 2005. The eligible samples were of the children residing in the 11 zip codes designated as EPA lead site area, and those surrounding the downtown Omaha.

### Home visits:

Two home visits to two different families with children who have elevated blood lead levels identified at UNMC Pediatrics clinic were made at different times, to assess the parents.

- Behavioral and developmental problems
- Experiences and the burden of caring for their children
- What type of services the families receive from the state
- Other organizations
- Gaps in the services provided

### Analytical Technique

- Finger prick blood was collected in heparinised capillary tubes
- For those children whose results showed elevated blood lead levels, a second test was required to confirm the results of the first test
- An intravenous blood was collected in a heparinised glass container
- Erythrocyte Protoporphyrin extraction method using the gas chromatography was used to analyze the blood samples according to Centers for Disease Control and Prevention (CDC) guidelines. (CFR NO.1191, 1997 and 2002)

## Results

Out of the 170 specimens tested, a total of 42 were eliminated from the study, 28 came from zip codes outside the EPA designated lead site and had EBLL <10 ug/dl. Nineteen came from Council Bluffs, Iowa in the zip codes that surround downtown Omaha. Their EBLL <10 ug/dl. Five had a history of EBLL >10 ug/dl but at the time of follow-up testing between January and March 2005, the quantity supplied was not sufficient and therefore, no tests were performed, leaving a sample size of 123 subjects to be studied. All the children with EBLL >10 ug/dl reside in the 11 zip codes in the EPA designated lead site area, with older homes and residences built prior to 1978. Zip code 68105 had the highest number of subjects tested 36 in total with 24 subjects having EBLL <10 ug/dl, 10 subjects with EBLL >10 ug/dl; zip code 68111 had a total of 35 subjects tested 19 had EBLL <10 ug/dl; 5 had EBLL > 10ug/dl; 7 had EBLL > 10-14 ug/dl and 3 had EBLL > 25-44 ug/dl. Although zip code 68108 had only 5 subjects tested, had EBLL <10 ug/dl, 2 had EBLL > 44 ug/dl and 1 subject had EBLL > 70 ug/dl.

Table 1.1. Shows the Blood Levels in Micrograms per Deciliter by Zip Code from January to March 2005. Elevated Blood Levels in ug/dl

| Zip Code | 0-9 | 10-14 | 15-24 | 25-44 | 45-69 | 70+ | Total | % Tested |
|----------|-----|-------|-------|-------|-------|-----|-------|----------|
| 68102    | 1   | 0     | 0     | 0     | 0     | 0   | 1     |          |
| 68104    | 4   | 0     | 0     | 0     | 0     | 0   | 4     |          |
| 68105    | 24  | 10    | 2     | 0     | 0     | 0   | 36    |          |
| 68106    | 5   | 4     | 0     | 0     | 0     | 0   | 9     |          |
| 68107    | 8   | 3     | 0     | 0     | 0     | 0   | 11    |          |
| 68108    | 5   | 0     | 0     | 2     | 0     | 1   | 6     |          |
| 68110    | 8   | 0     | 0     | 0     | 0     | 0   | 8     |          |
| 68111    | 19  | 6     | 7     | 3     | 0     | 0   | 35    |          |
| 68112    | 4   | 2     | 0     | 0     | 0     | 0   | 6     |          |
| 68131    | 2   | 1     | 0     | 0     | 0     | 0   | 3     |          |
| 68134    | 5   | 1     | 0     | 0     | 0     | 0   | 6     |          |
| Total    | 85  | 19    | 8     | 1     | 0     | 1   | 123   |          |

Source: Data collected from UNMC Pediatrics Clinic, January to March, 2005

## Home visits

One family whose two year old son had an EBLL >79 ug/dl, reported that they were on Medicaid, which took care of the medical bills. Her husband works full time and the mother stays at home since they have three other children. However, the child had not been evaluated for behavior and development impairment, I.Q. testing, or early school intervention. The landlord had replaced some windows to the house and two were still waiting to be replaced. The EPA had excavated the soil around the house, repainted the house and cleaned the carpet. They reside in zip code 68108, which is EPA designated lead site area in Omaha.

## Recommendations to the family

- Seek neurological effect, behavioral and developmental impairment evaluation from Munroe-Meyer Institute.
- Ask for early school intervention from the Omaha Public School District since the family resides in the OPS jurisdiction.

## Second home visit

The second family visited resides in zip code 68104 which is also in the EPA lead site area in Omaha. The child had a history of BLL of 2 ug/dl on 4-25-03 and 19.9 ug/dl on 2-18-05. The other sibling had a history of 8.4 ug/dl on 02-23-05. The father works with auto repair and does not shower or change clothes after leaving work prior to having contact with the child. The mother provides part time in home child-care to five different 2-6 year old children. She has informed all parents of the recommendations of the Douglas County Health and Human Services (DCHHS) to have their children tested for BLL. Two of the children have been tested with results of EBLL <10ug/dl.

## Services Received

The parents do not qualify for any public assistance because they make between \$30,000-50,000 per year. The child, at 3 years of age had not received both early school intervention and behavior and developmental impairment evaluations. The home was inspected on the day of the visit and was found to have lead based paint. The home qualifies for soil excavation, window replacement from EPA Superfund. It was recommended that the parents seek the OPS early intervention for the child, and the behavioral and developmental impairment evaluation from Munroe-Meyer Institute.

## Discussion

It is clear that blood lead levels have fallen significantly over the last 40 years in some states in the United States and elsewhere in the developed world. Despite this fall in lead exposure, it could be argued that current baseline blood lead levels continue to constitute health risk for children residing in the 11 EPA designated zip codes as demonstrated by table 3 for the year 2003, and table 4 for the year 2004, showing the number of children tested and the trend of EBLL in Omaha. With the recent evidence demonstrating an inverse association between blood lead levels and cognitive function in children exposed to low levels of lead, there is no safety margin at existing exposures in Douglas County. Aggressive mandatory efforts to continue to test all children six years and under who reside in Omaha and the rest of the state in order to ensure minimization of childhood exposures is important.

The magnitude of the lead- I.Q. dose response relationship is small on a population basis and should be set against the far greater combined effect of socioeconomic status (SES) and quality of the care giving environment. Instead of "chasing after an ever receding lead threshold", attention and EPA funds should be focused on the more complex social ills that are associated with continued lead exposure in small segments of low level income housing in inner city minority populations in Omaha. Current lead exposure accounts for a very small amount of variance in cognitive ability (4%) from tables 3 and 4, whereas covariates such as social and parenting factors account for 40% or more (My clinical experience at Munroe-Meyer Institute).

Genetic predisposition can also effect vulnerability to lead-induced neurotoxicity. Lidsky and Schneider (2003) have recently reviewed this area of research and found out that three genes are currently believed to play a role in lead neurotoxicity: the ALAD gene, which codes for S (alpha) aminolevulinic acid dehydratase; the vitamin D receptor (VDR) gene; and the hemochromatosis gene coding for a defective protein known as HFE.

There are two types of ALAD protein, ALAD1 and ALAD2; lead has a higher affinity for ALAD2. Children with ALAD1 phenotype are more resistant to the effects of lead or behavior and attention than ALAD2 children. There are two types of alleles (b and B) and three variants of the VDR genotype, and among adults occupationally exposed to lead, b individuals have higher lead levels in blood and bone. Mutated HFE protein is known to cause hemochromatosis, in which large quantities of iron are deposited in internal organs. Because lead can be incorporated into processes requiring iron, polymorphisms, in HFE might be expected to influence lead absorption.

Figure 1

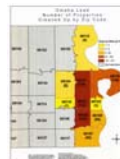


Table 3

| Zip Code | Year | Number of Children Tested | Number of Children with EBLL > 10 ug/dl |
|----------|------|---------------------------|---|
| 68102    | 2003 | 1                         | 0                                       |
| 68104    | 2003 | 4                         | 0                                       |
| 68105    | 2003 | 36                        | 10                                      |
| 68106    | 2003 | 9                         | 4                                       |
| 68107    | 2003 | 11                        | 3                                       |
| 68108    | 2003 | 6                         | 0                                       |
| 68110    | 2003 | 8                         | 0                                       |
| 68111    | 2003 | 35                        | 7                                       |
| 68112    | 2003 | 6                         | 2                                       |
| 68131    | 2003 | 3                         | 1                                       |
| 68134    | 2003 | 6                         | 1                                       |
| Total    | 2003 | 123                       | 28                                      |

Table 4

| Zip Code | Year | Number of Children Tested | Number of Children with EBLL > 10 ug/dl |
|----------|------|---------------------------|---|
| 68102    | 2004 | 1                         | 0                                       |
| 68104    | 2004 | 4                         | 0                                       |
| 68105    | 2004 | 36                        | 10                                      |
| 68106    | 2004 | 9                         | 4                                       |
| 68107    | 2004 | 11                        | 3                                       |
| 68108    | 2004 | 6                         | 0                                       |
| 68110    | 2004 | 8                         | 0                                       |
| 68111    | 2004 | 35                        | 7                                       |
| 68112    | 2004 | 6                         | 2                                       |
| 68131    | 2004 | 3                         | 1                                       |
| 68134    | 2004 | 6                         | 1                                       |
| Total    | 2004 | 123                       | 28                                      |