Galvanized Plumbing Key Questions & Answers

You may download the complete FAQ sheet on household plumbing (PDF 950 kb)

Why did DC Water decide to hire a firm to do a study on lead and old household plumbing?

DC Water wanted an independent expert to provide scientific scrutiny of its data and commissioned a study conducted by HDR Engineering Inc. to examine the relationship between lead in drinking water and galvanized plumbing.

The study was presented in October 2009 and a journal publication is being prepared that will go through a peer review process before publication.

What are galvanized pipes?

Galvanized iron pipes are actually steel pipes that are covered with a protective layer of zinc.

Galvanized pipes were installed in many homes that were built before the 1960s.

Over many years, zinc erodes from galvanized pipes. Corrosion can build-up on the inside walls of the pipes and creates the potential for lead to accumulate over time.

Corrosion in galvanized pipes can lead to lower water pressure and water quality issues.

Should I be concerned about my galvanized pipes?

Customers, who have galvanized pipes and have or had lead service lines, can potentially have lead released in tap water from these corroded pipes.

Customers that had lead service lines replaced, but still have galvanized pipes, are still susceptible to lead in water from lead released from the galvanized pipes.

Customers that never had lead service lines, but have galvanized pipes, are not at significant risk for lead release from galvanized iron pipes.

How can customers determine if they have galvanized pipes?

Find where your piping enters your home and then scratch it. If the piping is:

- Copper —the scratched area will have the look of a copper penny.
- Galvanized steel —the scratched area will be a silver-gray color and have threads.
- Plastic —usually white in color and you will be able to see a clamp where it is joined to the water supply piping.

A plumber can advise you of the type of pipes in your home.

What is the relationship between galvanized pipes and lead?

LEAD IN DRINKING WATER

Information provided by the Environmental Protection Agency

Lead is a common metal found throughout the environment in lead-based paint, air, soil, household dust, food, certain types of pottery, porcelain, pewter, and in drinking water. Lead can pose a significant risk to your health. It can cause damage to the brain, red blood cells and kidneys. The greatest risk is to young children and pregnant women. Lead has been shown to slow down normal mental and physical development of infants and children.

Lead enters drinking water primarily as a result of the corrosion, or wearing away, of materials containing lead in the water distribution system and plumbing. These materials include lead-based solder used to join copper pipe, brass and chrome plated faucets, and in some cases, pipes made of lead.

You can evaluate various means to reduce lead levels. This may include replacing fixtures and piping that may be contributing lead to the water and/or installing chemical corrosion control treatment. The program selected should be conducted in accordance with the requirements of the EPA, the State of Connecticut, Department of Public Health (DPH) and your local health department.

Sources of Lead in Drinking Water:

Lead levels in your drinking water are likely to be highest if:

- Your home has faucets or fittings of brass which contains some lead, or
- Your home or water system has lead pipes, or
- Your home has copper pipes with solder, and
- The house is less than five years old, or
- You have naturally soft water, or
- Water often sits in the pipes for several hours.

Q: Why is lead a problem?

A: Although it has been used in numerous consumer products, lead is a toxic metal now known to be harmful to human health if inhaled or ingested. Important sources of lead exposure include: ambient air, soil and dust (both inside and outside the home), food (which can be contaminated by lead in the air

or in food containers), and water (from the corrosion of plumbing). On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total exposure (from all sources). Known effects of exposure to lead range from subtle biochemical changes at low levels of exposure, to severe neurological and toxic effects or even death at extremely high levels.

Q: Does lead affect everyone equally?

A: Young children, infants and fetuses appear to be particularly vulnerable to lead poisoning. A dose of lead that would have little effect on an adult can have a big effect on a small body. Also, growing children will more rapidly absorb any lead they consume. A child's mental and physical development can be irreversibly stunted by over-exposure to lead. In infants, whose diet consists of liquids made with water makes up an even greater proportion of total lead exposure (40 to 60 percent).

Q: How could lead get into my drinking water?

A: Typically, lead gets into water after water leaves your local treatment plant or well. That is, the source of lead in your home's water is most likely pipe or solder in your home's own plumbing. The most common cause is corrosion, a reaction between the water and the lead pipes or solder. Dissolved oxygen, low pH (acidity) and low mineral content in water are common causes of corrosion. All kinds of water, however may have high levels of lead. One factor that increases corrosion is the practice of grounding electrical equipment (such as telephones) to water pipes. Any electric current traveling through the ground wire will accelerate the corrosion of lead in pipes. (Nevertheless, wires should not be removed from pipes unless a qualified electrician installs an adequate alternative grounding system.)

Q: Does my home's age make a difference?

A: Lead-contaminated drinking water is most often a problem in houses that are very old or very new. Up through the early 1990's, it was common practice, in some areas of the county, to use lead pipes for interior plumbing. Also, lead piping was often used for the service connections that join residences to public water supplies. (This practice ended only recently in some localities.) Plumbing installed before 1930 is most likely to contain lead. Copper pipes have replaced lead pipes in most residential plumbing. However, the use of lead solder with copper pipes is widespread. Experts regard this lead solder as the major cause of lead contamination of household water in U. S. homes today. New brass faucets and fittings can also leach lead, even though they are "lead-free." Scientific data indicate that the newer the home, the greater the risk of lead contamination. Lead levels decrease as a building ages. This is because, as time passes, mineral deposits form a coating on the inside of the pipes (if the water is not corrosive). This coating insulates the water from the solder. But, during the first five years (before the coating forms) water is in direct contact with the lead. More likely than not, water in buildings less than five years old has high levels of lead contamination.

Q: How can I tell if my water contains too much lead?

A: You should have your water tested for lead. Testing costs between $20 and $100. Since you cannot

see, taste, or smell lead dissolved in water, testing is the only sure way of telling whether or not there are harmful quantities of lead in your drinking water. You should be particularly suspicious if your home has lead pipes (lead is a dull gray metal that is soft enough to be easily scratched with a house key), if you see signs of corrosion (frequent leaks, rust colored water, stained dishes or laundry, or if your non-plastic plumbing is less than five years old). Your water supplier may have useful information, including whether or not the service connector used in your home or area is made of lead. Testing is especially important in high-rise buildings where flushing might not work.

Q: How do I have my water tested?

A: Water samples from the tap will have to be collected and sent to a qualified laboratory for analysis. Contact your local water utility or your local health department for information and assistance. In some instances, these authorities will test your tap water for you, or they can refer you to a qualified laboratory. Contact the CTDPH Laboratory Certification Program, at 860-509-7389, to find out which laboratories have been certified for conducting lead analyses.

Q: What are the testing procedures?

A: Arrangements for sample collection will vary. A few laboratories will send a trained technician to take the samples; but in most cases, the lab will provide sample containers along with instructions as to how you should draw your own tap-water samples. If you collect the samples yourself, make sure you follow the lab's instructions exactly. Otherwise, the results might not be reliable. Make sure that the laboratory is following EPA's water sampling and analysis procedures. Be certain to take a "first draw" and a "fully flushed" sample.

Q: How much lead is too much?

A: Federal standards initially limited the amount of lead in water to 50 ppb. In light of new health and exposure data, EPA has set an action level of 15 ppb. If tests show that the level of lead in your household water is in the area of 15 ppb or higher, it is advisable, especially if there are young children in the home, to reduce the lead level in your tap water as much as possible. (EPA estimates that more than 40 million U. S. residents use water that can contain lead in excess of 15 ppb.) Note: One ppb is equal to 1.0 micrograms per liter (µg/1) or 0.001 milligrams per liter (mg/1).

Q: How can I reduce my exposure?

A: If your drinking water is contaminated with lead, or until you find out for sure, there are several things you can do to minimize your exposure. Two of these actions should be taken right away by everyone who has, or suspects, a problem. The advisability of other actions listed here will depend upon your particular circumstances.

STEPS TO REDUCE EXPOSURE TO LEAD IN DRINKING WATER

The following simple steps can be taken to reduce your exposure to lead in drinking water. This is a simple and inexpensive measure you can take to protect your health. "Flush" the tap before using the water for consumption. Flushing the tap means running the cold water faucet until the water gets noticeably colder, usually about 15-30 seconds. Do not cook with, or drink water from the hot tap. Hot water can dissolve more lead; more quickly than cold water. You can consult a variety of sources for additional information. Your family doctor or pediatrician can perform a blood test for lead and provide you with information about the health effects of lead. You can also contact:

1. Your local health department.
2. The Drinking Water Section of the DPH at (860) 509-7333
3. EPA Safe Drinking Water Hotline 1-800-426-4791

Other Actions

- If you are served by a public water system, contact your supplier and ask whether or not the supply system contains lead piping, and whether your water is corrosive. If either answer is yes, ask what steps the supplier is taking to deal with the problem of lead contamination. Drinking water can be treated at the plant to make it less corrosive. (Treatment to reduce corrosion will also save you and the water supplier money reducing damage to plumbing.) Water mains containing lead pipes can be replaced, as well as those portions of lead service connections that are under the jurisdiction of the supplier.
- If you own a well or another water source, you can treat the water to make it less corrosive. Corrosion control devices for individual households include calcite filters and other devices. Calcite filters should be installed in the line between the water source and any lead service connections or lead-soldered pipe.

Definitions:

Corrosion: A dissolving and wearing away of metal caused by a chemical reaction (in this case, between two different metals).

First Draw: The water that immediately comes out when a tap is first opened.

Flush: To open a cold-water tap to clear out all the water which may have been sitting for a long time in the pipes. In new homes, to flush a system means to send large volumes of water gushing through the unused pipes to remove loose particles of solder and flux. (Sometimes this is not done correctly or at all).

Flux: A substance applied during soldering to facilitate the flow of solder. Flux often contains lead and can, itself, be a source of contamination.

Naturally soft water: Any water with low mineral content, lacking the hardness minerals calcium and magnesium.

Public Water System: Any water company supplying water to fifteen (15) or more consumers or twenty-five (25) or more persons, based on the "Design Population" as defined in Section 16-262m-8(a)(3) of the regulations of Connecticut State Agencies, jointly administered by the DPH and the Public Utilities Regulatory Authority, daily at least sixty days (60) of the year.

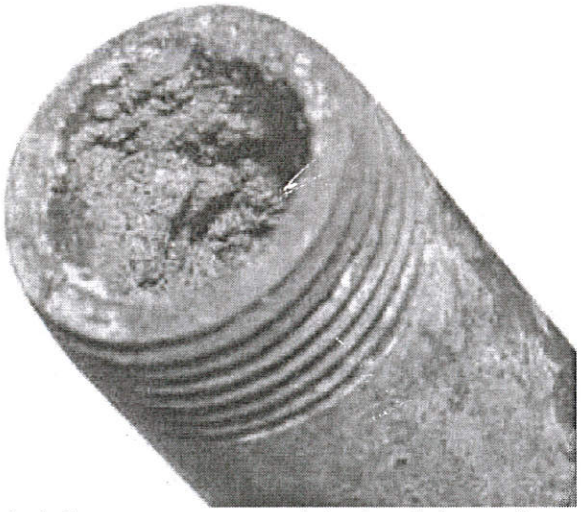
Service Connector: The pipe that carries tap water from the public water main to a building. In the past these were often made of lead.

Soft water: Any water that is not "hard." Water is considered to be hard when it contains a large amount of dissolved minerals, such as salts containing calcium or magnesium. You may be familiar with hard water that interferes with the lathering action of soap.

Solder: A metallic compound used to seal joints in plumbing. Until recently, most solder contained 50 percent lead.

Homes that have galvanized pipes and have or had lead service lines are at risk for the release of lead in water from corroded pipes.

In-home galvanized iron pipes are found to accumulate lead that is released from lead service lines.



Galvanized piping may accumulate lead deposits over time.

As galvanized pipes corrode and form rust, lead that is accumulated over decades is likely to be found deep in the interior walls of rusty pipes.

Lead in galvanized iron home plumbing can periodically contribute to lead in drinking water.

The only way to ensure that lead is not mobilized from plumbing to tap in a given home is to fully replace the galvanized plumbing and lead service lines.

Galvanized pipes may continue to serve as a lead source in drinking water long after all other sources of lead have been removed, including lead service lines and fixtures.

How can lead be released from galvanized pipes if the lead service lines have been replaced?

Lead accumulated in corroded pipes can persist and be present in household tap water after full replacement of lead service lines, potentially for the remaining service life of the galvanized plumbing.

Although lead service lines have been replaced, the rusted areas of galvanized pipes contain deep layers of iron and lead minerals that have accumulated over decades and continue to be released in water.

Lead released immediately after lead service line replacement can increase as a result of disturbing the fragile interior surfaces of in-home corroded galvanized pipes.

Lead release following lead service replacement varies with location. Typically, a decreasing trend is found in lead release as time elapses following lead service replacement.

What factors should I look for that can increase the release of lead from galvanized pipes?

Lead release from galvanized plumbing can be increased by excessively high water flow or physical disturbances, such as water hammer (vibration of the pipes when they are suddenly turned on or off quickly).

Any modifications or improvements to the plumbing, including water heater installations or even fixture replacements, could potentially lead to short term spikes in lead release.

Does lead released from galvanized pipes vary by location?

The potential for lead release from galvanized plumbing at a given home must be assessed on an individual basis because lead released from galvanized plumbing can differ substantially in magnitude and behavior from one location to another.

Other factors, such as plumbing history, pipe layout in the home, and length of the lead service line might impact the degree to which lead is accumulated in galvanized plumbing at a given location.

Does the current corrosion control treatment effectively minimize lead release from galvanized pipes?

The Washington Aqueduct is responsible for treating the drinking water in the District of Columbia and adds the common food-grade chemical orthophosphate to reduce pipe corrosion.

Introduced in August 2004, orthophosphate has reduced lead concentrations to below EPA's action level of less than or equal to 15 parts per billion.

Orthophosphate works by creating a thin protective coating inside pipes and plumbing fixtures to minimize the corrosion of pipes.

Orthophosphate binds to galvanized pipes, but is only partially able to prevent the rust from breaking off and releasing lead and iron.

Does flushing your water for a specific time decrease the presence of lead from galvanized pipes?

If you have galvanized pipes and have or had lead service lines, lead can be released at any time, and may still be present in water after flushing your taps.

The study recommends replacing galvanized pipes or using NSF certified filters to prevent lead in drinking water.

If you have lead service lines and no galvanized pipes or if you have galvanized pipes and never had a lead service line, DC Water recommends flushing your water for at least two minutes prior to using water for cooking or drinking, when the water has not been used for several hours.

Do galvanized pipes cause discoloration in water?

Yes, in-home galvanized pipes can release iron and cause discoloration.

Based on the study results, is my water safe to drink?

Yes, the drinking water produced by the Washington Aqueduct and delivered to DC residents by DC Water meets all U.S. Environmental Protection Agency (EPA) drinking water standards.

DC Water takes exposure to lead very seriously. Since 2003, DC Water has made exceptional progress in reducing drinking water lead levels. We are far below EPA limits, in fact, our results are lower than the top five major US cities in the northeast, based on current consumer confidence reporting.

If you have or had lead service lines and still have galvanized plumbing, DC Water recommends replacing lead service lines and galvanized pipes or drinking filtered tap water.

What if I am pregnant or have young children?

We take exposure to lead very seriously. If you are pregnant; have children under the age of six; have lead service lines; and/or previously had lead service lines and still have galvanized plumbing:

1. drink filtered tap water and
2. use filtered tap water to prepare infant formula or concentrated juices until the source has been identified and removed.

Boiling water does not reduce lead levels.

The District of Columbia Department of Health's Childhood Lead Poisoning Prevention Program (DC DOH) provides information on how to get a simple blood lead test to check lead levels in young children, pregnant women, and nursing mothers. You can also learn more about how to protect you and your family from lead by contacting the DC DOH at (202) 442-9216, or by visiting its website www.dchealth.dc.gov. If you have additional concerns about a child's health, or would like the screening done by his/her own doctor, please contact his/her pediatrician.

Is it useful to have my water tested for lead?

If you have or had lead service lines and have galvanized pipes, it is likely lead is only periodically released in the water and a single lead test may not be an effective tool in identifying actual lead levels. However, if you have a concern, see our list of certified testing laboratories.

If you are interested in additional information, contact our Customer Service department at (202) 354-3600.

What types of filters does DC Water recommend for removing lead in water?

If you are purchasing a treatment device to reduce lead levels at your tap, choose a treatment device installed at the tap or use a filtration pitcher. These devices must be used, installed, operated and maintained according to manufacturer instructions.

Be sure to purchase a treatment device certified by an independent testing organization, such as NSF International. You can search the NSF International website for certified drinking water treatment devices by visiting.

Please be advised that neither the EPA nor DC Water certifies or endorses specific home drinking water treatment devices.

What do I do if I own a home that has galvanized pipes?

According to the study, the only way to fully ensure that lead is not mobilized from galvanized plumbing in a given home is to fully replace the galvanized plumbing.

What do I do if I live in a rental property that has galvanized pipes?

Contact your property manager or landlord to discuss this issue.

See the recommendations above for filter options.

How long has DC Water known about the finding of the HDR Report?

The study was presented in October 2009.

How is DC Water planning to alert stakeholders and residents of these new findings?

DC Water will be hosting a forum and will provide information and recommendations to all its customers on the website, in the customer newsletter and in a future bill.

Will the Department of Health and EPA be notified?

DC Water has shared the study results with DDOH, DDOE and EPA.

Where can I go for additional information or assistance?

DC Water and Sewer Authority —For questions relative to water quality in your home, contact the Drinking Water Division at (202)612-3440, email drinkingwater@dcwater.com.

DC Department of the Environment —You can learn more about how to protect you and your family from lead by contacting the DDOE at (202) 535-2600, or by visiting the website www.ddoe.dc.gov.

Environmental Protection Agency —For information on reducing lead exposure around your home and the health effects of lead, visit EPA's website at www.epa.gov/lead.

MotherJones

Lead: America's Real Criminal Element

The hidden villain behind violent crime, lower IQs, and even the ADHD epidemic.

By Kevin Drum | Thu Feb 11, 2016 6:58 PM EST

When Rudy Giuliani ran for mayor of New York City in 1993, he campaigned on a platform of bringing down crime and making the city safe again. It was a comfortable position for a former federal prosecutor with a tough-guy image, but it was more than mere posturing. Since 1960, rape rates had nearly quadrupled, murder had quintupled, and robbery had grown fourteenfold. New Yorkers felt like they lived in a city under siege.

Throughout the campaign, Giuliani embraced a theory of crime fighting called "broken windows," popularized a decade earlier by James Q. Wilson and George L. Kelling in an influential article in *The Atlantic*. [1] "If a window in a building is broken and is left unrepaired," they observed, "all the rest of the windows will soon be broken." So too, tolerance of small crimes would create a vicious cycle ending with entire neighborhoods turning into war zones. But if you cracked down on small crimes, bigger crimes would drop as well.

Giuliani won the election, and he made good on his crime-fighting promises by selecting Boston police chief Bill Bratton as the NYPD's new commissioner. Bratton had made his reputation as head of the New York City Transit Police, where he aggressively applied broken-windows policing to turnstile jumpers and vagrants in subway stations. With Giuliani's eager support, he began applying the same lessons to the entire city, going after panhandlers, drunks, drug pushers, and the city's hated squeegee men. And more: He decentralized police operations and gave precinct commanders more control, keeping them accountable with a pioneering system called CompStat that tracked crime hot spots in real time.

[2]

Flint Kids Have So Much Lead in Their Blood That the Mayor Declared a State of Emergency. [2]

The results were dramatic. In 1996, the *New York Times* reported [3] that crime had plunged for the third straight year, the sharpest drop since the end of Prohibition. Since 1993, rape rates had dropped 17 percent, assault 27 percent, robbery 42 percent, and murder an astonishing 49 percent. Giuliani was on his way to becoming America's Mayor and Bratton was on the cover of *Time*. It was a remarkable public policy victory.

But even more remarkable is what happened next. Shortly after Bratton's star turn, political scientist John DiIulio warned that the echo of the baby boom would soon produce a demographic bulge of millions of young males that he famously dubbed "juvenile super-predators [5]." Other criminologists nodded along. But even though the demographic bulge came right on schedule, crime continued to drop. And drop. And drop. By 2010, violent crime rates in New York City had plunged 75 percent from their peak in the early '90s.

[4]

This Mom Helped Uncover Flint's Toxic Water Crisis [4]

All in all, it seemed to be a story with a happy ending, a triumph for Wilson and Kelling's theory and Giuliani and Bratton's practice. And yet, doubts remained. For one thing, violent crime actually peaked in New York City in 1990, four years before the Giuliani-Bratton era. By the time they took office, it had already dropped 12 percent.

Second, and far more puzzling, it's not just New York that has seen a big drop in crime. In city after city, violent crime peaked in the early '90s and then began a steady and spectacular decline. Washington, DC, didn't have either Giuliani or Bratton, but its violent crime rate has dropped 58 percent since its peak. Dallas' has fallen 70 percent. Newark: 74 percent. Los Angeles: 78 percent.

There must be more going on here than just a change in policing tactics in one city. But what?

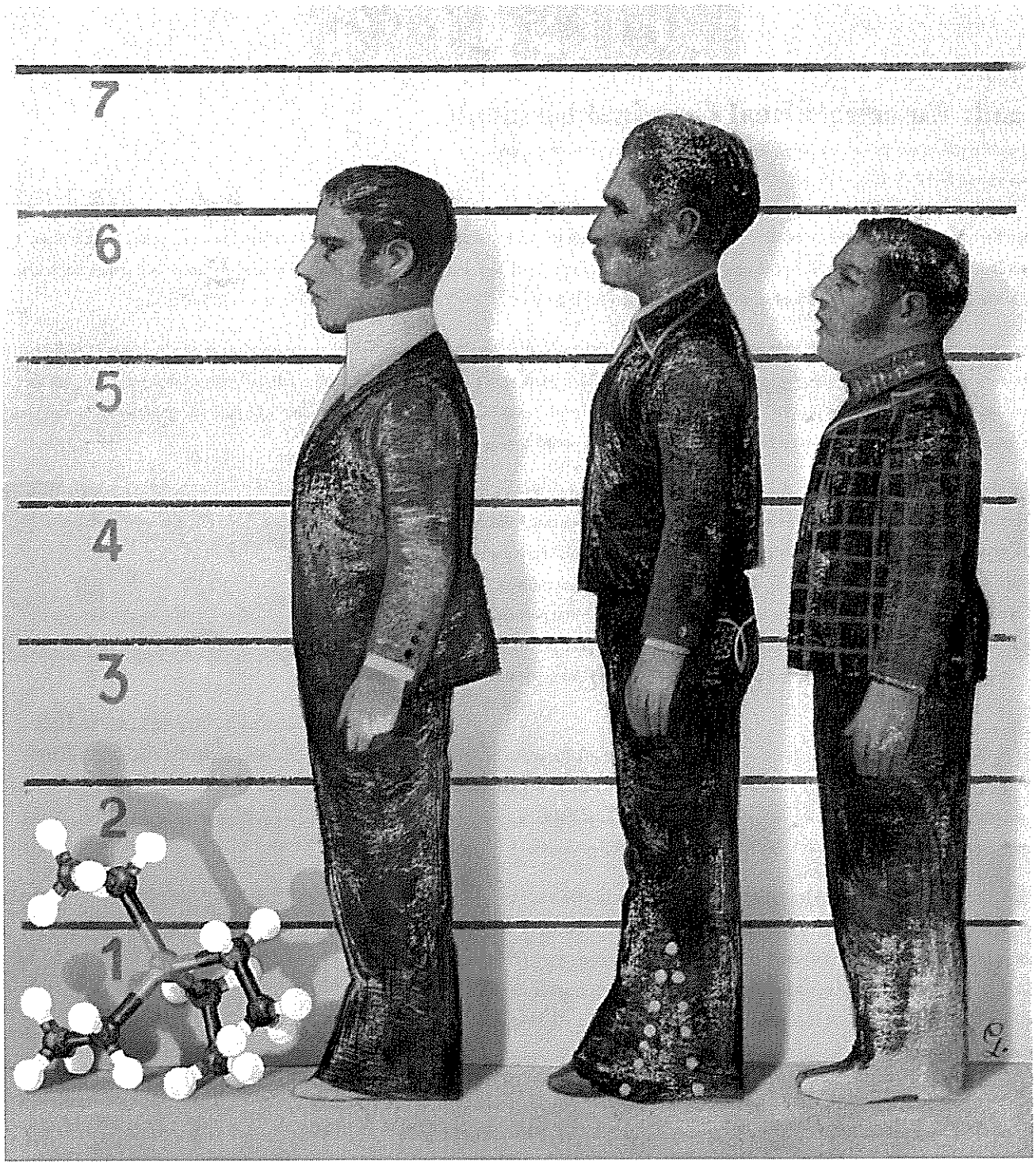


Illustration: Gérard DuBois

There are, it turns out, plenty of theories. When I started research for this story, I worked my way through a pair of thick [6] criminology tomes [7]. One chapter regaled me with the "exciting possibility" that it's mostly a matter of economics: Crime goes down when the economy is booming and goes up when it's in a slump. Unfortunately, the theory doesn't seem to hold water—for example, crime rates have continued to drop recently despite our prolonged downturn.

Another chapter suggested that crime drops in big cities were mostly a reflection of the crack epidemic of the '80s finally burning itself out. A trio of authors identified three major "drug eras" in New York City, the first dominated by heroin, which produced limited violence, and the second by crack, which generated spectacular levels of it. In the early '90s, these researchers proposed, the children of CrackGen switched to marijuana, choosing a less violent and more law-abiding lifestyle. As they did, crime rates in New York and other cities went down.

Another chapter told a story of demographics: As the number of young men increases, so does crime. Unfortunately for this theory, the number of young men increased during the '90s, but crime dropped anyway.

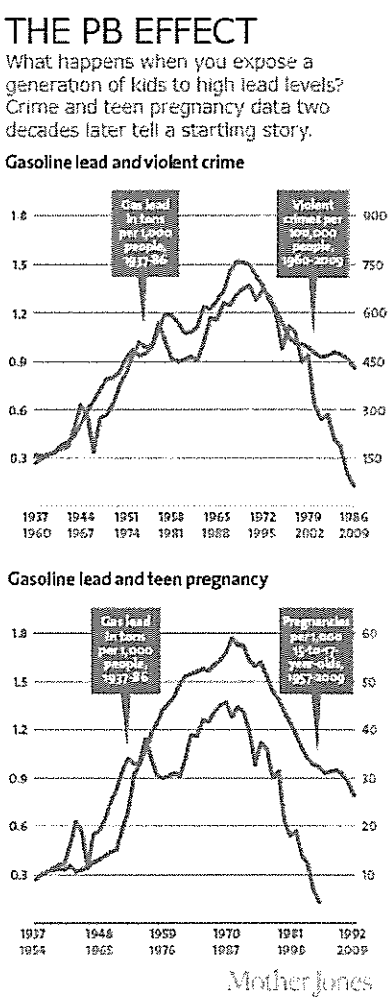
There were chapters in my tomes on the effect of prison expansion. On guns and gun control. On family. On race. On parole and probation. On the raw number of police officers. It seemed as if everyone had a pet theory. In 1999, economist Steven Levitt, later famous as the coauthor of *Freakonomics*, teamed up with John Donohue to suggest that crime dropped because of *Roe v. Wade* [8]; legalized abortion, they argued, led to fewer unwanted babies, which meant fewer maladjusted and violent young men two decades later.

But there's a problem common to all of these theories: It's hard to tease out actual proof. Maybe the end of the crack epidemic contributed to a decline in inner-city crime, but then again, maybe it was really the effect of increased incarceration, more cops on the beat, broken-windows policing, and a rise in abortion rates 20 years earlier. After all, they all happened at the same time.

To address this problem, the field of econometrics gives researchers an enormous toolbox of sophisticated statistical techniques. But, notes statistician and conservative commentator Jim Manzi in his recent book *Uncontrolled* [9], econometrics consistently fails to explain most of the variation in crime rates. After reviewing 122 known field tests, Manzi found that only 20 percent demonstrated positive results for specific crime-fighting strategies, and none of those positive results were replicated in follow-up studies.

So we're back to square one. More prisons might help control crime, more cops might help, and better policing might help. But the evidence is thin for any of these as the main cause. What are we missing?

Experts often suggest that crime resembles an epidemic. But what kind? Karl Smith, a professor of public economics and government at the University of North Carolina-Chapel Hill, has a good rule of thumb for categorizing epidemics [10]: If it spreads along lines of communication, he says, the cause is information. Think Bieber Fever. If it travels along major transportation routes, the cause is microbial. Think influenza. If it spreads out like a fan, the cause is an insect. Think malaria. But if it's everywhere, all at once—as both the rise of crime in the '60s and '70s and the fall of crime in the '90s seemed to be—the cause is a molecule.



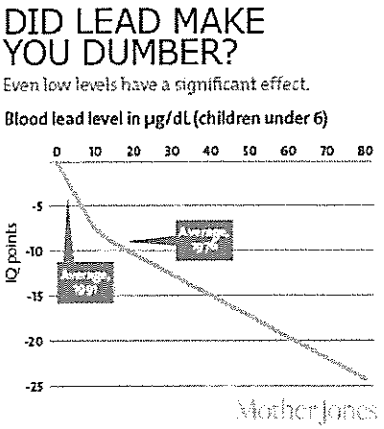
Top: Rick Nevin, USGS, DOJ; Bottom: Rick Nevin, Guttmacher Institute, CDC

A molecule? That sounds crazy. What molecule could be responsible for a steep and sudden decline in violent crime?

Well, here's one possibility: $Pb(CH_2CH_3)_4$.

In 1994, Rick Nevin was a consultant working for the US Department of Housing and Urban Development on the costs and benefits of removing lead paint from old houses. This has been a topic of intense study because of the growing body of research linking lead exposure in small children with a whole raft of complications later in life, including lower IQ, hyperactivity, behavioral problems, and learning disabilities.

But as Nevin was working on that assignment, his client suggested they might be missing something. A recent study had suggested a link between childhood lead exposure and juvenile delinquency later on. Maybe reducing lead exposure had an effect on violent crime too?



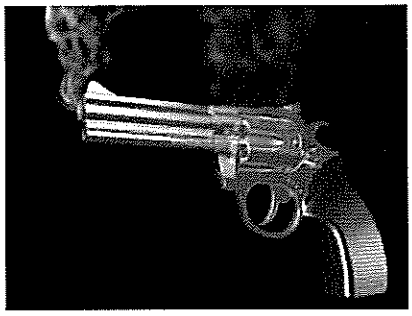
Rick Nevin/CDC

That tip took Nevin in a different direction. The biggest source of lead in the postwar era, it turns out, wasn't paint. It was leaded gasoline. And if you chart the rise and fall of atmospheric lead caused by the rise and fall of leaded gasoline consumption, you get a pretty simple upside-down U: Lead emissions from tailpipes rose steadily from the early '40s through the early '70s, nearly quadrupling over that period. Then, as unleaded gasoline began to replace leaded gasoline, emissions plummeted.

Intriguingly, violent crime rates followed the same upside-down U pattern. The only thing different was the time period: Crime rates rose dramatically in the '60s through the '80s, and then began dropping steadily starting in the early '90s. The two curves looked eerily identical, but were offset by about 20 years.

> Gasoline lead may explain as much as 90 percent of the rise and fall of violent crime over the past half century.

So Nevin dove in further, digging up detailed data on lead emissions and crime rates to see if the similarity of the curves was as good as it seemed. It turned out to be even better: In a 2000 paper [11] (PDF) he concluded that if you add a lag time of 23 years, lead emissions from automobiles explain 90 percent of the variation in violent crime in America. Toddlers who ingested high levels of lead in the '40s and '50s really were more likely to become violent criminals in the '60s, '70s, and '80s.



[12]

How Dangerous Is Lead in Bullets? [12]

And with that we have our molecule: tetraethyl lead, the gasoline additive invented by General Motors in the 1920s to prevent knocking and pinging in high-performance engines. As auto sales boomed after World War II, and drivers in powerful new cars increasingly asked service station attendants to "fill 'er up with ethyl," they were unwittingly creating a crime wave two decades later.

It was an exciting conjecture, and it prompted an immediate wave of...nothing. Nevin's paper was almost completely ignored, and in one sense it's easy to see why—Nevin is an economist, not a criminologist, and his paper was published in *Environmental Research*, not a journal with a big readership in the criminology community. What's more, a single correlation between two curves isn't all that impressive, econometrically speaking. Sales of vinyl LPs rose in the postwar period too, and then declined in the '80s and '90s. Lots of things follow a pattern like that. So no matter how good the fit, if you only have a single correlation it might just be a coincidence. You need to do something more to establish causality.

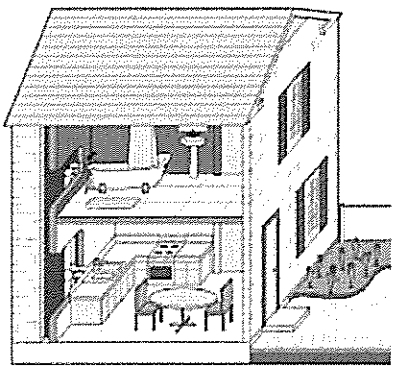
As it turns out, however, a few hundred miles north someone was doing just that. In the late '90s, Jessica Wolpaw Reyes was a graduate student at Harvard casting around for a dissertation topic that eventually became a study she published in 2007 as a public health policy professor at Amherst. "I learned about lead because I was pregnant and living in old housing in Harvard Square," she told me, and after attending a talk where future *Freakonomics* star Levitt outlined his abortion/crime theory, she started thinking about lead and crime. Although the association seemed plausible, she wanted to find out whether increased lead exposure *caused* increases in crime. But how?

> In states where consumption of leaded gasoline declined slowly, crime declined slowly. Where it

The answer, it turned out, involved "several months of cold calling" to find lead emissions data at the state level. During the '70s and '80s, the introduction of the catalytic converter, combined with increasingly stringent Environmental Protection Agency rules, steadily reduced the amount of leaded gasoline used in America, but Reyes discovered that this reduction wasn't uniform. In fact, use of leaded gasoline varied widely among states, and this gave Reyes the opening she needed. If childhood lead exposure really did produce criminal behavior in adults, you'd expect that in states where consumption of leaded gasoline declined slowly, crime would decline slowly too. Conversely, in states where it declined quickly, crime would decline quickly. And that's exactly what she found [13].

declined quickly, crime declined quickly.

Meanwhile, Nevin had kept busy as well, and in 2007 he published a new paper looking at crime trends around the world [15] (PDF). This way, he could make sure the close match he'd found between the lead curve and the crime curve wasn't just a coincidence. Sure, maybe the real culprit in the United States was something else happening at the exact same time, but what are the odds of that same something happening at several *different* times in several *different* countries?

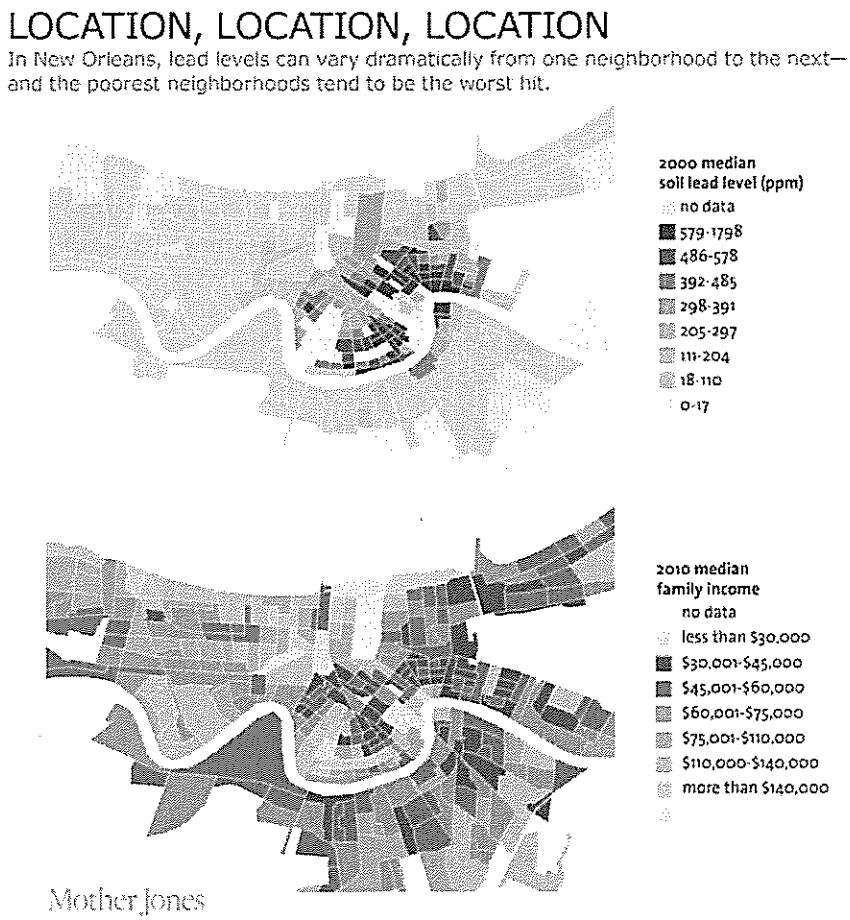


[14]

Is There Lead in Your House? [14]

Nevin collected lead data and crime data for Australia and found a close match. Ditto for Canada. And Great Britain and Finland and France and Italy and New Zealand and West Germany. Every time, the two curves fit each other astonishingly well. When I spoke to Nevin about this, I asked him if he had ever found a country that didn't fit the theory. "No," he replied. "Not one."

Just this year, Tulane University researcher Howard Mielke published a paper [16] with demographer Sammy Zahran on the correlation of lead and crime at the city level. They studied six US cities that had both good crime data and good lead data going back to the '50s, and they found a good fit in every single one. In fact, Mielke has even studied lead concentrations at the *neighborhood* level in New Orleans and shared his maps with the local police. "When they overlay them with crime maps," he told me, "they realize they match up."



Put all this together and you have an astonishing body of evidence. We now have studies at the international level, the national level, the state level, the city level, and even the individual level. Groups of children have been followed from the womb to adulthood, and higher childhood blood lead levels are consistently associated with higher adult arrest rates for violent crimes [17]. All of these studies tell the same story: Gasoline lead is responsible for a good share of the rise and fall of violent crime over the past half century.

Like many good theories, the gasoline lead hypothesis helps explain some things we might not have realized even needed explaining. For example, murder rates have always been higher in big cities than in towns and small cities. We're so used to this that it seems unsurprising, but Nevin points out that it might actually have a surprising explanation—because big cities have lots of cars in a small area, they also had high densities of atmospheric lead during the postwar era. But as lead levels in gasoline decreased, the differences between big and small cities largely went away. And guess what? The difference in murder rates went away too. Today, homicide rates are similar in cities of all sizes [18]. It may be that violent crime isn't an inevitable consequence of being a big city after all.

When differences of atmospheric lead density between big and small cities largely went away, so did the difference in murder rates.

The gasoline lead story has another virtue too: It's the only hypothesis that persuasively explains both the rise of crime in the '60s and '70s and its fall beginning in the '90s. Two other theories—the baby boom demographic bulge and the drug explosion of the '60s—at least have the potential to explain both, but neither one fully fits the known data. Only gasoline lead, with its dramatic rise and fall following World War II, can explain the equally dramatic rise and fall in violent crime.

If econometric studies were all there were to the story of lead, you'd be justified in remaining skeptical no matter how good the statistics look. Even when researchers do their best—controlling for economic growth, welfare payments, race, income, education level, and everything else they can think of—it's always possible that something they haven't thought of is still lurking in the background. But there's another reason to take the lead hypothesis seriously, and it might be the most compelling one of all: Neurological research is demonstrating that lead's effects are even more appalling, more permanent, and appear at far lower levels than we ever thought. For starters, it turns out that childhood lead exposure at nearly *any* level can seriously and permanently reduce IQ. Blood lead levels are measured in micrograms per deciliter, and levels once believed safe—65 µg/dL, then 25, then 15, then 10—are now known to cause serious damage. The EPA now says [19] flatly that there is "no demonstrated safe concentration of lead in blood," and it turns out that even levels under 10 µg/dL can reduce IQ by as much as seven points. An estimated 2.5 percent of children nationwide have lead levels above 5 µg/dL.

But we now know that lead's effects go far beyond just IQ. Not only does lead promote apoptosis, or cell death, in the brain, but the element is also chemically similar to calcium. When it settles in cerebral tissue, it prevents calcium ions from doing their job, something that causes physical damage to the developing brain that persists into adulthood.

Only in the last few years have we begun to understand exactly what effects this has. A team of researchers at the University of Cincinnati has been following a group of 300 children for more than 30 years and recently performed a series of MRI scans that highlighted the neurological differences between subjects who had high and low exposure to lead during early childhood.

High childhood exposure damages a part of the brain linked to aggression control. The impact is greater among boys.

One set of scans [20] found that lead exposure is linked to production of the brain's white matter—primarily a substance called myelin, which forms an insulating sheath around the connections between neurons. Lead exposure degrades both the formation and structure of myelin, and when this happens, says Kim Dietrich, one of the leaders of the imaging studies, "neurons are not communicating effectively." Put simply, the network connections within the brain become both slower and less coordinated.

A second study [21] found that high exposure to lead during childhood was linked to a permanent loss of gray matter in the prefrontal cortex—a part of the brain associated with aggression control as well as what psychologists call "executive functions": emotional regulation, impulse control, attention, verbal reasoning, and mental flexibility. One way to understand this, says Kim Cecil, another member of the Cincinnati team, is that lead affects precisely the areas of the brain "that make us most human."

So lead is a double whammy: It impairs specific parts of the brain responsible for executive functions *and* it impairs the communication channels between these parts of the brain. For children like the ones in the Cincinnati study, who were mostly inner-city kids with plenty of strikes against them already, lead exposure was, in Cecil's words, an "additional kick in the gut." And one more thing: Although both sexes are affected by lead, the neurological impact turns out to be greater among boys than girls.

Other recent [23] studies link [24] even minuscule blood lead levels with attention deficit/hyperactivity disorder. Even at concentrations well below those usually considered safe—levels still common today—lead increases the odds of kids developing ADHD.

[22]
How Hidden Lead Can Sicken Your Kids
[22]Zurijeta/Shutterstock

In other words, as Reyes summarized the evidence in her paper, even moderately high levels of lead exposure are associated with aggressivity, impulsivity, ADHD, and lower IQ. And right there, you've practically defined the profile of a violent young offender.

Needless to say, not every child exposed to lead is destined for a life of crime. Everyone over the age of 40 was probably exposed to too much lead during childhood, and most of us suffered nothing more than a few points of IQ loss. But there were plenty of kids already on the margin, and millions of those kids were pushed over the edge from being merely slow or disruptive to becoming part of a nationwide epidemic of violent crime. Once you understand that, it all becomes blindingly obvious. *Of course* massive lead exposure among children of the postwar era led to larger numbers of violent criminals in the '60s and beyond. And *of course* when that lead was removed in the '70s and '80s, the children of that generation lost those artificially heightened violent tendencies.

But if all of this solves one mystery, it shines a high-powered klieg light on another: Why has the lead/crime connection been almost completely ignored in the criminology community? In the two big books I mentioned earlier, one has no mention of lead at all and the other has a grand total of two passing references. Nevin calls it "exasperating" that crime researchers haven't seriously engaged with lead, and Reyes told me that although the public health community was interested in her paper, criminologists have largely been AWOL. When I asked Sammy Zahran about the reaction to his paper with Howard Mielke on correlations between lead and crime at the city level, he just sighed. "I don't think criminologists have even read it," he said. All of this jibes with my own reporting. Before he died last year, James Q. Wilson—father of the broken-windows theory, and the dean of the criminology community—had begun to accept that lead probably played a meaningful role in the crime drop of the '90s. But he was apparently an outlier. None of the criminology experts I contacted showed any interest in the lead hypothesis at all.

> Police chiefs want to think what they do on a daily basis matters. And it does. But maybe not as much as they think.

Why not? Mark Kleiman [25], a public policy professor at the University of California-Los Angeles who has studied promising methods of controlling crime, suggests that because criminologists are basically sociologists, they look for sociological explanations, not medical ones. My own sense is that interest groups probably play a crucial role: Political conservatives want to blame the social upheaval of the '60s for the rise in crime that followed. Police unions have reasons for crediting its decline to an increase in the number of cops. Prison guards like the idea that increased incarceration is the answer. Drug warriors want the story to be about drug policy. If the actual answer turns out to be lead poisoning, they all lose a big pillar of support for their pet issue. And while lead abatement could be big business for contractors and builders, for some reason their trade groups have never taken it seriously.

More generally, we all have a deep stake in affirming the power of deliberate human action. When Reyes once presented her results to a conference of police chiefs, it was, unsurprisingly, a tough sell. "They want to think that what they do on a daily basis matters," she says. "And it does." But it may not matter as much as they think.

So is this all just an interesting history lesson? After all, leaded gasoline has been banned since 1996, so even if it had a major impact on violent crime during the 20th century, there's nothing more to be done on that front. Right?

Wrong. As it turns out, tetraethyl lead is like a zombie that refuses to die. Our cars may be lead-free today, but they spent more than 50 years spewing lead from their tailpipes, and all that lead had to go somewhere. And it did: It settled permanently into the soil that we walk on, grow our food in, and let our kids play around.

That's especially true in the inner cores of big cities, which had the highest density of automobile traffic. Mielke has been studying lead in soil for years, focusing most of his attention on his hometown of New Orleans, and he's measured 10 separate census tracts there with lead levels over 1,000 parts per million.

To get a sense of what this means, you have to look at how soil levels of lead typically correlate with blood levels, which are what really matter. Mielke has studied this in New Orleans [26], and it turns out that the numbers go up very fast even at low levels. Children who live in neighborhoods with a soil level of 100 ppm have average blood lead concentrations of 3.8 µg/dL—a level that's only barely tolerable. At 500 ppm, blood levels go up to 5.9 µg/dL, and at 1,000 ppm they go up to 7.5 µg/dL. These levels are high enough to do serious damage.

"I know people who have move into gentrified neighborhoods and renovate everything. They create huge hazards for their kids."

Mielke's partner, Sammy Zahran, walked me through a lengthy—and hair-raising—presentation about the effect that all that old gasoline lead continues to have in New Orleans. The very first slide describes the basic problem: Lead in soil doesn't *stay* in the soil. Every summer, like clockwork, as the weather dries up, all that lead gets kicked back into the atmosphere in a process called resuspension. The zombie lead is back to haunt us.

Mark Laidlaw, a doctoral student who has worked with Mielke, explains how this works [27]: People and pets track lead dust from soil into houses, where it's ingested by small children via hand-to-mouth contact. Ditto for lead dust generated by old paint inside houses. This dust cocktail is where most lead exposure today comes from.

Paint hasn't played a big role in our story so far, but that's only because it didn't play a big role in the rise of crime in the postwar era and its subsequent fall. Unlike gasoline lead, lead paint was a fairly uniform problem during this period, producing higher overall lead levels, especially in inner cities, but not changing radically over time. (It's a different story with the first part of the 20th century, when use of lead paint did rise and then fall somewhat dramatically. Sure enough, murder rates rose and fell in tandem.)

And just like gasoline lead, a lot of that lead in old housing is still around. Lead paint chips flaking off of walls are one obvious source of lead exposure, but an even bigger one, says Rick Nevin, are old windows. Their friction surfaces generate lots of dust as they're opened and closed. (Other sources—lead pipes and solder, leaded fuel used in private aviation, and lead smelters—account for far less.)

We know that the cost of all this lead is staggering, not just in lower IQs, delayed development, and other health problems, but in increased rates of violent crime as well. So why has it been so hard to get it taken seriously?

There are several reasons. One of them was put bluntly by Herbert Needleman, one of the pioneers of research into the effect of lead on behavior. A few years ago, a reporter from the *Baltimore City Paper* asked him why so little progress had been made recently on combating the lead-poisoning problem. "Number one," he said without hesitation [28], "it's a black problem." But it turns out that this is an outdated idea. Although it's true that lead poisoning affects low-income neighborhoods disproportionately, it affects plenty of middle-class and rich neighborhoods as well. "It's not just a poor-inner-city-kid problem anymore," Nevin says. "I know people who have moved into gentrified neighborhoods and immediately renovate everything. And they create huge hazards for their kids."

Tamara Rubin, who lives in a middle-class neighborhood in Portland, Oregon, learned this the hard way when two of her children developed lead poisoning after some routine home improvement in 2005. A few years later, Rubin started the Lead Safe America Foundation [29], which advocates for lead abatement and lead testing. Her message: If you live in an old neighborhood or an old house, get tested. And if you renovate, do it safely.

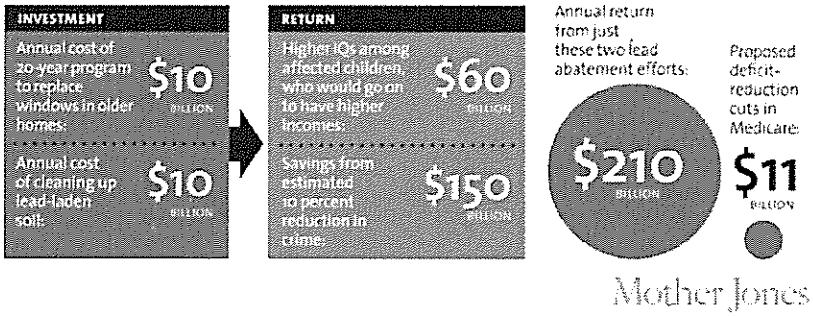
Another reason that lead doesn't get the attention it deserves is that too many people think the problem was solved years ago. They don't realize how much lead is still hanging around, and they don't understand just how much it costs us.

It's difficult to put firm numbers to the costs and benefits of lead abatement. But for a rough idea, let's start with the two biggest costs. Nevin estimates that there are perhaps 16 million pre-1960 houses with lead-painted windows, and replacing them all would cost something like $10 billion per year over 20 years. Soil cleanup in the hardest-hit urban neighborhoods is tougher to get a handle on, with estimates ranging from $2 to $36 per square foot. A rough extrapolation from Mielke's estimate to clean up New Orleans suggests that a nationwide program might cost another $10 billion per year.

So in round numbers that's about $20 billion per year for two decades. But the benefits would be huge. Let's just take a look at the two biggest ones. By Mielke and Zahran's estimates, [30] if we adopted the soil standard of a country like Norway (roughly 100 ppm or less), it would bring about $30 billion in annual returns from the cognitive benefits alone (higher IQs, and the resulting higher lifetime earnings). Cleaning up old windows might double this. And violent crime reduction would be an even bigger benefit. Estimates here are even more difficult, but Mark Kleiman suggests that a 10 percent drop in crime—a goal that seems reasonable if we get serious about cleaning up the last of our lead problem—could produce benefits as high as $150 billion per year.

We can either get rid of the remaining lead, or we can wait 20 years and then lock up all the kids who've turned into criminals.

Put this all together and the benefits of lead cleanup could be in the neighborhood of $200 billion per year. In other words, an annual investment of $20 billion for 20 years could produce returns of 10-to-1 *every single year* for decades to come. Those are returns that Wall Street hedge funds can only dream of.



There's a flip side to this too. At the same time that we should reassess the low level of attention we pay to the remaining hazards from lead, we should probably also reassess the *high* level of attention we're giving to other policies. Chief among these is the prison-building boom that started in the mid-'70s. As crime scholar William Spelman wrote a few years ago, states have "doubled their prison populations, then doubled them again, increasing their costs by more than $20 billion per year"—money that could have been usefully spent on a lot of other things. And while some scholars conclude that the prison boom had an effect on crime, recent research suggests that rising incarceration rates suffer from diminishing returns: Putting more criminals behind bars is useful up to a point, but beyond that we're just locking up more people without having any real impact on crime. What's more, if it's true that lead exposure accounts for a big part of the crime decline that we formerly credited to prison expansion and other policies, those diminishing returns might be even more dramatic than we believe. We probably overshot on prison construction years ago; one doubling might have been enough. Not only should we stop adding prison capacity, but we might be better off returning to the incarceration rates we reached in the mid-'80s.

So this is the choice before us: We can either attack crime at its root by getting rid of the remaining lead in our environment, or we can continue our current policy of waiting 20 years and then locking up all the lead-poisoned kids who have turned into criminals. There's always an excuse not to spend more money on a policy as tedious-sounding as lead abatement—budgets are tight, and research on a problem as complex as crime will never be definitive—but the association between lead and crime has, in recent years, become pretty overwhelming. If you gave me the choice, right now, of spending $20 billion less on prisons and cops and spending $20 billion more on getting rid of lead, I'd take the deal in a heartbeat. Not only would solving our lead problem do more than any prison to reduce our crime problem, it would produce smarter, better-adjusted kids in the bargain. There's nothing partisan about this, nothing that should appeal more to one group than another. It's just common sense. Cleaning up the rest of the lead that remains in our environment could turn out to be the cheapest, most effective crime prevention tool we have. And we could start doing it tomorrow.

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Beyond Flint: Excessive lead levels found in almost 2,000 water systems across all 50 states

TESTS FOR CITIES, RURAL SUBDIVISIONS AND EVEN SCHOOLS AND DAY CARES SERVING WATER TO 6 MILLION PEOPLE HAVE FOUND EXCESSIVE AND HARMFUL LEVELS OF LEAD.

Alison Young and (/staff/2018/alison-young)

Mark Nichols, USA TODAY (/staff/10047818/mark-nichols)

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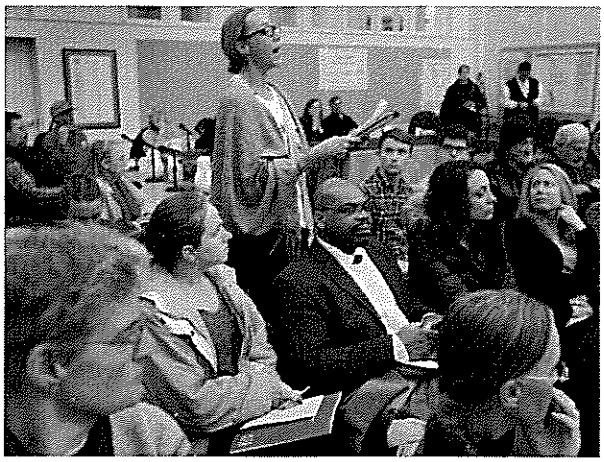
While a harsh national spotlight focuses on the drinking water crisis in Flint, Mich., a USA TODAY NETWORK investigation has identified almost 2,000 additional water systems spanning all 50 states where testing has shown excessive levels of lead contamination over the past four years.

The water systems, which reported lead levels exceeding Environmental Protection Agency standards, collectively supply water to 6 million people. About 350 of those systems provide drinking water to schools or day cares. The USA TODAY NETWORK investigation also found at least 180 of the water systems failed to notify consumers about the high lead levels as federal rules require.

Many of the highest reported lead levels were found at schools and day cares. A water sample at a Maine elementary school was 42 times higher than the EPA limit of 15 parts per billion, while a Pennsylvania preschool was 14 times higher, records show. At an elementary school in Ithaca, N.Y., one sample tested this year at a stunning 5,000 ppb of lead, the EPA's threshold for "hazardous waste."

"This is most definitely a problem that needs emergent care," Melissa Hoffman, a parent in Ithaca, forcefully pleaded with officials at a public hearing packed with upset parents demanding answers.

In all, the USA TODAY NETWORK analysis of EPA enforcement data identified 600 water systems in which tests at some taps showed lead levels topping 40 parts per billion (ppb), which is more than double the EPA's action level limit. While experts caution Flint is an extreme case of pervasive contamination, those lead levels rival the 400-plus of the worst samples in far more extensive testing of around 15,000 taps across Flint. The 40 ppb mark also stands as a threshold that the EPA once labeled on its website an "imminent" health threat for pregnant women and young children.



Melissa Hoffman, 40, expresses her concerns about the high lead levels found at her children's school, Caroline Elementary School, during a town hall meeting March 3, 2016, in Ithaca, N.Y.

(Photo: Romain Blanquart, USA TODAY NETWORK)

Even at small doses, lead poses a health threat, especially for pregnant women and young children. Lead can damage growing brains and cause reduced IQs, attention disorders and other problem behaviors. Infants fed formula made with contaminated tap water face significant risk. Adults are not immune, with evidence linking lead exposure to kidney problems, high blood pressure and increased risks of cardiovascular deaths. The EPA stresses there is no safe level of lead exposure (http://www.usatoday.com/story/news/nation/2016/03/16/what-lead-levels-in-water-mean/81534336/).

Fractured system, limited testing

Most Americans get their drinking water from a fragmented network of about 155,000 different water systems serving everything from big cities to individual businesses and school buildings. The EPA determines that a system has exceeded the lead standard when more than 10% of samples taken show lead levels above 15 parts per billion. It's called an "action level" because, at that level, water systems are required to take action to reduce contamination. But enforcement, which is implemented state by state, can be inconsistent and spotty. Some 373 systems have failed repeatedly, with tests continuing to find excessive lead in tests months or even years later, the EPA data shows. What's more, the systems have widely varying levels of financial resources and staff training.

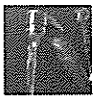
Amid cotton fields in Lamesa, Texas, for example, tests last year showed lead contamination more than seven times the EPA limit at Klondike Independent School District, which serves 260 students in a single K-12 building. "Some things just slip by," said the school superintendent Steve McLaren when pressed about skipping a round of testing in 2014. In a tiny school system, McLaren said leaders "wear a lot of hats." At times he's served as principal and bus driver, in addition to being superintendent and in charge of the drinking water system. The school replaced drinking fountains, and plans to replace its entire water system next fall. McLaren said he's concerned about how high lead levels might affect students and understands the need for action. But he said, "Our kids are strapping and healthy, and they've been drinking this water all their lives."

The testing required by the government can include samples from as few as five or 10 taps in a year, or even over multiple years. The system is designed only to give an indication of whether homes or buildings with lead pipes and plumbing may be at higher risk of lead leaching into water. Even the biggest water systems in cities are required to test just 50 to 100 taps.

The limited and inconsistent testing means the full scope of the lead contamination problem could be even more widespread. People in thousands more communities served by water systems that have been deemed in compliance with the EPA's lead rules have no assurance their drinking water is safe from the brain-damaging toxin.

"This is just a case where we have a rule that's not been adequately protective," said Lynn Goldman, a former EPA official and dean of George Washington University's school of public health. "The entire design of the regulation doesn't tell you about your own water."

Drinking water typically isn't contaminated with lead when it leaves the treatment plant. It becomes contaminated as it travels through lead service lines on individual properties and lead plumbing fixtures inside homes. At best, the EPA's rules and testing are a sentinel system, alerting officials of the need to treat their water with anti-corrosion chemicals. Doing so reduces, but does not eliminate, the lead in water reaching the tap.



USA TODAY
How much lead in water poses an imminent threat?

(http://www.usatoday.com/story/news/nation/2016/03/16/what-lead-levels-in-water-mean/81534336/)

There are about 75 million homes across the country built before 1980, meaning they're most likely to contain some lead plumbing. That's more than half of the country's housing units, according to the Census Bureau. The heaviest concentrations are in New York, Rhode Island, Massachusetts, Connecticut and Pennsylvania.

"You would hope that the cities and the counties and the state and the federal government would be holding people's feet to the fire when it comes to providing quality water to the consumer if there is an issue," said Terry Heckman, a board member at the Arizona Water Quality Association, a group that represents water systems. "That's what the government is supposed to do, is look over the general welfare of the populace."

Flint's risk factors not rare

Experts say what happened in Flint is an extreme case and helps show how the limited testing required by the EPA provides only a crude indicator of systems where harmful levels of lead may be in water at homes with lead pipes.

The struggling city of about 100,000 people passed the government's required lead tests. But one resident's vocal complaints spurred extra tests at her home, revealing shocking levels of lead contamination: 104 to 13,200 ppb. The crisis worsened as independent researchers tested 300 samples across the city, revealing homes with high lead levels that the government-mandated tests missed. More than 10% contained at least 27 ppb of lead. Since then, regulators conducted another 15,000 tests. More than 1,000 samples show lead above the 15 ppb limit, and more than 400 show dangerous levels above 40 ppb.

One unique factor in Flint: the water department changed to a corrosive river water source, then failed to treat it with anti-corrosion chemicals. The result: a pervasive contamination problem as the insides of old lead pipes broke down and released a torrent of poison.

Yet the fundamental risk factor in Flint – old lead service lines that deliver water to homes (https://youtu.be/nQSRWovWfvo), plus interior plumbing containing lead – is a common problem for tens of millions of homes mostly built before 1986. Unlike other contaminants that can be filtered out at the water plant, lead usually gets into drinking water at the end of the system, as it comes onto individual properties and into homes.

At greatest risk, experts say, are an estimated 7.3 million homes connected to their utility's water mains by individual lead service lines -- the pipe carrying water from the main under the street onto your property and into your home. The water passes through what amounts to "a pure lead straw," said Marc Edwards, a Virginia Tech environmental engineering professor who has studied water contamination in Flint and a similar, earlier crisis in Washington, D.C.

Lead service lines were mostly installed before the 1930s, although some communities continued to lay lead pipes for decades longer.

The way tap water becomes contaminated — at or even inside individual homes — poses a vexing problem for regulators, utilities and consumers. A home with a lead service line and older internal plumbing may have high levels of lead in its tap water. But a nearby, newly constructed home may have no lead contamination. The only way to know if your house is at risk is to find out about its water line and plumbing.

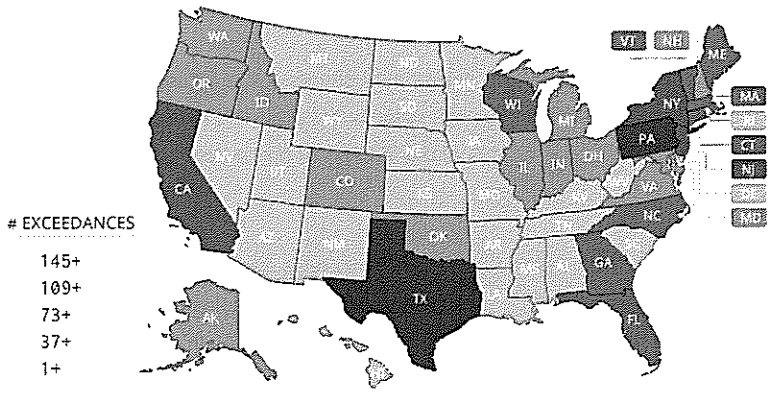
"People are legitimately concerned about what they're hearing in the wake of Flint," said Lynn Thorp, of the advocacy group Clean Water Action, who recently served on a federal work-group on lead in drinking water. "As long as we have lead in contact with drinking water, we can have exposure at the tap."

Thorp said consumers need to become educated about any risks at their individual homes.

LEAD IN THE WATER: A NATIONWIDE LOOK

Since 2012, nearly 2,000 water systems across the U.S. have found elevated lead levels in tap water samples, a public health concern that requires them to notify customers and take action. Search or click the map to find systems in your area. The map table shows the state / name of the water system; the county it serves; the range of lead levels over 15 parts per billion in samples that triggered an action status, and total action-level tests over the period.

United States



Search these results

STATE	SAMPLE MEASURE	# EXCEEDANCES
Texas	15.5ppb - 600ppb	15 3
Pennsylvania	15.5ppb - 1,273ppb	1~7
New York	15.5ppb - 2,300ppb	1~8
California	15.8ppb - 13,200ppb	11~
New Jersey	15.5ppb - 600ppb	111
Wisconsin	15.5ppb - 12,465ppb	96

SOURCE: USA TODAY analysis of EPA's Safe Drinking Water Information System (SDWIS) database.
Learn more about how we analyzed this data.

What is government doing?

Under the EPA's Lead and Copper Rule, implemented in 1991, the government's approach for protecting people from lead in drinking water has relied heavily on water systems monitoring for indications that their water has become more corrosive. The more corrosive the water, the more lead will be drawn out of pipes. Treatment of water with anti-corrosion chemicals can only reduce, not eliminate, lead from leaching into tap water in invisible and tasteless doses.

That's why the EPA's National Drinking Water Advisory Council wrote agency leaders in December calling for removing lead service lines "to the greatest degree possible." It's a daunting recommendation since in most cases, the water utility owns part of the line and the rest belongs to the homeowner. A credit ratings firm warned this month that replacing lead service lines could cost tens of billions of dollars.

"We're now dealing with a legacy issue on private property distributed throughout many communities," said Tracy Mehan, the American Water Works Association's executive director of government affairs. The cost to replace each service line can range from hundreds to thousands of dollars.

Meanwhile, the EPA advisory council, whose members include experts from water utilities and state agencies, recommended that EPA take numerous steps to strengthen the existing regulation. They include developing a "household action level" that would trigger public health actions when lead contamination reaches certain levels and ensuring the public receives more information about the risks they face.

In addition, state water regulators say, federal officials need to tell water utilities what level of lead contamination indicates an acute health risk that should trigger a "do not drink" alert to all of the systems' customers. The EPA is evaluating the recommendations and expects to propose revisions to its lead contamination regulations in 2017.

"We really recognize there's a need to strengthen the rule," Joel Beauvais, deputy assistant administrator for EPA's Office of Water, said in an interview.

While he characterized Flint as an outlier, he said, "There's no question we have challenges with lead in drinking water across the country. Millions of lead service lines in thousands of systems."

Changing the rules could take at least a year. Beauvais said the EPA is working now to make sure states fully enforce existing rules. The agency last month sent letters to governors and state regulators calling for greater attention to drinking water oversight. While federal rules are made by the EPA, they're enforced by the states.

Because of Flint, some utilities and state water regulators said they were already taking a closer look at water systems where testing identified excessive lead.

"It has caused a sort of shock wave through the drinking water industry generally," said Jim Taft, executive director of the Association of State Drinking Water Administrators. States are looking at water systems' performance and oversight, he said, "to make sure we're not missing something."

High lead in systems large, small

At a trailer home at the Maple Ridge Mobile Home Park in Corinna, Maine, Christi Woodruff recalls the notice hung on her door last year alerting her to potential lead contamination in the neighborhood.

A mom with an 8-year-old daughter, Woodruff initially planned to get her water tested. But, she shrugged it off after the park's landlord told her testing was unnecessary. "The manager said not to worry because it was only certain trailers ... He didn't think my trailer was one of them," she said.

Property manager Randy Dixon blamed tap water from a single old trailer with lead-soldered copper pipes for causing the park's water to fail the EPA's testing. He then told a USA TODAY NETWORK reporter to stop interviewing residents.

The analysis of EPA's data show the Maine park is among almost 2,000 water systems flagged for having an "action level exceedance" for lead during 2012 through 2015. That generally means more than 10% of tap water samples taken during a testing period showed lead contamination above 15 ppb.

Christi Woodruff of Corinna, Maine, doesn't know whether her trailer's water has lead problems but says she's drinking bottled water anyway because of a notice delivered several weeks ago to residents of her trailer park.

(Photo: Andrew West, USA TODAY NETWORK)

If you're living in a home with a lead service line and received a notice about possible lead contamination, "it's a good idea to get your water tested," said Beauvais, the EPA water office official.

Most of the water systems that failed the EPA's lead standard serve anywhere from a few hundred to several thousand people each, often running their lines to homes in rural communities, or managing water for individual schools or businesses in remote areas.

In Lake Mills, Wisc., about 50 miles west of Milwaukee, EPA records show the utility serving water to 5,300 people failed lead tests in 2013, 2014 and again in 2015 with some readings several times the federal limit.

Paul Hermanson, director of Public Works, said Lake Mills sent fliers with water bills since 2010 urging residents in older homes to run their water 15 to 30 seconds before using it. The idea behind not using the first water out of the tap is to avoid drinking water that's been touching the old pipes and has the greatest risk of containing lead. "I don't know that there's a good solution to it other than running the water," he said.

Some of the older homes in the growing bedroom community of Firestone, Colo., about 30 miles north of Denver, tested for excessive lead four times since 2014, records show. Town officials said they have repeatedly notified their 9,500 water customers of potentially harmful lead levels and distributed information explaining how to reduce risk. "The fact that they haven't fixed this, that's annoying," said resident Heath Gaston.

The USA TODAY NETWORK analysis showed three of every four water systems that exceeded the lead standard from 2012 to 2015 served 500 people or less. They often lack the resources and staff expertise of larger systems. "Some of these small systems don't even have a full-time operator," said Taft, of the state water regulators association. They may rely on one person, responsible for several systems, he said. In the case of schools, the same staff that does building maintenance may be managing the water system.

But nearly 70 of the systems with excessive lead findings during the past four years each provide water to at least 10,000 people. They include:

Passaic Valley Water Commission, New Jersey: More than 315,000 people are served by the water system in the industrialized area of northern New Jersey with a history of other pollution crises. It failed to meet EPA's lead standards during two testing periods last year and one in 2012. Commission officials said a $135 million construction project is underway to improve corrosion control. The utility officials also are publicly encouraging more people to participate in its lead-testing program.

New Bedford, Mass.: This municipal water system, which serves about 95,000 in a seaport city about an hour south of Boston, has been cited for excessive lead in 2014 and early 2015, EPA data show. Ron Labelle, the city's public infrastructure commissioner, said the area's housing is among the oldest in the Northeast and some still have lead service lines. A consultant has helped improve the system's anti-corrosion treatments, he said, and the city passed its most recent testing in December. Additional testing will be done this spring.

Bangor Water District, Maine: More than 28,000 people receive water from this system, which exceeded EPA's lead standards three times in 2012 and 2013. Operators tweaked chemicals used in its corrosion control program, and have been in compliance since.

Failure to notify people

When testing does reveal high lead levels, the USA TODAY NETWORK found many people were not warned as required. Of the 180 cited for failing to notify the public, almost half were cited more than once, records show.

In Ohio, in the past year, seven water systems serving a combined 8,800 customers failed to notify residents (http://www.mansfieldnewsjournal.com/story/news/local/2016/02/29/sebring-ohios-lead-problem/81099964/) of potential lead contamination within 60 days as required.

Tests found excessive lead last summer at homes in the village of Sebring. The water system didn't alert customers until January, after Flint started making national headlines. The Ohio EPA placed two employees on leave while investigating. State records show six other Ohio water systems also did not provide timely warnings to residents after failing lead tests. The systems supply water to mobile home parks, a subdivision, an arboretum and a church and its day care.

In Arizona, several water systems that found unsafe amounts of lead in drinking water samples taken several years ago failed to act until February, after the USA TODAY NETWORK began requesting data about lead levels in drinking water.

The principal at a boarding school near the Navajo Reservation was unaware until February that water from a faucet in a church at the property tested high for lead in 2013. Operators of a small water utility near the Mexico border and a small community system in eastern Arizona both had high lead test results in 2013. One said he didn't know any action was needed. The other conceded the lack of action was an oversight.

Misael Cabrera, director Arizona Department of Environmental Quality, acknowledged lapses in following up with some water systems. Cabrera said he's since asked all water providers for high lead levels to notify their customers. His department also is creating a system to better track compliance.

Without action, issues fester

Without strong action by regulators, problems can fester, especially in small systems with limited resources.

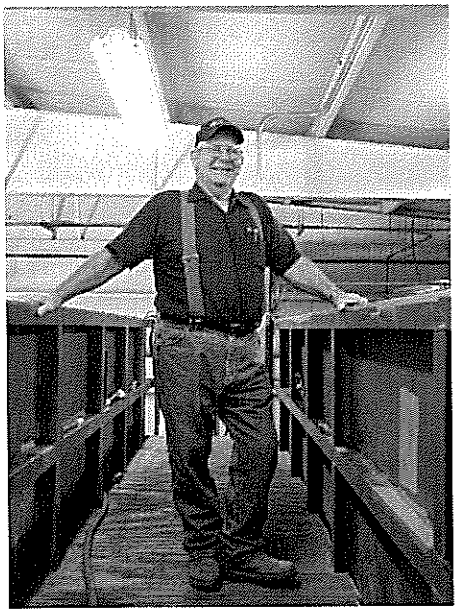
In southeastern Oklahoma's Latimer County, a rural water system serving about 1,500 people has had excessive lead levels during seven testing periods since 2013, EPA data show. The Latimer County Rural Water District #2 failed more tests in the past three years than any water system in the country.

Little has been done to fix the problem. The Latimer #2 district points its finger at its water supplier, and the supplier blames homeowners for not replacing bad plumbing.

"There's nothing we can do," said Linda Petty, office manager for the Latimer #2 district, which doesn't treat its own water. Latimer buys its water from the nearby Sardis Lake Water Authority. "We're at their mercy," she said.

"The water that we have coming out of the lake does not have lead in it," said Willie Williams, the Sardis Lake system's operator. "They have some houses in their system that have horrendous plumbing. There's not a single thing Latimer #2 can do about it and not a single thing I can do about it."

Customers received notices of the lead issue in their bills, the water system and residents said. County officials say they have not gotten calls from concerned residents.



Willie Williams, plant operator for the Sardis Lake Water Authority in Clayton, Okla., said water that comes from his plant has no detectable lead.

(Photo: Shane Bevel, USA TODAY)

"I haven't heard anybody saying anything about it," said John Medders, a county commissioner whose home is on the system. He recalled getting a notice in the fall. "Most of the time I just throw mine in the trash. I don't pay much mind to it."

Water regulators at the Oklahoma Department of Environmental Quality said they now plan to meet with both water systems and send state engineers to Latimer and 18 other water systems that don't comply with lead-contamination limits.

"The Flint, Michigan, situation has really opened our eyes to what's going on," said Patty Thompson, engineering manager for the department's public water supply group.

Contributing: Mark Alesia, The Indianapolis Star; Jessie Balmert, The (Newark, Ohio) Advocate; Patricia Borns, The (Fort Myers, Fla.) News-Press; Trevor Hughes, USA TODAY; Eric Litke, USA TODAY NETWORK-Wisconsin; Jacy Marmaduke, Fort Collins Coloradoan; Caitlin McGlade, The Arizona Republic; Marty Schladen, The El Paso Times; Todd Spangler, Detroit Free Press; Laura Ungar, USA TODAY; Jim Waymer, Florida Today; and Russell Zimmer, Asbury Park (N.J.) Press.

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Tweet (https://twitter.com/intent/tweet?url=http%3A//usat.ly/1pdGEYQ&text=Beyond%20Flint%3A%20Excessive%20lead%20levels%20found%20in%20almost%202%2C000%20water%20systems%20across%20all%2050%20states&via=USATODAY)

17,938 (http://www.facebook.com/share.php?u=http%3A//www.usatoday.com/story/news/2016/03/11/nearly-2000-water-systems-fail-lead-tests/81220466/)

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WisconsinWatch.org

FAILURE AT THE FAUCET

February 1, 2016

Lead pipes, antiquated law threaten Wisconsin's drinking water quality

Madison was the first city in nation to help homeowners replace all lead service lines; Flint, Michigan, crisis dramatizes hazards

By **Silke Schmidt and Dee J. Hall**

(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/inside-flint-pipes.jpg)

Siddhartha Roy / FlintWaterStudy.org

Lead from corroded pipes in Flint, Michigan, is partially to blame for a public health crisis in the impoverished community. After the city switched its drinking water source in 2014 to the highly corrosive Flint River, there was a spike in lead poisoning among Flint's children. Residents are now drinking bottled water, and Michigan Gov. Rick Snyder and President Barack Obama have both declared a state of emergency.

Experts, and even some regulators, say existing laws are failing to protect Wisconsin and the nation from harmful exposure to lead in drinking water that leaches from aging plumbing — a danger illustrated by the public health crisis (http://www.freep.com/story/news/local/michigan/2016/01/16/president-obama-declares-emergency-flint/78898604/) in Flint, Michigan.

At least 176,000 so-called lead service lines connect older Wisconsin homes to the iron water mains that deliver municipal water, according to an estimate by the U.S. Environmental Protection Agency. Milwaukee alone, where 60 percent of the state's known lead-poisoned children live, has 70,000 lead service lines.

Regulators concede that the Lead and Copper Rule, the 25-year-old federal law that seeks to minimize the danger from these lead pipes and indoor plumbing fixtures, is failing on several fronts:

- Methods for sampling often fail to detect the highest level of lead in a consumer's home.
- Too few homes are sampled, and those that are may not be in the neighborhoods most at risk.
- The requirement that utilities replace some lead lines when they exceed federal

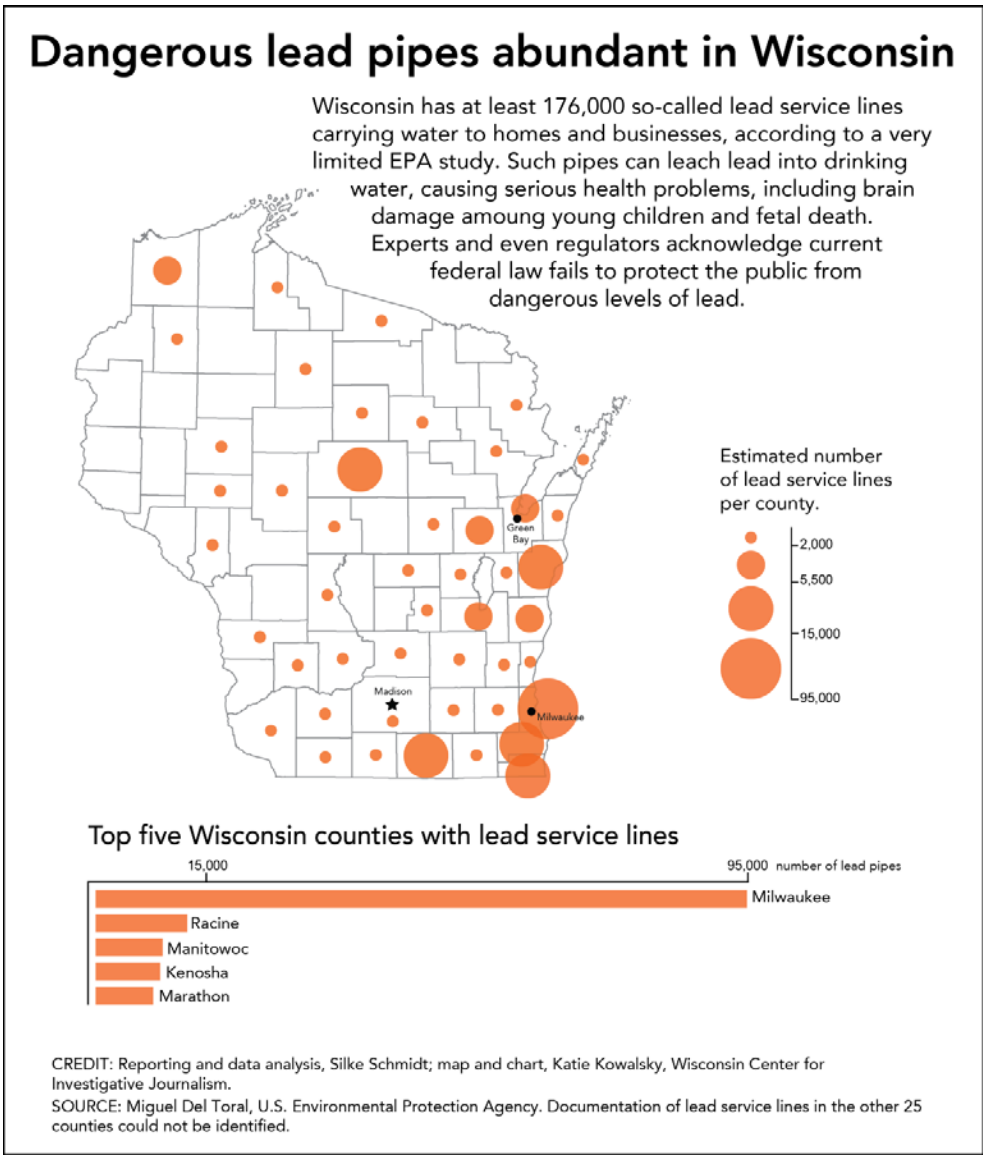
thresholds may actually cause dangerous increases of lead in drinking water.

Lead is primarily leached into Wisconsin's drinking water by the corrosion of lead pipes and indoor plumbing components.

Health effects of lead include irreversible brain damage in children under age 6 and an increased risk of miscarriage in pregnant women.

Decades ago, when it became clear that lead was one of the worst toxins for the developing brain, U.S. regulatory agencies began to eliminate the heavy metal from gasoline, paint and new plumbing. But the efforts to address the nation's existing water infrastructure were limited.

Marc Edwards, an engineering professor at Virginia Tech and one of the nation's foremost experts on lead in drinking water, helped Flint address its massive problem (http://flintwaterstudy.org/) with lead-contaminated drinking water that has poisoned a number of the city's children.



(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/leadpipes-UPDATE3.png)

Edwards said millions of U.S. homes have some lead components in their water delivery system, although he acknowledged "no one knows" the exact number. He agreed with some who have called the widespread risk posed by lead pipes and the astronomical cost to

replace them one of the biggest environmental disasters in U.S. history.

Lead hazards underestimated

The American Water Works Association estimated in 1990 that the U.S. water infrastructure had about 3.3 million lead service lines and 6.4 million connections made of lead, many of them installed well over 100 years ago. Wisconsin is one of nine states, all in the Midwest and Northeast, where they are particularly common.

In addition to Milwaukee, several other Wisconsin communities have a high percentage of lead service lines, including Wausau (http://www.ci.wausau.wi.us/Portals/0/Departments/Water/Documents/WWaterWSummer2015.pdf) , Wauwatosa and Racine, according to the EPA.

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Edwards-leaking-pipe.jpeg)

Virginia Tech

Marc Edwards, a Virginia Tech engineering professor who is a national expert on lead in drinking water, collects a sample from a leaking water pipe. Edwards' research has shown that existing federal requirements can increase rather than decrease the exposure of consumers to lead.

"Although most cities in the United States were moving away from lead water pipes by the 1920s," a 2008 report (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2509614/) said, "it appears that this trend was not universal. National model plumbing codes approved lead into the 1970s and 1980s, and most water systems based their regulations on those codes."

Another 2008 study (http://www.waterrf.org/PublicReportLibrary/91229.pdf) found that these service lines account for 50 to 75 percent of lead contamination in public tap water, with most of the remainder due to indoor lead pipes and plumbing components, such as faucets and connections.

The risk of these aging pipes is so high that Madison's public water utility made the controversial decision to replace not only the portion of the lead service lines that it owned, but also the privately owned portion

from the curb stop to the house beginning in 2001. The $19 million program, partially paid for by property owners, is thought to be the first in the United States and now serves as a model for other cities.

(http://u6efc47qb7f1gsvo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/corroded-lead-pipe.jpg)

Madison Water Utility

Lead pipes, such as this one in a Madison home, are blamed for putting dangerous lead levels in drinking water. Madison replaced all of the lead service lines leading from water mains into buildings, and is thought to be the first U.S. city to do a "full" lead pipe replacement.

The problem posed by lead service lines is likely underestimated in Wisconsin, where census figures show about 27 percent of homes were built before 1950 and 63 percent before 1980.

Miguel Del Toral, a regulations manager at the EPA's Chicago office, said that after five years of effort, he could only track down written documentation of lead pipes in 113 Wisconsin communities in 47 of the state's 72 counties. The number of lead pipes outside of these communities is anybody's guess.

A nationwide EPA survey of 153 public water utilities in 1984 found that "30 percent of the respondents could not offer any estimate of the number of lead service lines remaining in their cities," according to a 2008 report (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2509614/) .

"In the smaller towns, the institutional knowledge about this is lacking," Del Toral said. "A private well connected to a home can have (lead pipes) too. They are pretty universal. But we have no access to private records."

In addition, tap water from only a fraction of the 176,000 buildings in Wisconsin on known lead service lines has to be tested regularly as part of the federal Lead and Copper Rule (http://www.epa.gov/dwreginfo/lead-and-copper-rule) . The law requires utilities to collect water samples from households known or suspected to be served by these pipes.

But, said Del Toral, "If they don't know about the lead service lines, they may not be sampling at those sites, so unless they accidentally find them, the lead levels being reported might not reflect reality."

Milwaukee Water Works is currently on a reduced monitoring schedule because of a history of compliance with the federal law; it only has to test for lead in 50 homes every three years. Even before this schedule became effective, the city only had to test 100 homes per year for lead.

Finally, some testing under the federal rule may not accurately reflect consumers' actual lead exposure, according to a study by Del Toral (http://www.ncbi.nlm.nih.gov/pubmed/23879429) and another by Edwards (http://www.ncbi.nlm.nih.gov/pubmed/22552494) . The latter study found that "slight variations from one approved protocol to another may cause lead-in-water health

risks to be significantly underestimated."

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/flint_fire_station-giveaway.jpg)

Steve Carmody / Michigan Radio

An American Red Cross volunteer stacks cases of bottled water at a Flint, Michigan, fire station in January. A state of emergency has been declared over the levels of lead in Flint's drinking water. Authorities also are providing free water filters to residents of the beleaguered city.

"We've actually documented a few cases where these instructions caused us to miss lead problems and tell people that the water was safe when it wasn't," Edwards said.

Del Toral's 2013 study (http://www.ncbi.nlm.nih.gov/pubmed/23879429) found wide swings in lead levels in Chicago households when tap samples were taken 12 or more times during a single day. He concluded that "the existing regulatory sampling protocol under the U.S. Lead and Copper Rule systematically misses high lead levels and potential human exposure."

Corrosion control can keep lead out of water

A water utility is compliant with the federal law when at least 90 percent of household samples are below the action level of 15 parts per billion (ppb) of lead. Even when utilities greatly exceed the action level, unless it involves more than 10 percent of the samples, no system-wide remediation efforts are required.

If more than 10 percent of samples exceed 15 ppb, a water utility may be required to install or improve corrosion control. This involves adding a chemical, such as orthophosphate, to the water to make it less likely to eat away at lead pipes.

Determining the water treatment method that works best requires money, ongoing maintenance and specialized knowledge about water chemistry. Systems required to use corrosion control (http://www.awwa.org/portals/0/files/legreg/documents/20140226_ndwac_occtprimer.pdf) include those serving 50,000 or more customers and those in which 10 percent or more of the water samples tested above the federal action level.

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/flint-pipes2.jpg)

Siddhartha Roy / FlintWaterStudy.org

Blood lead levels in children increased after Flint, Michigan, began drawing its drinking water from the Flint River without adding anti-corrosive compounds. Several factors can cause lead spikes in water. One of them is the physical shaking of the lead pipes during replacement work, which can knock off lead inside the pipe.

In April 2014, when Flint began drawing its drinking water (http://www.mlive.com/news/flint/index.ssf/2015/09/new_testing_shows_flint_water.html) from the Flint River without adding anti-corrosives, blood lead levels spiked in children (http://www.npr.org/2015/09/29/444497051/high-lead-levels-in-michigan-kids-after-city-switches-water-source), inciting a public health crisis, protests and angry finger-pointing. The city has now switched back to Detroit water (http://www.usatoday.com/story/news/nation-now/2015/10/25/lead-poisoning-flint-water/74599112/).

"(Corrosion control) is a complicated subject that has kept water quality experts searching and even arguing for decades," said Abigail Cantor, a Madison-based chemical engineer who has worked with several Wisconsin water utilities as a technical consultant.

In addition, orthophosphate harms surface water quality. When treated water is released into lakes by the wastewater treatment plant, phosphate contributes to algal blooms, which can cause oxygen depletion and trigger the production of toxic chemicals.

That is one of the reasons that Madison, a city proud of its lakes, rejected corrosion control and instead replaced all of its lead service lines with copper pipes.

Required pipe replacements can boost danger

When a utility is not in compliance with the federal law and corrosion control is ineffective or rejected, it must replace 7 percent of the lead service lines that it owns. Additional replacements are required every year until the utility comes back into compliance.

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/drinking-water-lead.jpg)

Bridgit Bowden / Wisconsin Public Radio

Researchers and even some regulators agree that the current sampling protocol under the federal Lead and Copper Rule can fail to detect dangerous levels of lead in water. Among the problems: The amount of lead in a home's drinking water can vary widely even within a single day.

The utility-owned portion of the service line typically runs from the water main to the curb stop, while the section between the curb stop and the house is usually privately owned.

However, replacing only the utility-owned portion of the pipe, a so-called partial replacement, can have severe unintended consequences: it may increase, rather than decrease, lead levels in consumers' tap water.

Several factors can cause these lead spikes. One of them is the physical shaking of the lead pipes during the replacement work, which can knock off lead inside the pipe.

"In Chicago, the scale that came off the service line in one event where they cut the line was 300,000 ppb lead," Del Toral said. "The sediment that came off was 125,000 ppb lead. That would pass straight through a kitchen aerator and would put an infant or child in the hospital immediately, if not worse."

Lead levels in tap water may also increase after partial replacements due to a chemical phenomenon called galvanic corrosion.

(http://u6efc47qb7f1gsv06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/corroded-lead-pipe1.jpg)

Siddhartha Roy / FlintWaterStudy.org

This corroded pipe, taken from a building in Flint, Michigan, shows the process by which dangerous lead got into the drinking water of the impoverished city, leading to a spike in blood lead levels among children. Wisconsin has at least 176,000 lead service lines, according to a very conservative estimate by the U.S. Environmental Protection Agency.

"When old lead pipe is connected to a new copper pipe, the contact of the two metals creates a battery effect that activates lead, so that it enters the water at an accelerated rate," said Yanna Lambrinidou, one of Edwards' colleagues at Virginia Tech.

In 2012, a federal Centers for Disease Control and Prevention study (http://www.cdc.gov/mmwr/pdf/other/su6104.pdf) reported direct evidence that partial replacements may cause elevated lead levels — not just in drinking water, but also in the bodies of children under 6 years of age.

"Compared with children who had never had a lead service line," the authors found, "children having had a partial lead pipe replacement were at increased risk for increased (blood lead levels)."

They concluded that "the practice of partially replacing lead service lines as a method to comply (with the Lead and Copper Rule) should be reconsidered."

Water main repairs also can cause a physical disturbance of the lead service lines, resulting in the same risk of lead scale particles being released into the water. Milwaukee has hundreds of water main breaks a year (http://www.jsonline.com/news/milwaukee/milwaukee-avoids-water-system-crisis--but-not-main-breaks-b99584256z1-330196601.html).

"The water main work is the primary disturbance of the lead lines. That is

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Paul_Biedrzycki.jpg)

Milwaukee Public Health Department

Paul Biedrzycki, head of environmental health for the city of Milwaukee, says he's concerned about the dangers of water main repairs to residents. Such repairs can disturb lead in pipes, sending high levels of the toxic substance into homes.

going on, unregulated, on a daily basis in all major water systems in the country," Del Toral said. "That's a very big concern."

Paul Biedrzycki, director of environmental health for the city of Milwaukee, shared Del Toral's concern. Fixing water mains is "a tradeoff between replacing aging infrastructure … to ensure the continuity of drinking water service to our population … and a very real public health threat posed by this work," Biedrzycki said.

Because of the potential danger, a 2014 communications guide (http://www.awwa.org/Portals/0/files/resources/publicaffairs/pdfs/FINALeadServiceLineCommGuide.pdf) by the American Water Works Association urged utilities to notify customers of steps to protect their drinking water whenever nearby water mains are repaired or lead service lines replaced.

Milwaukee Water Works spokeswoman Sandra Rusch Walton said the city takes precautions against lead when it repairs broken water mains by flushing the line and asking homeowners to do the same.

Cantor said that may not always have the desired effect. "Flushing of building water lines is a complicated subject," she said. "Sometimes it does solve the problem. Sometimes, it riles up pipe wall debris (including lead) and makes matters worse."

Cantor also said that monitoring for lead in a building is difficult.

(http://u6efc47qb7f1g5v06kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2013/05/Milwaukee-water-fountain-2500px.jpg)

Kate Golden / Wisconsin Center for Investigative Journalism

The city of Milwaukee is considered a world leader in testing for contaminants in its drinking water. But thousands of Milwaukee children are diagnosed each year with lead poisoning, which some researchers say could be at least partially due to lead-tainted drinking water. The compound, which is linked to lower IQ and behavioral issues when consumed by children, can leach from lead pipes leading into older homes.

"Every plumbing system is different, and it's hard to predict where the problems lie in the system unless studied in depth — something a property owner can't do and something a water utility can't do for a complete city," she said.

Because of concerns (http://media.jrn.com/documents/leadletter01.27.16.pdf) that water main replacement work could cause lead levels to rise, Milwaukee officials in January informed state agencies (https://www.documentcloud.org/documents/2700320-Milwaukee-Water-Works-Letter-and-Commission.html) that the city is temporarily halting planned work on five miles of water mains serving about 500 homes.

New regulations years away, public on its own

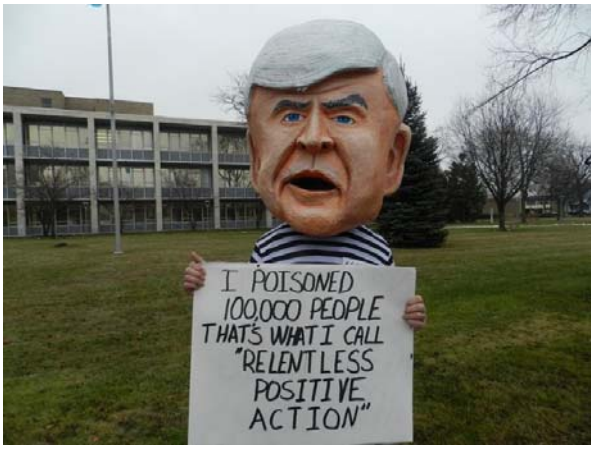
A quick fix of the nation's lead pipe problem is unlikely. Lambrinidou was part of an EPA-convened working group tasked with proposing changes to the Lead and Copper Rule. This group released its final report (http://www.awwa.org/Portals/0/files/legreg/documents/FinalLCR.pdf) in August.

One of the group's major recommendations: requiring water utilities to pursue full replacement of all lead service lines in collaboration with customers.

Lambrinidou estimates it will take at least another five to seven years before any revisions go into effect. Amy Kubly, a water supply engineer with Wisconsin's Department of Natural Resources, agrees that the EPA ought to move faster, given that the dangers of lead have been known for a very long time.

"I think (the Lead and Copper Rule) is overdue for revisions," Kubly said. "I've heard for years now that they're working on them, but haven't heard anything concrete as to what they would contain. Hopefully we'll hear something soon."

Until all lead pipes in the water infrastructure system are safely replaced, however, consumers are largely on their own when it comes to protecting their families from lead exposure, Edwards said.



(http://u6efc47qb7f1g5vo6kf9kfdcn.wpengine.netdna-cdn.com/wp-content/uploads/2016/01/Flint-water-protester.jpg)

Steve Carmody / Michigan Radio

A protester parodies Michigan Gov. Rick Snyder during a Jan. 8 protest over lead in the drinking water in Flint, Michigan. Snyder and President Barack Obama have called a state of emergency over the crisis. State environmental officials initially dismissed concerns about the water. Flint switched water sources without adding anti-corrosion chemicals, causing dangerous levels of lead to leach from water pipes. The problem was discovered after the drinking water became discolored and blood lead levels among children spiked.

Specific recommendations for residents include testing their water, ideally before starting a family, installing a water filter certified to remove lead and other metals, using only cold water for cooking and never drinking or cooking with tap water that has been sitting in pipes for several hours.

Even Cantor — who has a copper water system, has tested her water and knows she has no metals issues in her house — takes precautions.

"A good rule of thumb is to never drink water that has been stagnating — in any building," she said. "I fill up a big water jug after I wash dishes at night and put the jug in the refrigerator. That way, I know that I am always drinking water that came fresh from the water main instead of water that has been sitting in the pipes in my house."

Edwards called for "complete removal of all lead service lines" across the country.

"If we don't make a decision right now to get these lead pipes out of the ground, when are they going to be removed?" Edwards asked. "They just pose an unreasonable health risk to future generations."