PREVENTING THE NEXT FLINT

Learning from the Public Policy Lapses That Led to Water Contamination in the Mid-Atlantic Region

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HEALTH POLICY OUTCOMES THAT IMPROVE THE QUALITY OF HEALTH CARE
RESEARCH CONSORTIUM

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INTRODUCTION

There were many hazards present in municipal water supplies at the turn of the 20th century, but it soon became clear that appropriately-treated tap water would have a significant impact on the public's health. Not only did improving water safety improve health, this public health practice raised life expectancy[1] by a decade in little more than a quarter century.

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Cutler and Miller concluded that clean water technologies have, over time, played a "…strikingly large and cost-beneficial role…" in reducing mortality in the United States[2] (Cutler and Miller, 2004). They estimated that half of the total mortality reduction in major cities in early 20th century America, three quarters of the reduction in infant mortality, and two thirds of the reduction in child mortality could be attributed to clean water technologies. The purpose of this issue brief is to highlight the urgent need to protect the infrastructure that ensures the delivery of safe drinking water, drawing lessons learned from water contamination crises in the Mid-Atlantic region, and more recently, in Flint, Michigan.

The ongoing (as of September, 2017) crisis in Flint[3] is by now well-known. Michigan state authorities, who, at the time, were responsible for Flint's drinking water, decided to switch the city's water source from Detroit to the Flint River to save money. Unfortunately, no work was done to prevent the river's water from corroding the pipes, which resulted in lead leaching into the water supply. Devastating health consequences followed, despite repeated assurances from the state that the water was safe for human consumption.

Potential Water Quality Hazards

Community water systems can be contaminated by micro-organisms, and the following are the most common, according to the Centers for Disease Control and Prevention (CDC): Giardia; Legionella; Norovirus; Shigella; E. coli; Campylobacter; Salmonella; Cryptosporidium. [4] [5] In addition to lead, there are also inorganic contaminants such as arsenic, cadmium, chromium, mercury, nickel, selenium, and thallium, and organic contaminants such as pesticides, chlorinated solvents, and industrial waste (such as from the manufacture of plastics) that could contain carcinogens such as benzene.

The following are potential sources of lead in a home setting: lead solder, brass faucets/fittings (which can contain up to 8% lead), and galvanized iron pipes. Harmful health effects following exposure to lead vary from headaches and skin rashes to neurotoxicity that can result in lost IQ points and irreversible brain damage. Long term consequences could also include reproductive challenges and multiple organ failure.

Contaminated Water

Why So Many Lead Pipes?

The public health community has been concerned about the health effects of lead for over a century. The *American Journal of Public Health* (AJPH), for example, published an article[6] in 1923 indicating the New Hampshire Board of Health's interest in testing the State's drinking water for lead. The author highlighted that as far back as 1901 "New Hampshire physicians had displayed a lively interest in the subject of lead poisoning from drinking water." [7]

As recently as 2000[8] and 2008[9], *AJPH* published retrospectives about how those early concerns would be overpowered by the sophisticated lobby of the lead industry. The 2000 commentary focused on an advertising campaign by the lead industry to encourage the use of lead-based paint in the United States during the first half of the twentieth century, even though many countries had already banned their use for interior painting due to health concerns. The 2008 commentary catalogued the history of lead in water pipes. From the 1890s when the Massachusetts State Board of Health advised the state's cities and towns against the use of lead pipes, to the 1920s when many water authorities concluded that the engineering benefits of using lead in water pipes outweighed the health risks, to the 1970s when the lead pipe manufacturers would actively lobby local, state and federal officials to promote their products, lead manufacturers consistently sought new markets, and always responded aggressively to declining market share.

The power and influence of this lobby[10] had been honed, nationwide, in the 1930s, when the Lead Industry Association (LIA) mounted efforts to pressure local and federal officials and master plumbers and their professional

Increased understanding of toxicology and pathogenic bacteriology led to empirical evidence that many heavy metals (including lead), microbes, and other contaminants are very harmful to human health.

associations to install their products. If changing the building codes was what was necessary, then that's what the group would advocate. Their tactics would also include association staff making personal visits to federal construction sites to persuade those in charge to use lead pipes. Many of these pipes are still in the ground.

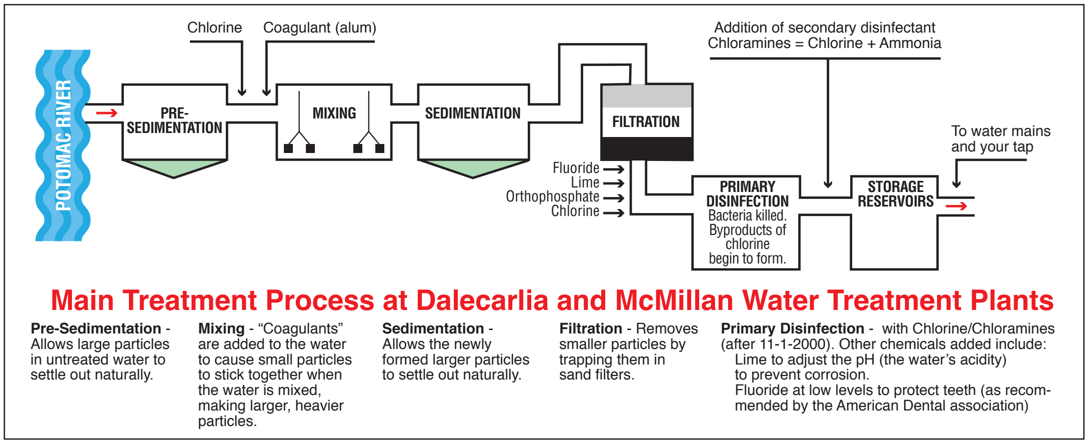
Science and Technology Advances

Increased understanding of toxicology and pathogenic bacteriology led to empirical evidence that many heavy metals (including lead), microbes, and other contaminants are very harmful to human health. Targeted public policy followed, including the push to eliminate lead from gasoline, paint, and water pipes, and the invention of water filtration and purification methods to remove heavy metals and harmful microorganisms from municipal water supplies. These activities resulted in a major triumph in public safety and health.

Researchers trace the beginning of the modern practice of public health to a cholera outbreak in London in 1854. The source of the outbreak resulted from a cholera-infected water pump on Broad Street, the source of drinking water for everybody in that neighborhood. Cholera causes violent diarrhea that can lead to dehydration, shock, and ultimately death within hours if left untreated. The local physician who made the discovery, John Snow, went on to become an epidemiology and anesthesiology pioneer who helped blaze the trail for creating municipal water and sanitation systems that would soon proliferate across the industrialized world.

By the 1890s effective water filters for municipal use had been invented and were being introduced in major cities. Cutler and Miller note the rapid expansion in the number and scale of municipally-owned (and operated) water systems at the turn of the twentieth century, the benefits of which were not limited to disease reduction, but also included "improved capabilities of combating fires."[11] Clean water technologies such as water filtration, water chlorination, primary sewage treatment, and sewage chlorination were considered cutting edge, and became more commonplace as studies began to show their utility among populations greater than 100,000 people.

Figure 1: Modern Drinking Water Treatment and Distribution



Source: DC Water

Infrastructure

Many of these early twentieth century systems are now at least a century old and nearing the end of their useful life.[12] The American Society of Civil Engineers (ASCE) reported in an assessment in 2013 of the nation's drinking water infrastructure, that approximately 240,000 water mains break every year in America. The most urgent of these repairs, however, would cost about $1 trillion, according to the American Water Works Association[13] (AWWA). AWWA stated that "delaying the investment can result in degrading water service, increasing water service disruptions, and increasing expenditures for emergency repairs."

ASCE was careful to note, however, that despite the age of these systems "outbreaks of disease attributable to drinking water are rare." This assertion begs the question – given the ongoing water-contamination crisis in Flint, Michigan, and the fact that many of the same risks are present nationwide – how much longer will we be able to make that claim?

The ASCE's assessment was summarized in a report card, and our nation's drinking water systems were assigned an overall grade: D. The report card evaluated 'conditions and capacity', 'investment and funding', and 'success stories', and their conclusion was followed by a shortlist of potential approaches for improving the system, including:

- Raise awareness for the true cost of water.
- Eliminate the state cap(s) on private activity bonds for water infrastructure (in 2011 the cap was the greater of $95 per resident or $277.82 million).
- Establish a Water Infrastructure Trust Fund (a la the Highway Trust Fund).

The U.S. Environmental Protection Agency (EPA) completed their most recent review[14] of the nation's drinking water infrastructure, also in 2013, but their estimate came in much lower than AWWA's. Their forecast called for $384 billion investment to ensure safe drinking water for 297 million Americans between now and 2030. This estimate took into account 734,000 water systems nationwide, including American Indian and Alaska Native Village water systems. EPA's estimate included the need to upgrade:

- *Distribution and transmission*, to refurbish aging pipes ($247 billion);
- *Treatment*, to reduce the risk of water contamination ($72.5 billion);
- *Storage*, as in reservoirs ($39.5 billion);
- *Source protection*, as in wells, springs, and intake structures: ($20.5 billion).

It is worth noting the EPA's estimate would require much less investment, especially given the fact that AWWA's estimate was mostly about pipes, and not the other aspects necessary to ensure that the water is potable and disease-free.

How Science and Technology Helped Inform and Shape Public Policy

Some trace the history of bacteriology back to the invention of the microscope late in the 17th century, which made formerly invisible microbes visible to the naked eye. The understanding of bacteria and other microorganisms, and their link to disease, would come much later. The work[15] of scientists and physicians like Ferdinand Cohn, Louis Pasteur, Robert Koch, and Edward

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Jenner helped society understand the particular conditions under which bacteria grow and spread. They also discovered how the illness caused by bacteria could be stopped by processes that killed them or inhibited their growth. This helped to replace a preceding theory of disease, the 'miasma' theory[16], which held that a foul-smelling poisonous vapor (miasma) - in which were suspended particles of decaying matter - was responsible for the many diseases that prevailed during the centuries that the theory held sway. In fact the disease malaria got its name from *mala aria*, the Italian phrase that means, literally, 'bad air'.

The miasma theory seemed reasonable during the early industrial period, which created many malodorous neighborhoods that smelled better once the sanitation and housing conditions improved. Local authorities did not recognize at the time that their efforts were in fact disinfecting those neighborhoods and homes by killing (or otherwise inhibiting) the growth of disease-causing bacteria.

Given the John Snow discovery it made sense to avoid microbial contamination of drinking water, especially if it were delivered on a utility scale to large populations. Governing authorities understood the potential consequences for failure to achieve that goal, i.e. the likelihood of an epidemic being more costly to contain than to prevent, and potential loss of life.

Cutler and Miller remind us however that these large scale municipal water systems "pre-dated a correct understanding of waterborne disease", meaning that these systems were forced to adapt as knowledge increased.

The basic policy challenges to be met have not changed over the decades, and meeting them is not a linear or sequential proposition.

The following challenges highlight the complexity of this public health concern:

- **Defining** water quality standards (i.e. how clean is clean?);
- **Determining** which technologies are best positioned to facilitate the achievement of quality standards (i.e. which process will make our water the cleanest it can be?);
- **Optimizing** data collection to inform oversight, evaluation and improvement of these systems (i.e. how long does our water stay clean, and how many people get sick from drinking it?);
- **Understanding** the impact of clean water interventions on health outcomes (i.e. clean water reduces the disease burden by how much?);
- **Quantifying** the socioeconomic benefits of clean water, to make the case that clean water is worthy of society's investment (i.e. what is society's return on the investment in clean water?).

As with any population-level enterprise the need for capable leadership cannot be over-stated, given the need to bring together competing priorities and constituencies, the imperative to modify calcified corporate and civic cultures, and the ongoing fundraising necessary to support and enable the capacity and infrastructure upgrades necessary to keep our water safe for human consumption. Such leaders as legislators, governors, mayors, water utility managers, quality enforcement officers, and public health practitioners all play a leadership role in ensuring public health and safety via safe drinking water.

LEGAL AND PUBLIC POLICY FRAMEWORKS FOR KEEPING OUR WATER SAFE

Clean Water Act

The Clean Water Act[17] (CWA) regulates the discharges of pollutants into the nation's waterways and regulates quality standards for surface waters, with elaborate enforcement mechanisms for which the states are partly responsible.

EPA's Lead and Copper Rule

The Lead and Copper Rule[18] (LCR) was formulated to control lead (Pb) and copper (Cu) in drinking water, applicable especially to water utilities.

Reduction of Lead in Drinking Water Act

The Reduction of Lead in Drinking Water Act[19] (RLDWA) regulates the Pb content of pipes and plumbing fixtures. States are expected to have their own testing mechanisms.

Safe Drinking Water Act

Enacted 1974, and amended 1986 and 1996, the Safe Drinking Water Act[20] (SDWA) was designed to protect drinking water and its sources nationwide, except for private wells that serve less than 25 people.

SDWA authorizes EPA to set health-based standards for drinking water, to protect against man-made and naturally occurring contaminants. 1996 amendments to the law focused on protection of water sources, operator training, funding for water system improvements, and public information. Specifically, the 1996 amendments called for the following products: Consumer Confidence Reports[21] (Arlington's[22] 2014 report, for example, alerts customers re the age of their pipes, and potential for corrosion), Cost Benefit Analysis, Drinking Water State Revolving Fund, Stage 1 Disinfectants and Disinfection Byproducts Rule and the Interim Enhanced Surface Water Treatment Rule, Operator Certification, Public Information and Consultation, Source Water Assessment Program, and support for Small Water Systems.

EPA sets the standards (via National Primary Drinking Water Regulations) and gives states assistance and guidance to help them meet these standards, but the direct oversight of the water systems in each state is a state responsibility. States can apply to EPA for "primacy", which is the authority to implement SDWA within their jurisdictions. All states except Wyoming and the District of Columbia have applied for, and received, said primacy. The main condition for receiving primacy was that each state demonstrated that it would adopt water quality standards equal to or more stringent than the federal standard.

The EPA sets the following barriers against pollution: source water protection, treatment, distribution systems integrity, public information. Water suppliers are expected to notify their customers when quality standards are compromised. Suppliers interact with the public via citizens' advisory committees, rate boards, and volunteers, and many states and localities require utilities to provide annual reports about the quality of the water.

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Beyond the financing of infrastructure and treatment there is also the responsibility for defining and enforcing water quality standards.

National water quality standards are legally enforceable, i.e. EPA and/or the states can take legal action against water systems that compromise water quality standards. According to an analysis of federal data by the *New York Times* in 2009 at least 20% of the nation's water systems are in violation of the SDWA every year, but the same analysis showed that fewer than 6% of state or federal officials responsible for these systems are ever punished for breaking the law.[23] It is remarkable then that a few state and local officials will now face criminal charges in Michigan for the lead contamination that led to the crisis in Flint. These felony and misdemeanor charges include tampering[24] with evidence, such as misrepresenting the source of water samples for quality testing.

State Responsibility

The Drinking Water State Revolving Loan Fund (DWSRF)[25] was established in 1996 (see previous section). As a partnership between EPA and the states, it serves as a financial assistance (dependent on Congressional appropriation) program to help states meet the standards of SDWA. Specifically, the states, which provide a 20% match to the federal investment in the fund, use the assistance to improve: drinking water treatment (at the source and throughout the supply chain) and distribution (replace pipes and water storage tanks). Over time, the Fund has provided more than $27.9 billion to the states for these projects, according to the EPA.

EPA awards each state their share of the Fund based on each state's Drinking Water Infrastructure Needs Survey and Assessment[26]. The states are then free to provide financial assistance to their water systems by various means, including loans, bond insurance, and refinancing, at the most favorable interest and repayment rates possible.

Beyond the financing of infrastructure and treatment there is also the responsibility for defining and enforcing water quality standards. The following is a summary of those standards in the Mid-Atlantic region.

SAFE DRINKING WATER STANDARDS

Some jurisdictions, like the District of Columbia, consider the federal standards inadequate. Another notable difference between standards is that enforcement regimes vary, usually relative to resource allocation. The notes below highlight a few aspects that make each jurisdiction in the region unique, as well as underscores the fact that most of them adhere to a "reasonable" standard of water quality that prioritizes public health and safety.

MARYLAND

The purpose of water quality standards[27] is to protect, maintain and improve the quality of Maryland surface waters. The following make up the three components of water quality standards:

- Designated Uses
- Water Quality Criteria
- Anti-degradation policy

Designated Uses

A designated use (sometimes referred to as 'beneficial use') is a goal for water quality. Typically, the goal is the description of an appropriate intended use by humans and/or aquatic life for a water body. Designated uses for a particular water body (*term of art* for body of water) may include recreation, shell-fishing, water supply and/or aquatic life habitat. The designated uses established may or may not be met currently, but must be attainable. In Maryland, these designated uses are grouped into "Use Classes".

Water Quality Criteria

Water quality criteria are numeric criteria that set the minimum water quality to meet the designated uses. Maryland has numerous numeric criteria for protection of aquatic life and human health (e.g., 5 milligrams/liters for dissolved oxygen; 82 micrograms/liter for Pb (acute, freshwater).

Criteria are published for toxics, dissolved oxygen, turbidity, bacteria, and temperature. Where specific numeric criteria are not available (e.g., oil, grease, odor, nuisance), narrative criteria apply.

Anti-degradation policy

The state's antidegradation policy "assures that water quality continues to support designated uses", in compliance with EPA regulations that provide for three tiers of protection. These include a minimum standard ("fishable-swimmable"), and 2 levels of protection above that.

PENNSYLVANIA

The Division of Water Quality Standards[28] (DWQS) includes several programs (e.g. Standards, Monitoring, Vector Management) to protect and manage clean water and public health. The water quality[29] program implements portions of the Pennsylvania Clean Streams Law (P.L 1987, Act 394 of 1937, as amended (35 P.S. §§ 691.1 et seq.)) and the federal Clean Water Act (33 U.S.C. §1251 et seq. (1972)).

Water quality standards are used to assess whether Pennsylvania's rivers and lakes are clean and pure enough to support fish and other aquatic life; recreation; water supply for drinking, agriculture, and industry; and other protected uses.

VIRGINIA

The State Water Control Law[30] "mandates the protection of existing high-quality state waters and provides for the restoration of all other state waters" to "…permit reasonable public uses" and "…support the growth of aquatic life."

According to the Virginia Department of Environmental Quality (DEQ) designated uses[31] for Virginia waters include recreational, growth and propagation of indigenous aquatic life, production of edible and marketable natural resources.

Exceptional State Waters

Waters deemed to have "exceptional" qualities are afforded extra protection under Virginia law. DEQ is responsible for determining if nominated waters qualify for the "exceptional waters" designation.

DELAWARE

Delaware's surface water quality standards[32] are designed to achieve the goals summarized below.

- Maintain surface waters at quality level consistent with public health and public recreation purposes, to protect and propagate fish/aquatic life;

Often the only way to determine the health effects of contaminated water is to do blood tests that could, for instance, determine blood lead levels (BLL).

- Designated uses shall be paramount whenever conflicts arise between stated surface water uses;
- Create reasonable schedule for compliance whenever existing facilities operating under a permit are required to reduce pollution concentrations;
- Develop agency-wide program to assess, manage, and communicate human health cancer risks from the 'major categories of environmental pollution (of water sources).

DISTRICT OF COLUMBIA

DC Water strives to exceed federal standards.[33] The District is also concerned with water contaminants it characterizes as "emerging", because they have previously not been studied to any significant degree by the EPA. Such potential contaminants would include endocrine disrupting compounds (EDCs) such as pesticides and herbicides; pharmaceuticals, including antibiotics and livestock feed additives; and personal care products (PCPs) such as bug sprays and cosmetics. They note that these substances are currently only detectable in low levels in DC water, but consumption at higher concentrations could well pose yet undetermined health risks.

WEST VIRGINIA

Like Maryland, the West Virginia Water Quality Standard includes designated uses, water quality criteria, and an antidegradation policy. The state also highlights the need for flexibility, whether temporary or permanent, in addressing specific quality-related circumstances[34] that sometimes arise.

The following is a summary statement about the state's overall approach to water quality: "It is declared to be public policy of the State of West Virginia to maintain reasonable standards of purity and quality of the water consistent with (1) public health and public enjoyment thereof; (2) the propagation and protection of animal, bird, fish, and other aquatic and plant life; and (3) the expansion of employment opportunities, maintenance and expansion of agriculture and the provision of a permanent foundation for healthy industrial development."[35]

WHEN SYSTEMS FAIL

Vigilance is required for consistently meeting water quality standards, and some jurisdictions achieve this better than others. Often the only way to determine the health effects of contaminated water is to do blood tests that could, for instance, determine blood lead levels (BLL). Figure 2 shows how many children in the Mid-Atlantic region have tested for actionable levels of lead between 2000 and 2014. Pennsylvania has the largest overall population of the states listed, and some of the oldest municipal water systems.

On June 2, 2016, a class action lawsuit[36] was filed against the city of Philadelphia, alleging that the city knowingly allowed construction projects that "exponentially" increased the risk of "toxic" levels of lead contamination of the city's water, and that the city failed to warn residents of the risk. This is one example of policy lapses in a major American city that have led to compromised water quality. There are many more, given the growing potential for the corrosion of aging pipes, and city authorities taking shortcuts with water testing protocols.[37]

The Philadelphia Water Department has been providing water to citizens since 1801.[38] The system was designed in response to yellow fever epidemics that killed thousands. In the 1820s and 1830s the city and the state of Pennsylvania passed anti-pollution laws to protect drinking water at the source, i.e. the rivers running through the state, but the pipeline infrastructure carried both storm water and sewage. By the end of the Civil War the dumping of industrial waste was also added to this unsavory mix, resulting in repeated outbreaks of waterborne diseases such as typhoid fever. These public health disasters led to the construction of water filtration plants in Philadelphia during the first decade of the 20th century, which dramatically reduced the incidence of waterborne diseases.[39]

But lead pipes and service lines were commonly installed in the city until 1950[40], according to Philadelphia Water, and homes built prior to 1987 may also have copper pipes with lead-based solders. This has necessitated ongoing vigilance, to ensure that corrosion of these pipes do not result in lead leaching into the water supply.

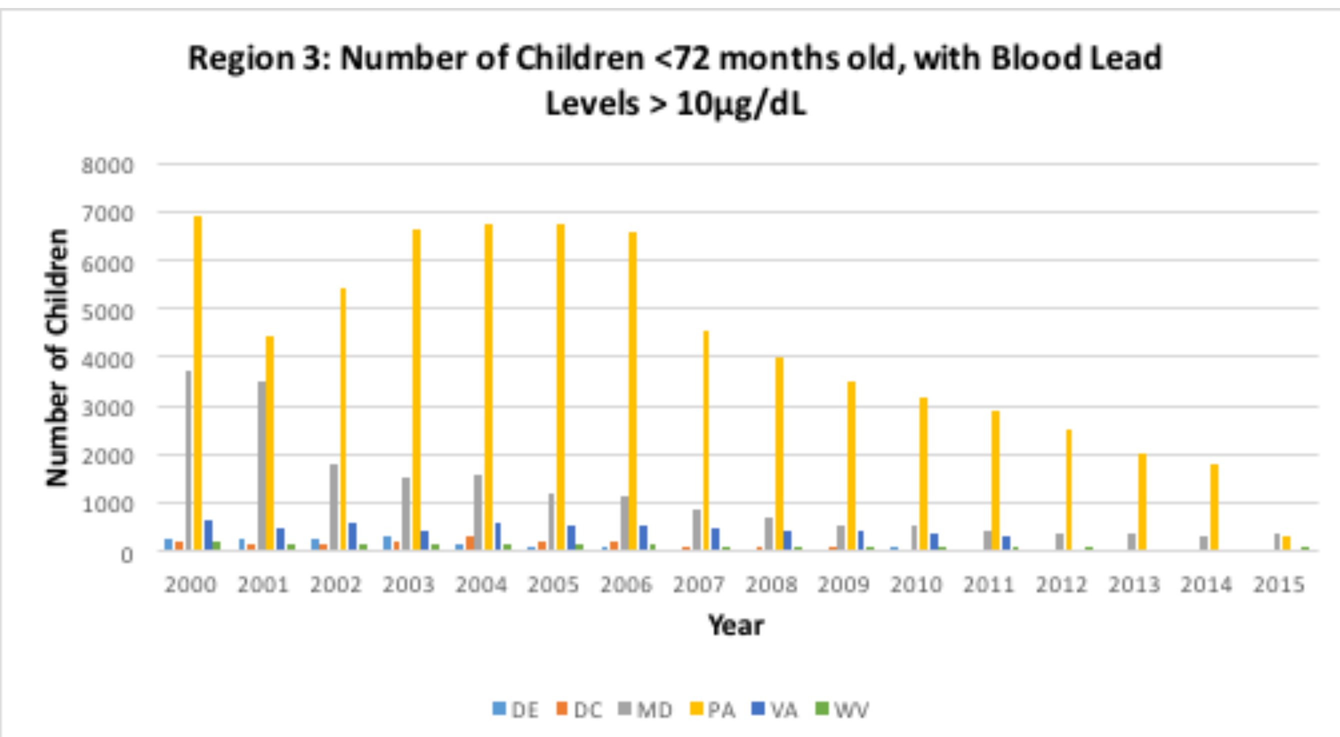
The policy lessons are straightforward. First and foremost: clean water matters for good health. Second: old systems require ongoing - not deferred - maintenance. Third: water system breakdowns can lead to a variety of harmful health effects that can quickly spiral into disasters.

Clean water matters for good health. Old systems require ongoing - not deferred - maintenance. Water system breakdowns can lead to a variety of harmful health effects that can quickly spiral into disasters.

The Value of Screening

Figure 2 shows a decline in the number of children with elevated BLL over time, as the problem of exposure to lead becomes less prevalent. Data have shown that the enactment and enforcement of lead abatement laws and regulations have

Figure 2



Source: CDC National Surveillance Data (1997-2015)

raised public awareness to the level where consumers are accustomed to asking the right questions. The problem has not been completely eliminated, but the progress over the last decade and a half is undeniable. Given aging infrastructure, dwindling resources for upgrades, repairs, and modernization, and the tendency of political realities to complicate effective public policy, municipal water systems can suffer catastrophic failures, with crushing impact on the health of communities.

LESSONS LEARNED: LEAD CONTAMINATION CRISES IN WASHINGTON, DC, FLINT, MICHIGAN, AND ELK RIVER, WEST VIRGINIA

Given aging infrastructure, dwindling resources for upgrades, repairs, and modernization, and the tendency of political realities to complicate effective public policy, municipal water systems can suffer catastrophic failures, with crushing impact on the health of communities.

WASHINGTON, DC

DC law requires that resident children be tested for lead when they are between 6 and 14 months of age and between 22 and 26 months of age. In addition, children should be screened whenever there is a possibility they have been exposed to lead.

A study[41] of lead exposure in DC, following the water contamination crisis of the early 2000s, found that there were more than 23,000 homes with lead service lines (LSL), which were all potentially harmful to human health because they represented an increased risk of lead exposure.[42]

The contamination originally came to light in 2001 when dozens of homes in the city had their water tested, and the lead levels exceeded 15 parts per billion (ppb), the action level threshold above which utilities are required to take action.

By 2002 there were enough cases to warrant media attention. By this time one resident had reported six to eighteen times the lead action level allowed by the EPA's Lead and Copper Rule (LCR). City-wide testing revealed that those with lead service lines had much higher lead levels than those that did not, so DC's Water and Sewer Authority (WASA) proceeded to replace[43] some of the lines to reduce the exposure and thus mitigate the hazard.

The lead levels began to drop below the action level, but by the following year WASA began to notice pinholes in the copper pipes. Further investigation led by Virginia Tech revealed lead levels so high investigators stated they would qualify as hazardous waste.[44]

Casting a wider net, WASA found even more customers with elevated lead levels in their water. WASA engaged a law firm to conduct an independent review of the crisis after the worst was over. Their findings (which would come to be known as *The Holder Report*[45]) led to numerous process and capacity-related recommendations, including:

- assigning responsibility for EPA compliance to one specific person in senior management;
- adopting more robust mechanisms to ensure the flow of information about water quality;
- involving WASA's Board in public education efforts; and
- creating an Interagency Working Group to coordinate all action on water quality issues across the District.

FLINT, MICHIGAN

A similar crisis would arise in another region of the country a decade later, this time in Flint[46], Michigan. Smartphones and multiple social media platforms had been invented in the intervening years, the combination of which led to a more 'viral' and complete dissemination of the details of this disaster. Flint is a less prominent city than the nation's capital, but it would now endure more glaring scrutiny.

There was another key difference between Flint and DC: citizens in Flint began to notice physical symptoms almost as soon as they realized the change in water quality, which led them to seek lab testing of their children to determine blood lead levels.

Problems began when Flint decided to switch their water supply from Detroit's water utility - sourced from the Great Lakes – to the Flint River, the waters of which were so corrosive that a nearby General Motors (GM) plant had prohibited its use because it was corroding the auto parts they manufactured. [47]

In addition, Flint was under the supervision of an emergency manager who reported to the Governor of Michigan, completely bypassing the elected leaders of the city. It was this state-appointed authority that decided to switch the water source to save the city money.

Unfortunately, the city's pipes were not treated with anti-corrosive agents in anticipation of the switch, per established protocols, and ultimately lead began to leach into the city's water supply. It was only a matter of time before the water changed color and took on a foul odor. Flint residents began to present with headaches, skin rashes, and other symptoms, and parents soon began to worry about lead's neurotoxic affects, and the possibility of impaired cognitive development and permanent brain damage.

The citizens' cries were met with repeated assurances from state[48] authorities that the water was safe, until the combination of a desperate mother, a well-respected environmental engineer, a dogged pediatrician, and a whistle-blowing EPA employee led to an explosion of unflattering information[49] about Flint in the public domain.[50] Flint now had a public health crisis, even though the city's residents were paying the highest water bills in the nation.[51]

Citizens in Flint began to notice physical symptoms almost as soon as they realized the change in water quality, which led them to seek lab testing of their children to determine blood lead levels.

The Governor appointed an independent Task Force[52] to determine what went wrong, and their findings, and recommendations, overlap, somewhat, with the findings of the Holder Report. But the Flint report exposed more fundamental problems, so that their recommendations were wider in scope and import. The Task Force's recommendations described leadership problems (such as a lack of accountability of the Michigan Department of Environmental Quality, MDEQ); the inability or unwillingness to follow established protocols and processes (such as routine blood lead screening of Flint's children); an obstruction in the flow of information between leaders and citizens, or worse, the dissemination of inaccurate information; the lack of coordination within and between agencies, at the state and municipal levels; the lack of capacity at the treatment plant to adequately staff the switch from Detroit to the Flint River; the undemocratic takeover of the electoral agency of the residents of Flint due to Michigan's Emergency Manager law; and the environmental injustice aspect of the crisis, given that the people most affected by the crisis were predominantly African American and low-income.

The Task Force offered the following policy-oriented recommendations:

- LEADERSHIP: addressing the failure of leadership (including failure of processes and procedures, culture, and the finger-pointing emblematic of diminished accountability)
- PUBLIC TRUST: restoring the public trust (first by returning Flint to the democratic tradition of electoral representation by locally-elected officials, and by revisiting the Emergency Manager law)
- PUBLIC HEALTH: emphasizing public health (such as by increasing screening rates, creating a cabinet level post for public health, creating subsidiary endowment fund for health-related activities)
- INVESTMENTS: increasing the commitment to invest (for water-related infrastructure and public health)
- RISK MANAGEMENT: enhancing risk management capability at civic and water utility levels (from planning for and mitigating risk to more robust crisis communication when the need arises)
- WORKFORCE CAPACITY: enhanced capacity of the workforce (from better training to recruiting more subject matter experts)
- INFRASTRUCTURE UPGRADES: upgrading the infrastructure (making the investment to replace the pipes and make water more affordable – the people of Flint were paying the nation's highest water bills for most of the crisis)
- INFORMATION FLOW: information flow (as with DC a decade earlier the inter and intra-departmental information flow did not serve the residents or their governments very well)
- ENVIRONMENTAL JUSTICE: Environmental Justice Plan (the Task Force recommended issuing an Executive Order to establish such a plan statewide).

CHARLESTON, WEST VIRGINIA

Roughly 10,000 gallons of crude 4-methylcyclohexanemethanol (MCHM) – an industrial solvent used to clean coal – was accidentally spilled into the Elk River in West Virginia[53] in January of 2014, resulting in the contamination of the drinking water source for about 300,000 West Virginians in nine counties in and around Charleston, the state's capital. The toxic substance was leaked from a chemical plant upriver from the local water utility's main intake, treatment, and distribution center. Unfortunately, the water utility was not informed in a timely fashion of the nature and scale of the event, compounding the potential for life-threatening health outcomes.

For several weeks after the spill, residents affected could not drink or bathe with local tap water, but those who had ingested or been otherwise exposed to the contaminated water reported nausea, rashes, dizziness, and headaches, and several were hospitalized. Thus began a regional emergency response to truck in potable water in tankers and plastic bottles. The several weeks-long ordeal for West Virginians became a months-long investigation into how the spill happened, and how to prevent such a disaster in the future.

Almost two years later the special commission appointed to study the crisis presented a formal report[54] to the state's legislature, recommendations of which included:

- Documented annual review of source water protection plans;
- Ensuring that authorities responsible for environmental protection and industry inform downstream water utilities about

'substantial' change in above-ground tanks that store toxic chemicals;

- Continuing the $2 million appropriation to the Bureau for Public Health to help keep track of water quality;
- Insisting that chemical spills are reported immediately, using established protocols, including location of spill, date and time of event, and nature of materials released.

Policy Signals

Earlier in this discussion we outlined key policy challenges to be met if drinking water is to remain a key asset in the quest for good health. Below we summarize the signals upon which policymakers and stakeholders should train their focus, in order to avoid what happened to the residents of the nation's capital, Charleston, West Virginia, and Flint, Michigan.

PROTECTING DRINKING WATER INFRASTRUCTURE A Dashboard for Health	
STANDARDS	• Filing Water Quality Report by July 1 every year, per EPA's Safe Drinking Water Act requirements? • Protecting water sources via state and local enforcement of the Clean Water Act? • Communicating water quality standards across constituencies, and across jurisdictions?
POLICY	• Collecting all data necessary to track system compliance with applicable laws and standards? • Ensuring proper evaluation of enforcement, and holding lawbreakers accountable? • Making investments necessary for replacing old pipes and preventing contamination?
TECHNOLOGIES	• Using the most effective intake, filtration, and distribution technologies? • Integrating the capacity to respond to chemical spills and environmental catastrophe? • Continually improving contaminant detection to protect the public's health?
HEALTH IMPACT	• Screening children for lead poisoning in addition to testing the drinking water? • Responding with alacrity when consumers report deteriorating water quality? • Engaging consumers in the conversation about water quality and safety?
RETURN ON INVESTMENT	• Measuring return on your system's investments in improved water quality? • Maintaining current cost estimates of infrastructure needs? • Holding policymakers and stakeholders accountable for making said investments?

ENVIRONMENTAL JUSTICE

The EPA incorporated Plan EJ 2014[55] into the Agency's Strategic Plan for 2011-2015, as "a road map for integrating environmental justice into its programs, policies, and activities." Plan EJ 2014 has Cross-Agency and Tool Development focus areas, acknowledging the need to treat environmental justice as an 'all hands on deck' proposition, and that turning goals into results requires tools and benchmarks. The plan is built on the notion that there is a long-standing legacy of vulnerable (low-income, racial and ethnic minority) communities being disproportionately

Old pipes and water mains must be replaced, and inspections and water quality reports must continue on schedule. Citizens should be familiar with, and engaged in the conversations about drinking water and the environment that gives it context and meaning.

affected by environmental degradation and pollution, resulting in harmful health effects and outcomes. The EPA saw an opportunity to reduce these burdens and increase environmental benefits within the framework of Title VI of the Civil Rights Act and the EPA's civil rights program, which formed the basis for Plan EJ 2014. The following are the plan's overarching goals: protect the environment and health in overburdened communities, empower communities to take action to improve their health and environment, and establish partnerships with local, state, tribal, and federal governments and organizations to achieve healthy and sustainable communities.

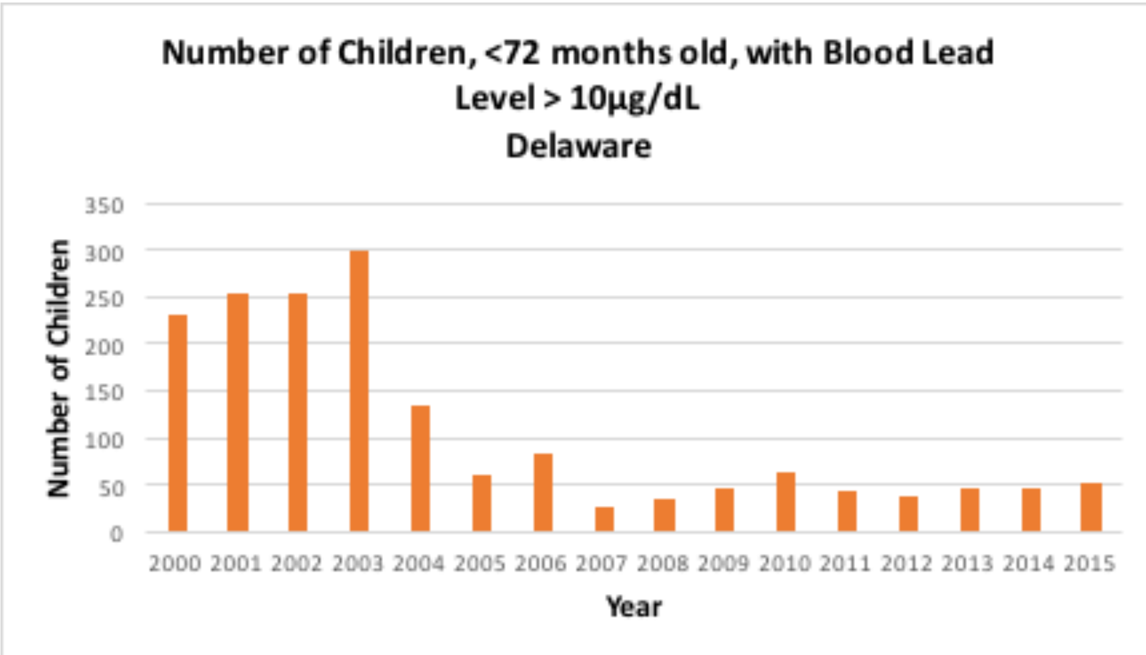
The thread of environmental justice runs through the examples of water contamination outlined in this brief. In every case the most vulnerable before the crisis remained the most vulnerable during and after the crisis. The health effects of water contamination can be easily compounded by other problems, such as the effects of industrial waste in the West Virginia situation, or the delay in replacing the pipes in Flint.

CONCLUSION

America's municipal water systems changed the game in public health a century ago by drastically reducing contamination in drinking water. This remains a vital public good, and society must make necessary and substantial investments to keep the infrastructure viable for the next century. Old pipes and water mains must be replaced, and inspections and water quality reports must continue on schedule. Citizens should be familiar with, and engaged in the conversations about drinking water and the environment that gives it context and meaning. Above all policymakers must be clear about the need to safeguard the public's health and safety, and equally clear about the resources necessary to avoid crises like the District of Columbia, Elk River, and Flint.

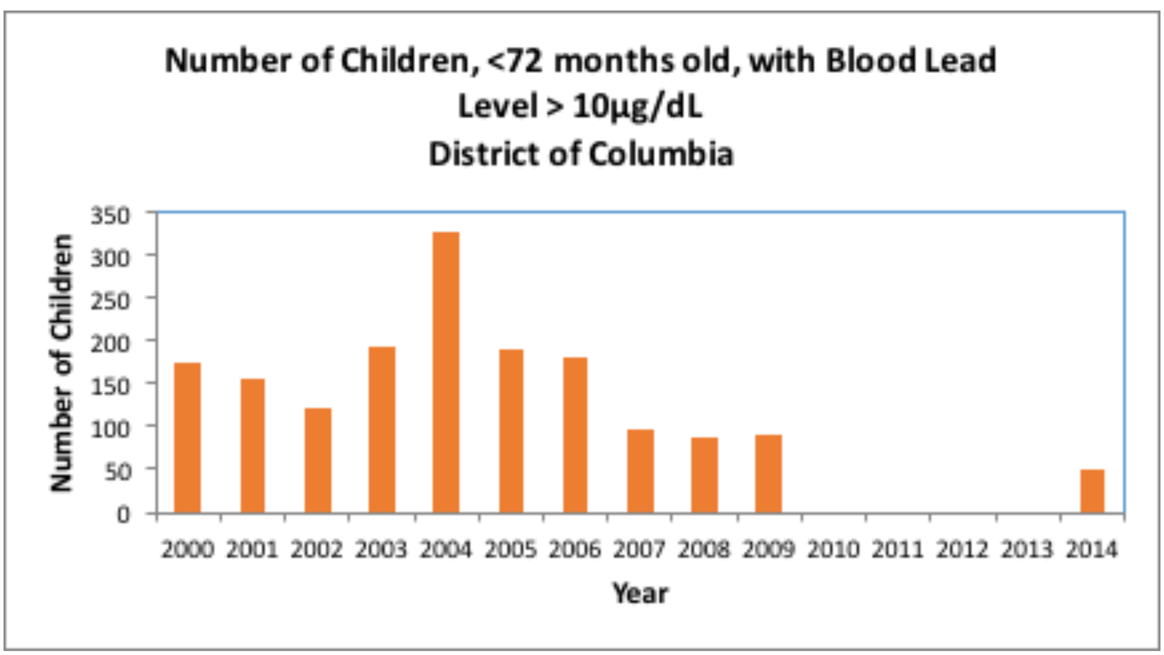
APPENDICES

Appendix A



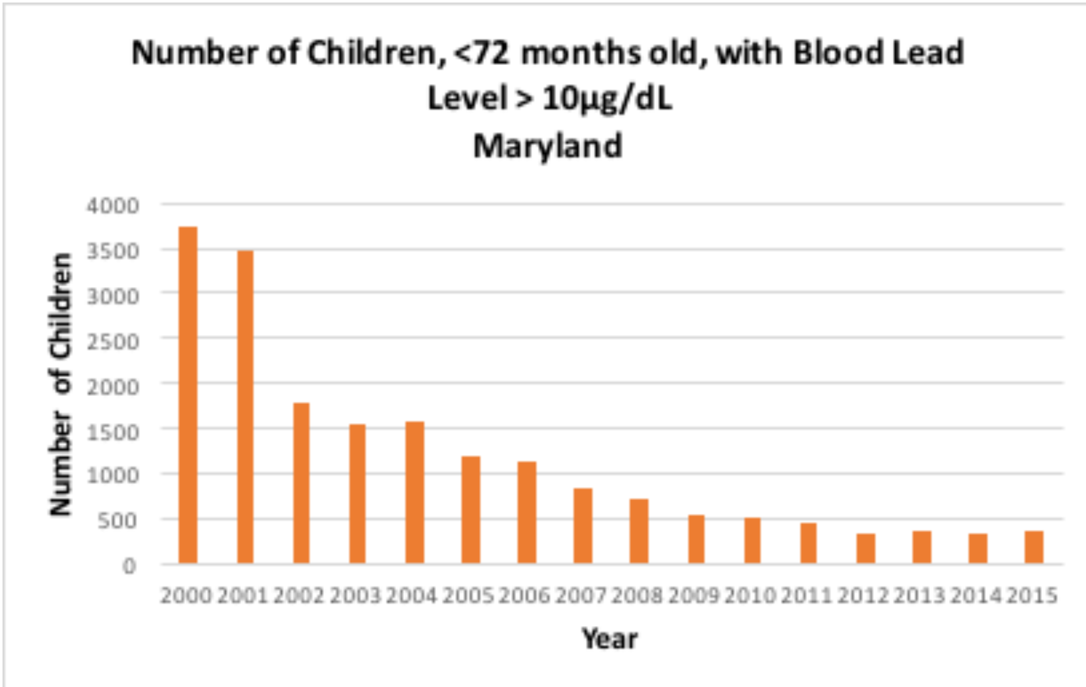
Source: CDC National Surveillance Data (1997-2015)

Appendix B



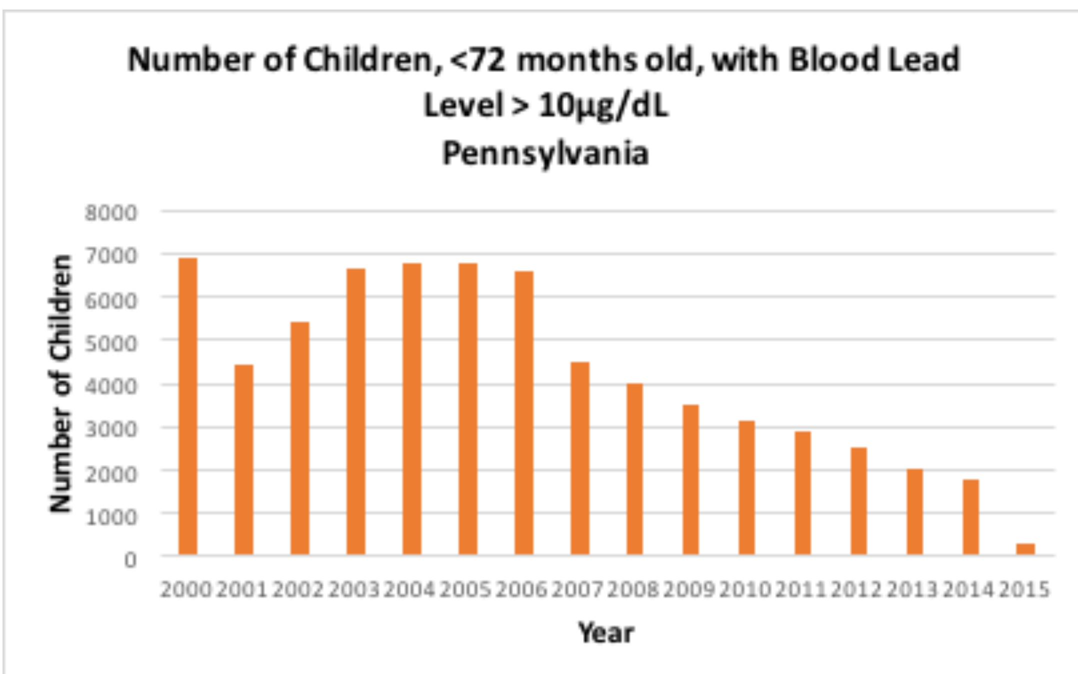
Source: CDC National Surveillance Data (1997-2015)

Appendix C



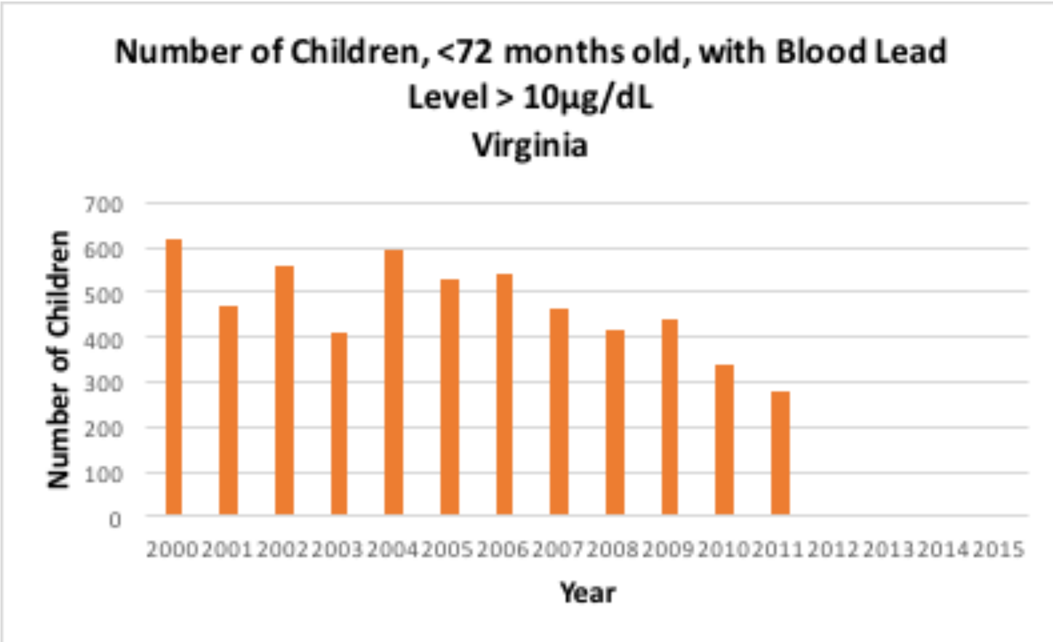
Source: CDC National Surveillance Data (1997-2015)

Appendix D



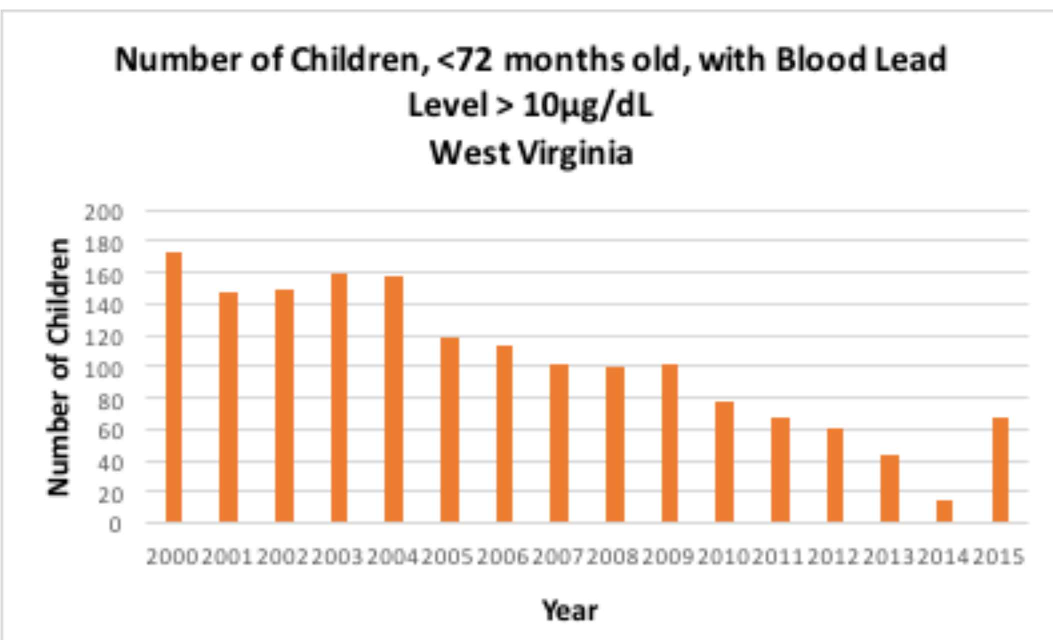
Source: CDC National Surveillance Data (1997-2015)

Appendix E



Source: CDC National Surveillance Data (1997-2015)

Appendix F



Source: CDC National Surveillance Data (1997-2015)

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