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The Flint Water Crisis: A Coordinated Public Health Emergency Response and Recovery Initiative

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Abstract

Context: The City of Flint was already distressed because of decades of financial decline when an estimated 140 000 individuals were exposed to lead and other contaminants in drinking water. In April 2014, Flint's drinking water source was changed from Great Lakes' Lake Huron (which was provided by the Detroit Water and Sewerage Department) to the Flint River without necessary corrosion control treatment to prevent lead release from pipes and plumbing. Lead exposure can damage children's brains and nervous systems, lead to slow growth and development, and result in learning, behavior, hearing, and speech problems. After the involvement of concerned residents and independent researchers, Flint was re-connected to the Detroit water system on October 16, 2015. A federal emergency was declared in January 2016.

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Program: The Centers for Disease Control and Prevention provided assistance and support for response and recovery efforts including coordinating effective health messaging; assessing lead exposure; providing guidance on blood lead screening protocols; and identifying and linking community members to appropriate follow-up services. In response to the crisis in Flint, Congress funded the Centers for Disease Control and Prevention to establish a federal advisory committee; enhance Childhood Lead Poisoning Prevention Program activities; and support a voluntary Flint lead exposure registry. The registry, funded through a grant to Michigan State University, is designed to identify eligible participants and ensure robust registry data; monitor health, child development, service utilization, and ongoing lead exposure; improve service delivery to lead-exposed individuals; and coordinate with other community and federally funded programs in Flint. The registry is also collaborating to make Flint “lead-free” and to share best practices with other communities.

Discussion: The Flint water crisis highlights the need for improved risk communication strategies, and environmental health infrastructure, enhanced surveillance, and primary prevention to identify and respond to environmental threats to the public’s health. Collecting data is important to facilitate action and decision making to prevent lead poisoning. Partnerships can help guide innovative strategies for primary lead prevention, raise awareness, extend outreach and communication efforts, and promote a shared sense of ownership.

Keywords

drinking water; Flint; lead poisoning; public health response

Context

Prior to the decision by a state-appointed emergency manager to switch the water source to the Flint River in an effort to cut costs, the residents of Flint were impacted by many factors that negatively affected a wide range of health and development risks and quality-of-life outcomes.¹ Once an industrial center with the highest median income for young workers in the nation,² Flint had been in crisis for decades due to multiple socioeconomic factors such as disinvestment, unemployment, racism, poverty, violence, food insecurity, and depopulation. About 43% of the population lived in poverty, 45% of homes were renter-occupied, only 11% of the population had a bachelor’s degree or higher, and almost 13% of persons younger than 65 years were without health insurance.³ In addition, just as in many low-income and minority urban centers, children in Flint were already at increased risk for lead exposure because of older and deteriorated housing stock and poor nutrition.⁴

Flint water crisis

Recognizing no safe level of exposure to lead has been identified, the US Environmental Protection Agency’s (EPA’s) health-based maximum contaminant-level goal for lead in water is 0 parts per billion (ppb).⁵ However, the non-health-based action level of 15 ppb is set as a feasibility goal: 90% of a water system’s samples must be below 15 ppb to comply with the Lead and Copper Rule.⁶ When Flint’s drinking was switched from treated Lake Huron water provided by the Detroit Water and Sewerage Department to the Flint River water source (FWS) on April 25, 2014, it was not treated properly to prevent corrosion. Lead

levels in Flint tap water increased above the action level of 15 ppb.⁷ Protective scales inside pipes can destabilize if corrosion inhibitors are not used. This mobilizes lead from leaded pipes and lead, iron, zinc, and cadmium from galvanized pipes, thus causing the concentration of lead in water to increase.⁸ Flint's untreated corrosive water flowed through an aging and oversized water distribution system that was built, like most cities, prior to the restriction of lead in service lines (1986) and lead in brass fixtures (2014).⁹

Childhood lead exposure can result in damage to the brain and nervous system; slowed growth and development; learning and behavior problems; and hearing and speech problems.⁶ A well-studied neurotoxin, there is no known safe level of lead in children as even very low levels of lead can result in adverse health effects.¹⁰ In adults, exposure to lead can increase risk for high blood pressure, heart disease, kidney disease, and reduced fertility.⁶

Shortly after the switch to the FWS in April 2014, residents raised concerns about the color, odor, and taste of their water as well as concerns about rashes they attributed to the water change.¹¹ In response to bacterial detection, the City of Flint issued boil water advisories in August and September 2014 while also boosting chlorine levels. In October 2014, the General Motors assembly plant in Flint announced that it was switching from the FWS back to Lake Huron water because of the corrosive effect the FWS water was having on its engine parts.¹² On January 2, 2015, the city issued a water advisory because total trihalomethane concentrations, which are known carcinogenic disinfection by-products, exceeded federal limits. In January 2015, testing by the University of Michigan-Flint revealed elevated lead levels in their water.¹³ Two outbreaks of Legionnaires' disease in 2014–2015, in which 12 people died and 79 people became ill, coincided with the water source switch. Re-searchers eventually linked 80% of the Legionnaires' cases to a decline in chlorine levels in the FWS secondary to iron corrosion.¹⁴ Residents continued to raise concerns about the quality of the water prompting the involvement of journalists, the EPA, and independent researchers.¹¹

In September 2015, environmental engineer Dr Marc Edwards from Virginia Tech, working with citizen scientists, reported that residential water samples throughout Flint had high lead levels. Lead in one sample collected after 45 seconds of flushing was greater than 1000 ppb, which is almost 70 times the EPA drinking water action level.¹⁵ On September 24, 2015, Dr Mona Hanna-Attisha, a Flint pediatrician at Hurley Medical Center and Michigan State University (MSU), publicly reported an increase in the percentage of blood lead levels (BLLs) of 5 $\mu\text{g}/\text{dL}$ or greater (the CDC reference value) in children 5 years of age and younger after the water switch and urged for precautions including a health advisory and a return to treated Great Lakes water.^{4,11} The following day, the City of Flint issued a lead advisory urging residents to flush their tap water and use only cold water for drinking, cooking, and making baby formula. The Genesee County Health Department, where Flint is located, declared a public health emergency on October 1, 2015. After 18 months on untreated corrosive water, Flint was reconnected to Great Lakes water provided by the Detroit Water and Sewerage Department on October 16, 2015. However, the severely corroded pipes and plumbing continued to release lead into the drinking water.^{16–18}

Emergency response

The Flint mayor declared a state of emergency on December 14, 2015, followed by the governor of Michigan declaring a state of emergency for Genesee County on January 5, 2016.^{19,20} President Obama issued an emergency declaration on January 16, 2016, and the US Department of Health & Human Services (HHS) was designated as the principal federal agency of the Unified Coordination Group for response and recovery efforts.²¹ The HHS, including the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry (CDC/ATSDR), worked with the city and the state to develop a response and recovery plan, and CDC's Emergency Operations Center was activated from February 1, 2016, to March 15, 2016, to coordinate the response.

The CDC/ATSDR assisted the state of Michigan with (1) coordinating effective health messaging; (2) assessing lead exposure in the community; (3) providing guidance on blood lead screening protocols; and (4) identifying and linking community members to appropriate educational, social, and environmental follow-up services. The CDC staff assisted the Genesee County Health Department with processing BLL tests and contacting families with children who had elevated lead levels to ensure that they received necessary services. The CDC conducted a Community Assessment for Public Health Emergency Response (CASPER), which is an epidemiologic tool designed to quickly collect information about a community's needs following a disaster, during May 17 to 19, 2016, to evaluate potential behavioral and physical health effects and assess water-related resource needs, barriers to accessing care, and risk communication.²² More than 50% of households reported that at least 1 member had "more behavioral health concerns than usual" since October 2015 and that behavioral health services were needed. About 50% of households reported that at least 1 member believed that his or her physical health was worse because of the water source switch with skin rashes being the most common condition reported.

As part of the Federal Unified Coordination Group, the CDC/ATSDR investigated reports of rashes and other skin conditions that residents attributed to the water in order to better understand and characterize the cases, explore possible causes, and make recommendations for interventions.²³ Between January 29 and May 11, 2016, individuals previously exposed to the FWS with current or worsening onset of rashes after October 15, 2015, were (1) identified and administered a questionnaire to assess the characteristics of the rashes and tap water usage; (2) asked to provide tap water samples from their homes; and (3) evaluated by a local dermatologist who was blinded to the water-quality data. Investigators also reviewed historical water-quality data reported by the FWS. The investigation found that more than 77% of respondents reported that their rash began at the same time they noticed changes in water color, odor, or taste. Dermatologists classified rashes in about 80% of respondents as being possibly related to the tap water. However, no water-quality parameters at the time of the investigation (after switch back to treated water) were identified as a possible cause of the rashes. In addition, the water samples did not show any clear pattern of contamination or specific water-quality parameters in sampled homes.

Water testing conducted by EPA in spring 2016 confirmed that National Sanitation Foundation (NSF) International-approved point-of-use filters effectively removed or reduced lead to levels below 15 ppb. Despite unfiltered water-lead level levels that exceeded

the NSF filter clearance limit (150 ppb), some by several orders of magnitude, most filtered water samples had concentrations less than 1 ppb.²⁴ Water samples were collected from locations likely to have lead-contaminated water (eg, buildings with lead service lines [LSLs] and galvanized plumbing) and from locations with vulnerable populations (eg, residences with pregnant mothers and/or children). These results confirmed the results of previous testing conducted by Virginia Tech and NSF International.

To validate the earlier conclusions of Hanna-Attisha et al⁴ and to help guide appropriate interventions, the CDC/ATSDR analyzed BLLs of 5 $\mu\text{g}/\text{dL}$ or greater of a larger sample size derived from Michigan's Childhood Lead Poisoning Prevention Program (CLPPP) surveillance data. Among 7306 children younger than 6 years of age before, during, and after the switch in water source, the percentage of BLLs of 5 $\mu\text{g}/\text{dL}$ or greater increased from 3.1% to 5.0% during the early period after the switch (defined as the time after the switch to FWS, but before the water advisory was issued [April 25, 2014, to January 2, 2015]) compared with before the switch (defined as April 25, 2013, to April 24, 2014).²⁵ After the water switched back to Lake Huron water, the percentage of BLLs of 5 $\mu\text{g}/\text{dL}$ or greater returned to levels similar to before the switch. To determine risk of ongoing lead exposure after emergency declaration, the CDC recommended that all Flint children younger than 6 years receive blood lead testing if they had not had a blood lead test since October 2015.²⁵ The CDC also recommended that children with BLLs of 5 $\mu\text{g}/\text{dL}$ or greater should receive outreach and individual case management focusing on water and other potential sources of lead exposure.

Long-term recovery efforts

As a result of the sustained community involvement, intense media attention, and support from policy makers, the Water Infrastructure Improvements for the Nation Act of 2016 was passed. This legislation authorized the HHS agencies to take actions to support the Flint recovery and put infrastructure in place to assist lead poisoning prevention programs.²⁶ The CDC received \$35 million to (1) establish a new federal advisory committee; (2) enhance CLPPP activities; and (3) support the development of a voluntary Flint lead exposure registry.

The 2016 Water Infrastructure Improvements for the Nation Act authorized the Secretary of HHS to establish a new Lead Exposure and Prevention Advisory Committee (LEPAC) under the requirements of the Federal Advisory Committee Act of October 2, 1972. The Lead Exposure and Prevention Advisory Committee is charged with reviewing federal programs and services available to lead-exposed individuals and communities; reviewing current research on lead poisoning to identify additional research needs; reviewing and identifying best practices, or the need for best practices, regarding lead screening and the prevention of lead poisoning; and identifying effective services for individuals and communities affected by lead exposure.²⁷

In addition, the CDC received funding to enhance CLPPP activities that allowed the CDC to support 14 newly funded state and local health departments through cooperative agreements. These awards are aimed at strengthening blood lead testing, surveillance, processes to link lead-exposed children to appropriate services, and population-based interventions.

A 4-year, nonresearch grant was awarded on August 1, 2017, to a consortium of investigators from MSU, the Greater Flint Health Coalition, the City of Flint, and others, which was led by Dr Hanna-Attisha at MSU. The grant established a lead exposure registry to collect data on a voluntary basis from residents who were exposed to the Flint water between April 25, 2014, and October 15, 2015. The Flint Registry (www.flintregistry.org), building upon a registry-planning grant awarded to MSU by the Michigan Department of Health & Human Services in January 2017, aims to (1) identify eligible participants and ensure robust registry data; (2) monitor health, child development, service utilization, and on-going lead exposure; and (3) improve service delivery to lead-exposed individuals.

The Flint Registry is a collaborative community-participatory effort that brings together many diverse partners to synergistically accomplish the registry's goals. The registry structure includes a leadership team; an external advisory board with expertise in lead exposure, environmental justice, and informatics; parent partners, youth advisory council, and community advisory board; a marketing and communications team; and a public health law team. Work groups on various aspects of the registry include Flint residents and representatives from the Michigan Department of Health & Human Services.

Registry implementation

Recognizing the population-wide exposure, the Flint Registry eligibility criteria target individuals who lived, worked, or attended daycare or school at an address serviced by FWS from April 25, 2014, to October 15, 2015, including pregnant women and their prenatally exposed offspring. Based on geo-graphic, census, education, state, and employment data, an estimated 140 000 individuals were exposed to the Flint water and met the registry eligibility criteria. For the highest risk groups including children and residents of Flint, population-based lists identify potentially eligible people for direct mail and telephone recruitment. Recruitment strategies also include a multimedia publicity and outreach campaign leveraging community partners. Several data challenges exist including the number of partners and sources; existing laws and prerequisites for sharing and protecting data; different methods of transferring and exchanging data; and specific elements of obtaining consent.

The Flint Registry aims to enroll at a minimum 20 000 registrants (approximately 1200 per month). The Flint Registry launched a preenrollment phase in January 2018, and in the first 4 months, more than 1000 adults and children had preenrolled. The preenrollment period offered another avenue for community feedback in addition to advisory, stakeholders, and focus groups. Preenrollment also sought to identify perceived barriers to participation; strategies were then developed to overcome those barriers. Enrollment started in fall 2018 and consists of a tiered consent process; a baseline survey that screens for health and development concerns, service utilization, and on-going lead exposure and triggers referral to needed services; and follow-up surveys that will be administered about 12 months after the baseline survey.

A major emphasis of the registry is assessing service needs and eligibility of all registrants and referring them to appropriate services to promote health, development, and lead elimination. A custom community referral software platform allows the registry to directly

connect registrants with service agencies. Community service providers record referral outcomes in the platform, making the referral process a closed feedback loop with trackable metrics.

The Flint Registry will ascertain the registry's impact by assessing eligibility, service needs, and referrals and by tracking and evaluating improvements in health and developmental outcomes. Short-term goals include increasing community awareness of the registry and providing training on the impact of lead on health. Longer-term goals include determining self-reported barriers to use of preventive services, increasing use of preventative services and lead elimination services among registrants, and evaluating associations between specific preventive services and health, behavior, and functional status outcomes. Medicaid encounter data will be used to help track outcomes.

“Flint lead-free” initiative

The Flint Registry consortium includes a diverse set of public, private, and nonprofit members, stakeholders, and partners including property managers, housing organizations, legal services, community organizations, foundations, and city/county/state government striving to make Flint a lead-free city by 2022. The program's primary prevention focus seeks to identify service gaps, strategically align resources to accomplish their mission, and determine cost-effectiveness of local lead elimination. Flint is uniquely positioned to eliminate lead exposure because of a confluence of factors: ongoing LSL removal, the initiation and completion of home investigations and abatement, and community-wide engagement and awareness.

The Flint Action and Sustainability Team Start Pipe Replacement Program is renovating the city's aging water system with federal and state funding by re-moving and replacing LSLs in an estimated 30 000 homes, and Habitat for Humanity is replacing corroded lead-based fixtures in eligible owner-occupied properties.^{28,29} Achieving the lawsuit-mandated pipe replacement by 2020 would make Flint the third US city to have accomplished replacing all LSLs.^{30,31}

“Flint Lead Free” will track progress of both the Greater Flint Health Coalition's elevated blood lead environmental inspection and abatement program and the Michigan Department of Health & Human Services Lead Safe Home Program. The Lead Safe Home Program uses Centers for Medicare & Medicaid Services Children's Health Insurance Program funds for lead inspection and abatement.^{32,33} It is an example of an innovative approach to protect low-income children from exposure to lead before blood lead detection. Both programs provide environmental lead testing and lead hazard control to eligible families. Tracked metrics include the number of environmental investigations completed; the number of homes identified for abatement; and the number of homes abated. Working with state and local partners, other tracked metrics include the number of children with BLLs above the CDC reference value, the number of existing and replaced LSLs, the number of water tests greater than 10 ppb, and ultimately the economic return on investment of lead elimination.

Discussion

The Flint water crisis highlights the need for targeted risk communication strategies, improved environmental health infrastructure, enhanced surveillance, and primary prevention to identify and respond to the often invisible, disparate, and preventable environmental threats to the public's health. It has also created a unique opportunity for a diverse group of stakeholders to contribute to policy development.

Increased attention on childhood lead exposure in Flint prompted the Flint Medicaid Waiver expansion that allows for coverage of children younger than 21 years and pregnant women who were impacted by the Flint water system and whose income levels are up to 400% of the federal poverty level.³⁴ The waiver provides these additional groups with access to doctors, behavioral health specialists, nutrition support, and other education and social services. Furthermore, increased attention on childhood lead exposure in general has resulted in additional support for CDC's CLPPP. The CDC has used the additional funding to expand lead poisoning prevention activities with a goal of re-establishing a robust national program to conduct blood lead surveillance at the state/territorial/tribal/local level, support referral systems for appropriate follow-up services, and implement prevention activities. This cross-sector and multiagency effort further seeks to bridge the many jurisdictions involved in lead exposure and control.

The Flint Lead-Free initiative has the goal of becoming a model lead-free city by 2022. Leveraging new and existing resources is key to achieving this milestone in Flint and elsewhere. The Lead Service Line Replacement Collaborative is an example of a successful multi stakeholder resource to help with community-specific voluntary full LSL replacement.³⁵

A comprehensive framework for lead elimination that incorporates both community and scientific involvement and broad perspectives will help further this goal. Ongoing education among policy makers about the effectiveness of infrastructure improvements and prevention of lead exposure can help sustain this momentum.

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This evaluation was reviewed and deemed nonhuman subjects research by the Centers for Disease Control and Prevention Institutional Review Board.

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Implications for Policy & Practice

- Centers for Disease Control and Prevention notice of funding opportunity to support Flint emphasized the importance of collecting data that facilitates action and decision making for the prevention of lead poisoning.
- The Flint Registry was granted public health authority status by the CDC, which has facilitated data-sharing agreements by allowing entities to share data with the registry without obtaining individual authorization.
- Partnerships between private, public, and nonprofit organizations provide opportunities for collaboration that can help guide innovative strategies for primary lead prevention, raise awareness, extend outreach and communication efforts, and promote a shared sense of ownership.³⁶