*Project S.E.N.S.O.R. News

Volume 27 No. 2 Spring 2016

Elevated Blood Lead Levels in Flint, Michigan

The news media has actively covered the story about the quality of the drinking water in Flint after the city switched the source of its drinking water on April 25, 2014 from Lake Huron to the Flint River to save money (1). A recently published paper (12/21/2015) in the American Journal of Public Health (Am J Pub Health) from Dr. Hanna-Attisha and colleagues at Hurley Children's Hospital and Michigan State University provides a peer-reviewed analysis of the extent to which children's blood lead levels increased after the water source change (2).

Initially after the switch in the source of drinking water, residents of Flint expressed concerns about the appearance, odor and taste of the water. In response to the identification of elevated bacterial contamination (fall 2014), increased chlorination was initiated which caused elevated levels of chlorine byproducts (trihalomethanes). Results released August 31, 2015 identified elevated lead levels in the water. Recognition that not only the water levels of lead were above the United States Environmental Protection Agency (US EPA) standard of 15 parts per billion (ppb) but that the blood lead levels of children in Flint had increased after the change in water source led to the emergency reconnection of the City of Flint water supply to the Detroit Water and Sewage Department's Lake Huron water source on October 16, 2015. The source of the lead in the City of Flint drinking water was not the Flint River but rather the lead in the pipes and solder in the City of Flint's water infrastructure. Because of the higher chloride and higher chloride-to-sulfide mass ratio, the Flint River water was more corrosive. The increased corrosiveness coupled with the failure to add a phosphate corrosive inhibitor to the water system after the switch in the water source caused the release of lead from the pipes and solder in the City of Flint's water infrastructure into its drinking water.

In the analysis in the Am J Pub Health, a comparison was made between the percentage of Flint children less than five years of age with elevated blood lead (≥ 5 µg/dl) before and after the switch of its water source to the Flint River. Overall for the entire City of Flint, the percentage of children with elevated blood leads increased after the water source switch, from 2.4% to 4.9% ($P < 0.05$). In the areas of Flint with the highest percentage of elevated water lead levels after the water source switch, the percentage of children with elevated blood lead levels increased from 4.0% to 10.6% ($P < 0.05$). Table I shows the percentage of children with elevated blood lead levels before and after the water source switch by the nine Flint wards; wards 5, 6 and 7 are considered the high level water lead wards because more than 25% of the samples from these wards were above the EPA standard of 15 ppb (2).

We conducted additional analyses looking at changes in blood lead levels in adults (≥ 16 years of age) for the Flint zip codes 48501 through 48507; these are the areas which received the City

Table I. Elevated Water Lead Levels and Pre- and Post- Water Source Elevated Blood Lead Levels among Children, by Ward: Flint MI

Ward	WLL%>15 ppb[a]	Pre EBLL%[b]	Post EBLL%[b]
1	10	0.0	2.8
2	25	0.0	1.4
3	18	1.0	4.5
4	6	3.1	1.7
5[c]	32	4.9	15.7
6[c]	28	2.2	9.3
7[c]	28	5.4	5.9
8	20	2.7	1.4
9	20	3.4	1.6

[a]WLL=water lead level
[b]EBLL=elevated blood lead level
[c]Wards defined as high WLL risk

(Adapted Hanna-Attisha et al, 2015)

Table II. Adults with Blood Lead Tests in Flint-Area Zip Codes 48501 - 48507, January 2014 - September 30, 2015

	January-March 2014	April-December 2014	January-September 30th, 2015
All Flint-Area Adults[a]	43	104	161
Average BLL[b]- All Tests (#)	2.8 (46)	3.1 (110)	2.6 (166)
Number ≥ 5 ug/dL	5	17	16
Average BLL All tests ≥ 5 ug/dL (#)	9.7 (6)	9 (20)	10.1 (16)
% Adults ≥ 5 ug/dL	11.6	16.3	9.9
Flint-Area Adults with a non-occupational and non-hobby source of exposure	34	88	143
Average BLL - All Tests (#)	1.8 (34)	2.1 (89)	2.2 (148)
Number ≥ 5 ug/dL	2	8	8
Average BLL All tests ≥ 5 ug/dL (#)	5 (2)	**5.4 (8)**	**9.1 (8)**
% Adults ≥ 5 ug/dL	5.9	9.1	5.4

[a]Represents a total of 322 blood lead tests for 290 adults.
[b] Blood Lead Level

of Flint drinking water (Table II). The percentage among all Flint-area adults with elevated blood lead levels (≥ 5 µg/dl) increased after the water source switch from 11.6% to 16.3%. Similarly, the percentage among Flint-area adults who had no identified work or hobby source of lead exposure increased after the water source switch from 5.9% to 9.1%. Neither increase was statistically significant.

A likely explanation for the lack of statistical significance among adults despite a similar change as that seen in children was the small number of adults tested for blood lead, thus limiting the statistical power. The increase in the percentage of adults with elevated blood lead levels was only seen in the first nine months after the switch, although there was a non-statistically significant rise in the average blood lead level from 5.4 to 9.1 µg/dl in the latter nine months among adults with no occupational or hobby source of lead exposure.

A possible explanation for not continuing to find an increased percentage of elevated blood lead in adults is that there may have been a resulting decrease in the use of the City of Flint water because of concerns about its quality.

The problem of lead in drinking water is not unique to Flint. Lead is a potential problem in any urban area with an aging water infrastructure. What makes the issue so dramatic in Flint is the change in water source and lack of provision to anticipate, identify and correct the corrosiveness of the new water source.

The abrupt change in water source in Flint allowed for the recognition of dangerous changes in blood lead levels; this would otherwise not normally be identified if there was an ongoing slow deterioration of a water infrastructure. As a society, we have significantly reduced human lead exposure by removal of lead from gasoline and consumer products and have instituted programs to remove lead paint from housing built before 1978. We anticipate that lead in drinking water from aging water infrastructures will increasingly account for a greater percentage of lead exposure among the general population. This will be particularly true for infants ingesting

formula made with tap water, who are not yet mobile and therefore do not yet have the potential to ingest paint chips or dust.

Work remains the source of 80% of elevated blood lead levels in adults from manufacturing work and recycling of lead storage batteries, work in brass and bronze foundries, removal of lead paint from housing built before 1978 and from outdoor structures (bridges and water towers), and work at firing ranges. Among the 20% of adults with a non-work-related source of lead exposure, the most common source of lead is from gun hobbyists using firing ranges, as well as casting and reloading bullets. The data from Flint would indicate that lead in drinking water can be a contributing source.

Lead is a cumulative toxin and a nonessential element that has no benefit to human physiology or metabolism. The occurrence of nephrotic, neurotoxic and vascular effects after long term low level exposure to lead are well documented in the medical literature (3). These adverse health effects emphasize the importance of minimizing lead exposures. A study performed by the University of Michigan prior to the awareness of lead in the Flint drinking water demonstrated the economic benefits of providing increased resources to perform lead paint abatement in Michigan to reduce lead exposure to children (See box below).

The determination of whether an individual has lead exposure is simple and relatively inexpensive. A venous blood sample is tested for exposure to lead. A blood lead test is recommended for children at ages one and two and should be considered in an adult based on work or a hobby that has been associated with lead or in a situation where there is concern about lead contamination in the drinking water. See reference 4 for a table summarizing lead management in adults.

Economic Impacts of Lead Exposure and Remediation in Michigan June, 2014

The University of Michigan Risk Science Center and the Michigan Network for Children's Environmental Health prepared an assessment of the economic impacts of lead poisoning among Michigan children. They concluded that the cost of lead paint abatement in Michigan, estimated to cost $600 million would have marked economic and public health benefits, would pay for itself in three to six years, and that over 30 years would provide $10.50 in benefits for every $1 spent.

The full report can be found at
https://assets.documentcloud.org/documents/2472249/lead-cost-report-mi-2014-smaller.pdf

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In this issue: v27n2 Elevated Blood Lead Levels in Flint

*PS *Remember to report all cases of occupational disease!*

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The Project SENSOR News is published quarterly by Michigan State University-College of Human Medicine with funding from the National Institute for Occupational Safety and Health and is available at no cost. Suggestions and comments are welcome.

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