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Lead Toxicity and Flint, Michigan

Adam Bishop, Marvel Davis, Patricia Flatt

Abstract

In light of the recent events in Flint, Michigan this poster will review lead poisoning and its long term effects. We will be covering the multitude of sources of lead poisoning, the mechanisms by which lead does its damage, detection methods, treatment options, and limitations therein. The issues in Flint have highlighted the flaws in current acceptable detection procedures as well as brought to light the dangers of lead. Public concerns about clean drinking water have brought these issues to the forefront.

Sources of Lead Exposure

- Folk remedies and supplements/herbal treatments
- Ceramics
- Lead pipes/water
- Antique toys
- Lead paint
- Soil
- Occupation
- Cheap toys
- Some Mexican candies
- Leaded crystal
- Kohl: A Traditional Cosmetic



Figure 3: Sources of Lead
Figure Source: Diet.com

Testing and Acceptable Limits

Acceptable Limits

- Water:
 - 10% of water tested must exceed 15 ppb^[1]
- Blood:
 - 10 µg/dl for Adults
 - 5 µg for Children^[2]
- Soil:
 - 400 ppm in play areas
 - 1200 ppm in non-play areas^[3]



Figure 4: Adverse Health Effects of Lead Exposure
Figure Source: Canadian Environmental Health Atlas

Testing

- Venous blood level (BLL) testing is the recommended diagnostic tool to identify patient lead levels.
- Handheld X-ray Fluorimeter can be used to detect lead in paint on walls
- X-ray Fluorimeters can be used to detect lead in soil

Cities Affected

- Sebring, Ohio (2016)^[8]
- Travis County, Texas (2016)^[9]
- New Jersey (2016)^[7]
- Atlantic City
- Cumberland County
- East Orange
- Elisabeth
- Irvington
- Jersey City
- New Brunswick
- Newark
- Passaic
- Paterson
- Plainfield
- Salem County
- Trenton
- Flint, Michigan (2015)^[11]
- Jackson, Mississippi (2015)^[8]
- North Carolina (2006)^[8]
- Durham
- Greenville

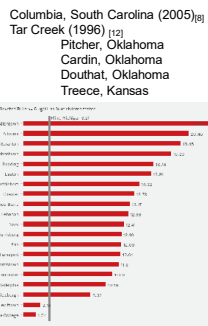


Figure 5: 18 Pennsylvania Cities with higher lead levels than Flint
Source: CBS - Pittsburgh

Methods and Mechanisms

Lead has the capability of passing the blood-brain barrier, causing edema. Intracellularly, lead replaces calcium as a second messenger, binding more readily than calcium, altering the protein's conformation. Intracellular concentrations of Ca²⁺ increase in two ways: opening the calcium channels in the cell membrane or release of stored calcium. Lead has a high binding affinity even at low levels, often higher than calcium itself.

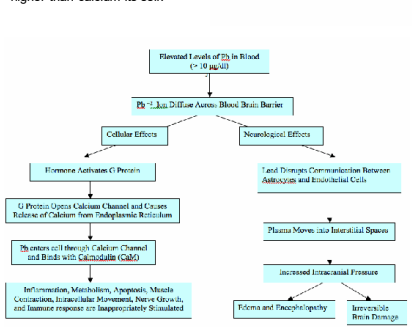
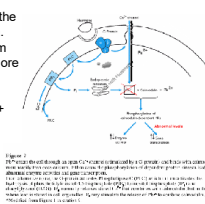


Figure 2: Pathway of Lead in the Brain
Source: Brochin, Robert. The Cellular Effect of Lead Poisoning and its Clinical Picture. Georgetown University-Jour Health Sciences (2008) Vol 5, No 2.

Symptoms and Toxicity

Symptoms

- Developmental delay
- Learning difficulties
- Irritability
- Loss of appetite
- Weight loss
- Sluggishness and fatigue
- Abdominal pain
- Vomiting
- Constipation
- Hearing loss

Newborns

- Exposure before birth:
 - Learning difficulties
 - Slowed growth

Adults

- High blood pressure
- Abdominal pain
- Constipation
- Joint pains
- Muscle pain
- Declines in mental functioning
- Pain, numbness or tingling of the extremities
- Headache
- Memory loss
- Mood disorders
- Reduced sperm count, abnormal sperm
- Miscarriage or premature birth in pregnant women

Source: Mayo Clinic. Lead Poisoning: Symptoms

Toxicity

By the time signs and symptoms appear people are typically already at toxic levels.

- Children
 - 1.98 µg/dL – greater peripheral resistance response to stress
 - PbB >20 µg/dL - Anemia
 - 60-100 µg/dL - Colic
 - 33-120 µg/dL - Decreased Vitamin D levels
- Adults
 - >10 ppm increased risk of high blood pressure^[14]



Figure 6: Symptoms of Lead Poisoning and Toxicity
Source: https://en.wikipedia.org/wiki/Lead_poisoning

Flint, Michigan

The Flint water crisis began in April of 2014 when local officials in the area switched the city's water source temporarily as a cost cutting move. The water source was switched from Lake Huron to the Flint River until the city could implement a new pipeline to Lake Huron. According to city officials the water piped from the river was to be treated at the local city water treatment plant, although the water did not receive the necessary treatment to make it safe for consumption. For almost two years now locals have unknowingly been exposed to high levels of lead in their drinking water. In a recent study done by a local pediatrician, the percentage of children tested and found to have elevated blood lead levels (above 5 µg/dl) in Flint had doubled from 2.4 to 4.9%. Recently the crisis in Flint, Michigan has come into the national spotlight with the Federal government declaring a state of emergency and the issue being a part of presidential debates.^[9]

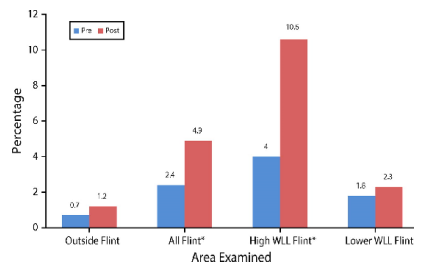


Figure 7: The percentage of children in each region with elevated blood lead levels (>5 µg/dL) in each region before and after switching the cities water source to the Flint River. (WLL= Water Lead Levels)
Source: Elevated Blood Lead Levels in Children Associated With the Flint Drinking Water Crisis: A Spatial Analysis of Risk and Public Health Response Authors: Mona Hanna-Attisha, MD, MPH, Jerry LaChance, MS, Richard Casey Sadler, PhD, and Allison Champney Schnepf, MD

A major issue in Flint, which also occurs across the nation, is that modifications were made to the EPA water testing procedures to lower the lead levels reported. The EPA calls for a minimum 100 of the most at risk homes to be tested for lead in a city; in Flint the least at risk homes were tested. The EPA procedures call for water samples to be taken from the first water to come out of the tap; in Flint, city officials called for the water to be run first to pre-flush the pipes before samples were taken. These modifications have made it so lead levels were never reported to be above the maximum acceptable level despite outdoor testing showing that lead levels in some homes had exceeded 10,000 ppb.^[10]

GETTING THE LEAD IN

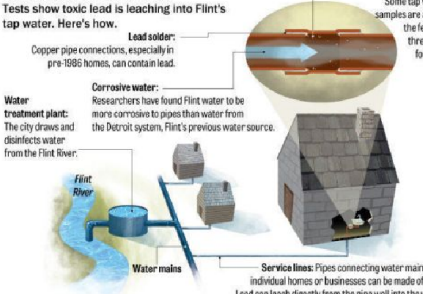


Figure 8: Getting The Lead In
Source: https://ethicalterms.files.wordpress.com/2016/01/how-lead-gets-into-1e9d798a-fede129.jpg?w=500&h=355

Treatment Options

Oral chelation therapies are used to lower blood lead levels, however they are not effective in removing lead from the bones, where lead can be stored. The effectiveness of chelation therapies to help those exposed to lead over long periods of time have been debated, and at the moment the only real effective treatment is to avoid exposure to lead altogether.

Severity	BLL	Treatment
Severe (medical emergency)	BLL of >70 mcg/dL or signs and symptoms of encephalopathy	Parenteral chelating agents reduce mortality from 65% to 30% • Dimercaprol 75 mg/m ² every 4 hours for 5 days as a deep intramuscular injection • Calcium disodium versenate 1000-1500 mg/m ² /day as a continuous infusion for 5 days
Moderate	45-69 mcg/dL without signs and symptoms of lead toxicity	• Oral succimer 350 mg/m ² 3 times a day for 5 days, then twice a day for 14 days, or • Parenteral agents • Succimer or D-penicillamine
Mild	5-44 mcg/dL	Succimer or D-penicillamine

Table: Lead Poisoning Severity and Treatment in Children
Source: https://s3.amazonaws.com/pharmcitymedia2/media_upload/imagelead2.jpg

Conclusions

In conclusion, we found that there are many hidden sources of lead in and around the house which can contribute to lead toxicity. We also found that there is limited testing available for lead toxicity and the acceptable lead limits in water are at a rate which that signs and symptoms of lead toxicity are already beginning to appear. Surprisingly toxically high levels of lead found in the blood of children are all over the United States dating back into the 1990s, with 29 more cities with higher rates than Flint showing up this year alone.

Lead passes through the blood brain barrier via the calcium channel causing a multitude of symptoms to occur due to its higher affinity of binding to the substrate than calcium. Since studies have shown that even low levels of lead cause a degree of toxicity, often before symptoms occur, signs and symptoms are often the last sign that toxicity has occurred.

The crisis in Flint, Michigan should be a teaching moment for all of us. City officials had knowingly modified the procedures for testing lead levels in water so as to artificially lower the levels they reported to the EPA. This is a shocking trend that is being seen across the country in cities that are strapped for cash. If lead testing procedures are continually allowed to be modified, we will continue to see high lead levels across our country. The best course of action would be for legislation to be passed creating a standardized procedure for lead testing that cannot be modified by individual cities

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