Lead in Drinking Water & Your New Baby

Is your water safe for making infant formula?

A national investigation finds that
40% of homes have too much lead for babies

Study includes how to test your water
and reduce the lead levels

Healthy Babies Bright Futures

Jane Houlihan, Research Director | Healthy Babies Bright Futures | October 2020

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Lead in Drinking Water and Your New Baby

Is your water safe for making infant formula? Our findings show what parents, water utilities, and EPA should do to get toxic lead out of drinking water and infants' first food.

SUMMARY

Most parents know the routine of preparing a bottle for a baby – mixing and warming formula and then cradling a little one intent on enjoying a good meal. But in too many homes this ritual includes an unwanted, extra ingredient – toxic lead that leaches from pipes and fixtures to taint tap water in both old and new homes.

An estimated 6 to 10 million homes nationwide get water through lead pipes that can release harmful amounts of the toxic heavy metal. Lead-bearing solder and fixtures add additional traces.

Formula-fed infants face the greatest risks, with higher exposures to lead in drinking water, pound for pound, than any other family member, at a time in life when the brain is most vulnerable to lead-induced harm such as lowered IQ or learning and behavioral problems.

Despite these obvious risks, the Environmental Protection Agency (EPA) is relaxing regulations to permit two more decades of exposure for infants, extending the prior 14-year timeline to a new 33-year grace period for utilities to replace lead pipes with safer materials. The rollback creates the prospect of yet another generation of children harmed by lead in water.

New tests from an HBBF and Virginia Tech partnership uncover the extent of risks for those most vulnerable to these failures – formula-fed infants.

Nearly 800 families nationwide collected tap water samples for testing. The lab found lead in water from 79 percent of the homes tested, often in amounts too high to be safe for formula-fed infants. In 40 percent of homes, amounts topped the 1 part-per-billion limit recommended by the American Academy of Pediatrics (AAP). **In one in seven homes, lead in water could steal enough IQ points from a formula-fed infant to erode their lifetime economic productivity by one percent or more.**

TEST RESULTS:
785 HOMES TESTED NATIONWIDE

79% of homes tested have detectable levels of lead in tap water.

Many homes have lead levels of concern for formula-fed infants:

40% of homes – Lead in water above American Academy of Pediatrics' recommended limit for children (1 ppb*).

15% of homes – Lead in water above level that causes up to 1% loss in lifetime economic productivity for a formula-fed infant, due to IQ loss (3.9 ppb, Abt 2020).

Some homes have lead above federal standards and far above health-protective levels:

3.6% of homes – Lead in water above EPA's legal limit, the action level of 15 ppb. Up to 10% of homes in a city can be above this limit before water utilities are required to improve corrosion control. Formula-fed infants in these homes face high risks.

*ppb = parts per billion, or micrograms of lead per liter of water (ug/L)

For the first six months of life, breastmilk and formula are a baby's only food. Formula made with tap water is far more likely than breastmilk to contain significant lead levels.

Sixteen percent of U.S. babies are exclusively fed infant formula and 75 percent consume at least some.

Federal standards for lead in water do not protect infants. Punching in at 15 times the AAP's recommended limit for children, EPA's 15 part-per-billion action level is based on cost and feasibility, not health. It prompts utilities to improve corrosion control only if more than 10 percent of tested homes exceed it, and does not apply to individual homes, where any lead level is legal. Most homes are never tested. Even in the largest cities, EPA requires water utilities to test as few as 50 homes with lead pipes as infrequently as once every three years.

EPA's health-based goal for lead in water is zero, the only known safe exposure level. Most families have no idea that their water contains lead, let alone whether it's safe enough to make formula for a baby.

For low-income and minority families, the problem of lead in water is even more urgent. Black babies drink more formula than other babies. They are less likely to receive breastmilk throughout infancy and are nearly twice as likely to drink only formula beginning at birth.

Researchers commonly find racial disparities in lead exposures: "High lead contamination of drinking water is disproportionately reported or uncovered in low income and minority communities. Flint MI is the best known, but not exceptional. It typifies the disparity in lead exposures by race and income" (Levin and Zilli Vieira 2020).

Our findings raise concerns, but on the spectrum from worry to action, parents can choose to act. For an individual child, risks from lead in water are typically fairly low. In the short term, a baby's need for regular, adequate, nutritious food, whether breastmilk or formula, is far more important than filtering the lead out of tap water.

WHAT'S NEW ABOUT THIS STUDY?

Lead in water has been in the news for years, but this is the first study to focus on family members who face the highest risk of all – bottle-fed infants drinking powdered formula made with tap water. The study advances the field in three ways:

Wide range of towns, home age, and plumbing types:
We've tested water from 343 towns in 46 states, in homes built between 1840 and 2019, with plumbing and pipes of all types – lead, copper, galvanized, and brass – for a wide-ranging view of lead levels and risks.

Three-sample kit pinpoints lead source and gives customized actions:
Our 3-sample kit shows where the lead is coming from – home plumbing, the service line in the yard, or the main pipes. Many water utilities test only one sample and can easily miss a lead problem. The 3 samples allow us to provide personalized action reports on how to protect vulnerable family members like formula-fed infants.

First-ever look at IQ loss for formula-fed infants:
We commissioned a new study to quantify for the first time the health impacts for formula-fed infants who receive a higher dose of lead than any other group in the population – babies who drink powdered formula made with tap water. We found that one of every 7 homes tested has enough lead in the water to significantly reduce IQ and erode lifetime productivity by at least 1%.

While no amount of lead is considered safe, less is always better, and parents can lower their babies' exposures by testing their water and taking simple actions to reduce exposures. This report includes practical recommendations for parents.

Our testing program substantiates the widespread presence of lead in U.S. tap water, an absence of federal standards that protect infants, and the common occurrence of lead in excess of recommended limits for children. It also reveals how standard water testing practices and health agencies' stock advice to parents can perversely increase risks for formula-fed infants. Ten key findings from our tests are detailed in this report.

National lead-in-water testing program

Samples collected from 2016-2020

785 homes in 343 cities and 46 states

3 water samples from each home

Laboratories

681 homes tested by Virginia Tech

104 homes tested by Waypoint Analytical

Focus

688 homes across the country

97 homes in New Orleans

ABOUT HBBF'S LEAD IN WATER TESTING PROGRAM

HBBF has offered low-cost lead-in-water test kits for purchase online since 2016 in partnership with Virginia Tech (hbbf.org/lead-drinking-water). Our goal is to provide affordable test kits that help families learn if lead is in their water and what to do about it, with an emphasis on protecting formula-fed infants.

Each kit includes 3 sample bottles, to be filled after water has sat unused in pipes overnight. Bottles include a "first-draw" and two subsequent "flush" samples collected after running the water for 45 seconds and then for 5 minutes. The first sample shows if the home faucet and plumbing are a source of lead. For most homes the second and third samples show if the service line is leaching lead, or if lead is already present in the water main, before traveling through pipes in the family's property and home. In some homes, tests also find particles of lead that have been scoured from the service line as the water passes by.

Until September 2020, limited seed funding allowed HBBF to offer test kits for as little as $12. A pay-as-you-can menu included the option to purchase a subsidized kit, cover the full kit cost, or donate a kit to another family. Kits are now offered at-cost for all families – $47 for materials, shipping and analysis. HBBF continues to subsidize research and administration needs for the program.

The three-sample kit allows us to give each family a personalized action report. We indicate the severity of each test result and provide advice on filtering and flushing water before use based on the relative and absolute amounts in each bottle for each home. Every home is different. We developed a custom web application that creates a personalized action report for each family's particular situation, giving actions specifically designed to protect formula-fed infants.

Samples are analyzed using standard EPA methods for toxic elements in water (EPA 1994; APHA, AWWA, and WEF 1998).

Of the 785 homes included in this report, water samples from 104 were analyzed by Waypoint Analytical in Memphis TN as part of HBBF's Vida Lead in Homes pilot study testing for a wide range of lead sources in the home (hbbf.org/lead-home). For all other homes, samples were assessed by Virginia Tech.

The at-cost tests provided by HBBF and Virginia Tech help parents navigate water safety. We found that simple changes can significantly lower a baby's exposures to lead contamination.

PARENTS, CITIES AND WATER UTILITIES, AND EPA ALL HAVE A ROLE TO PLAY IN REDUCING BABIES' EXPOSURES

The concentrated risk for formula-fed infants underscores the crucial need for action from EPA, cities and water utilities, and parents to reduce lead levels in tap water.

Denver Water provides a model for other cities and utilities to follow. Their Lead Reduction Program includes identifying and replacing all customer-owned lead service lines at no direct cost to the customer. As that proceeds, they are providing a free water pitcher, filter and replacement filters, certified to remove lead, to all customers suspected of having lead services lines until six months after their line is replaced. To minimize the potential for lead leaching across the entire distribution system, they are adjusting the water chemistry (increasing the pH) to reduce corrosion. All of this is being done with a health equity and environmental justice lens and involves significant ongoing outreach and the ability for any customer to request a free water quality test kit at denverwater.org.

HBBF's Bright Cities program has begun catalyzing increased testing and enhanced communications to help parents reduce infants' exposures to lead in water. Cities taking initial actions include Columbia SC, where the water utility has tested water fountains at all city parks and boosted their health communications, Missoula MT, which has improved their health-risk outreach, and Anchorage AK, where the utility is now promoting on-demand testing for its customers.

Significant investments in water infrastructure will be necessary for all families to have safe, affordable drinking water, including water with minimal lead. Priorities should include federal funding for complete lead service line replacement. A model is provided in the Moving Forward Act's (H.R. 2) provision for up to $4.5 billion in federal grants for full removal of LSLs, including portions of the lead lines on private property, prioritized for disadvantaged communities.

Protecting babies requires replacing lead service lines in the next 10 years, not the next 33 (or more) years as currently prescribed by EPA. EPA should lower its action level to 5 ppb and require not only a "first-draw" compliance sample from every home tested by each water utility, but also a service line sample from every home. Additionally, EPA should mandate monitoring at least every 6 months until all LSLs in a water system are replaced.

Finally, the government's national dietary survey should be expanded to provide an accurate view of the amounts and types of formula and foods U.S. babies are consuming, to provide the critical, basic information health agencies need to develop safety standards and educate parents.

Many sources contribute to children's exposures to heavy metals, from drinking water and imported toys to lead in chipping paint and soil tracked into the house. Lead in water is a major source for formula-fed infants, but also a solvable problem. The government, water utilities, and parents can all act – and are, in some cases, already acting – to measurably lessen exposures for babies.

STRONG RETURN ON INVESTMENT:

Removing lead from drinking water systems more than pays for itself.

Each lead service line costs about $6,000 to fully replace, from the water main to the residential structure, a daunting cost in cities with many lines to deal with (LSLRC 2020a).

But study after study shows that removing these lead lines more than pays for itself in health benefits.

Assessments find, for example, returns of $200 for every $100 spent removing lead from drinking water infrastructure in Minnesota, considering benefits from enhanced brain development and lifetime productivity (MDH 2019); $131 for every $100 spent replacing lead service lines in New York (Altarum 2019, considering lifetime productivity); and more than $310 for every $100 invested to replace all lead service lines nationally, considering decreased deaths from cardiovascular disease, another confirmed risk from lead exposures (EDF 2020a).

At least 200 communities are making progress toward removing lead service lines, of the approximately 11,000 total communities estimated to have them (EDF 2020b, LSLRC 2020b).

TEN FINDINGS FROM OUR TESTS OF 785 HOMES

HBBF tested water from 785 homes across the country, from 343 cities and 46 states, between 2016 and 2020. Samples were analyzed by two nationally recognized laboratories with expertise in heavy metal assessment, Virginia Tech's Environmental Laboratory with Dr. Marc Edwards, and Waypoint Analytics in Memphis TN.

HBBF's analysis of test results shows that many homes have lead levels of concern for formula-fed infants:

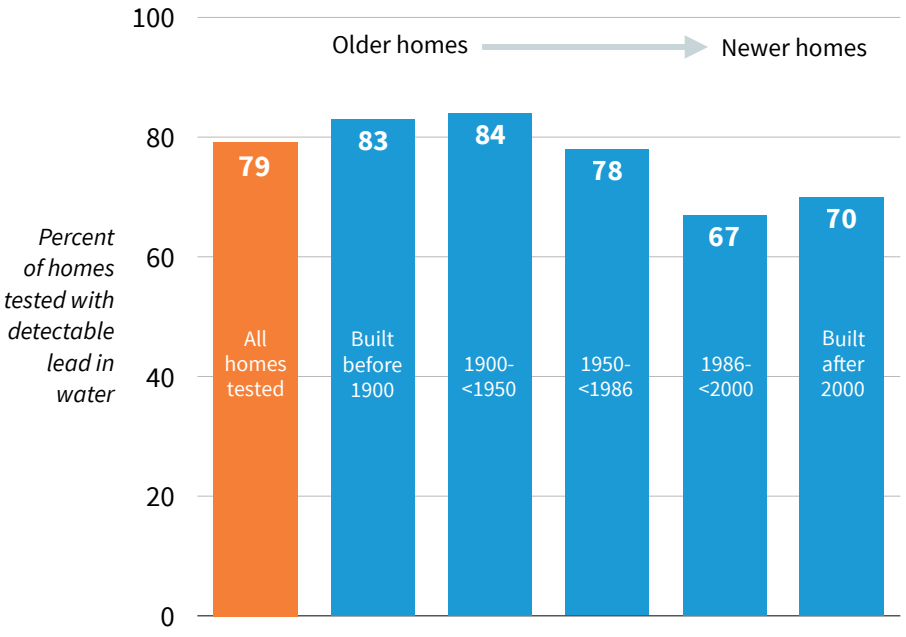
1 79 PERCENT OF HOMES TESTED HAVE DETECTABLE LEVELS OF LEAD IN TAP WATER.

Both new and older homes had detectable lead (Figure 1). Our study found no sure way to predict if a particular home has lead in the water. We found that families need to test their water to know if lead is present.

Older homes with older pipes and solder are more likely to have high levels, but even newer homes with new faucets and fixtures can test high for lead. For example, our tests found comparably high lead levels in a 1908-era single-family house in downtown Seattle and a 1980's country house in Mars Hill, NC.

Fig 1. Eight of every 10 homes tested had detectable lead levels in tap water.

Old homes are more likely to have lead, but new homes are also at risk.



Source: HBBF analysis of tests from 785 homes across the country, 2016-2020

2 FORMULA-FED INFANTS FACE THE HIGHEST RISK OF ANYONE IN THE FAMILY.

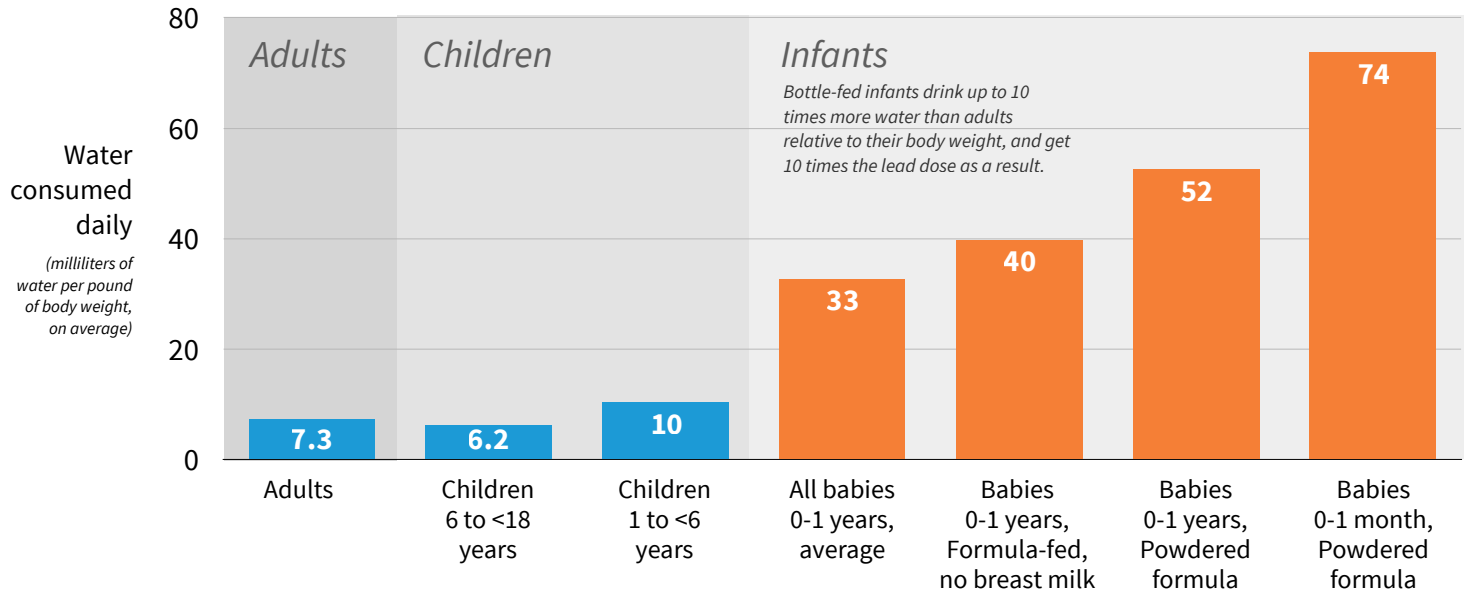
When they drink formula made with tap water, infants ingest a higher dose of lead, pound for pound, than other family members. Formula-fed infants drink up to 10 times more water than adults relative to their body weight and get 10 times the lead dose as a result (Figure 2).

Exposures are highest for infants who drink powdered formula, compared to babies served formula from concentrate and ready-to-feed varieties.

Formula made from powder is about 20 percent less expensive than formula made from concentrate, and is likely to be especially popular when the economy is weak, unemployment is high, and family incomes are lower.

EPA's action level for lead in water is not health-based and does not protect formula-fed infants. The agency has proposed a method that could yield a "household action level" intended to protect formula-fed infants, but they haven't acted on it (EPA 2017). Their method would underestimate exposure by 24 percent for a baby drinking powdered formula made with tap water (see Table 1 in Appendix A).

Fig 2. Infants drink more water than any other age group, pound for pound, for a higher lead dose than any other family member.



Source: Abt 2020, CDC 2001, EPA 2011. See Appendix A for details.

3 HEALTH-BASED LIMITS ARE OFTEN EXCEEDED.

Lead is notably poisonous at high doses, but also harmful in the trace amounts found in water. It alters the developing brain and erodes a child's IQ—and the impacts add up with each bottle a baby drinks.

In the absence of protective federal standards for lead in tap water, public health organizations have recommended limits and urged their adoption. HBBF's test results show that formula-fed infants often incur exposures that exceed these limits (Figure 3, page 8).

Forty percent of homes tested had more lead than the 1-ppb limit endorsed by the American Academy of Pediatrics (AAP 2016), while 15 percent of homes had lead above a limit that causes up to 1 percent loss in lifetime economic productivity for an exposed child, due to IQ loss (3.9 ppb, from Abt 2020).

Higher water lead levels correspond to even greater losses in IQ and achievements in life. **Studies show that every additional IQ point a child loses equates to a 2 percent loss in lifetime economic productivity** (Grosse 2002, Trasande and Liu 2011, Attina and Trasande 2013).

Each child's susceptibility to lead's impacts is unique, as is their ability to thrive despite the exposures. Lead's harm is often equated with IQ loss or a financial burden that can include special education costs and loss of lifetime productivity, but these numbers fail to capture the true costs – the tragedy of lead poisoning for an individual child, the diminishment of full potential for a child exposed to even small amounts, or the tremendous decline in societal intellectual resources as each successive generation of children is exposed to lead from old water pipes yet again.

4 BLACK BABIES ARE MORE LIKELY TO BE EXPOSED TO LEAD IN FORMULA.

Infants can receive formula as their sole food, making it a uniquely concentrated source for heavy metal exposure. Black babies are more likely to incur the highest exposures. Compared to white infants, black infants are twice as likely to never receive breastmilk and to subsist on formula alone: 26% percent of black infants are exclusively formula fed, compared to only 17.1% of Hispanic babies and 13.4% of non-Hispanic white babies (CDC 2018, Beauregard 2019).

Income is another driver of inequity for exposures to lead in drinking water. A recent study found that in the wealthiest areas of Washington DC, two-thirds of households were able to pay for full replacement of their lead pipes during ongoing infrastructure projects, compared to only one-quarter in neighborhoods with the lowest incomes – **a 2.3-fold difference** (EDF and AUCEP 2020).

5 FEDERAL REGULATIONS FOR LEAD IN DRINKING WATER DO NOT PROTECT FORMULA-FED INFANTS.

EPA regulations allow up to 15 parts per billion (ppb) of lead in up to 10 percent of the homes included in water utility testing programs (Figure 3). Only if that limit is exceeded are utilities required to reduce the water's corrosivity to cut down on lead leaching from pipes and fixtures. Fifteen ppb is 15 times higher than the 1 ppb limit recommended for children by the American Academy of Pediatrics (AAP 2016).

FDA's limit for lead in bottled water, 5 ppb, is more stringent than EPA's action level, but still 5 times higher than the AAP recommendation. FDA pegged it at an amount that bottlers could readily meet, after a survey revealed that most were already using water free from significant lead contamination (GAO 2009).

California's health-based limit of 0.2 ppb lead in water is far lower than either regulatory standard. It was set to protect a baby's developing brain. EPA's action level is 75 times higher.

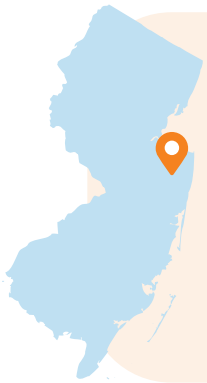
Ideally, there would be no lead in tap water. EPA's goal for lead in water is zero (the MCLG, or Maximum Contaminant Level Goal), in deference to the fact that there is no known safe level of exposure.

Fig 3. Federal regulations for lead in drinking water do not protect formula-fed infants.

Lead in drinking water	Limit	Basis	Homes exceeding	Impact: Higher blood lead levels
0 ppb	U.S. EPA's health-based limit, the MCLG (Maximum Contaminant Limit Goal), recognizing that there is no known safe exposure level (EPA 2020b)	**Health-based** *limits, non-enforceable*	>79%	1 ppb lead in water: Up to **35% increase** in blood lead levels for a child, after 150 days of exposure (Ngueta 2016)
0.2 ppb	California EPA's Public Health Goal (CalEPA 2009) to protect against neurodevelopmental effects in fetuses and infants.		79%	
1 ppb*	American Academy of Pediatrics' recommended limit for lead in water for children (AAP 2016)		40%	
5 ppb	U.S. FDA's limit for lead in bottled water (FDA 2020)	**Bottled water - regulatory limit:** *Based on feasibility, not health (GAO 2009)*	12%	5 ppb lead in water: **20% increase** in blood lead levels for children (Lanphear 2002) and **30% increase** for women (Fertman 2004)
10 ppb	U.S. EPA's trigger level that requires water utilities to develop a corrosion control plan when 10% of tested homes exceed (EPA 2020a)	**Tap water - regulatory limits:** *Based on cost & feasibility, not health*	6.0%	
15 ppb	U.S. EPA's action level that requires water utilities to implement corrosion control plans, if 10% of tested homes exceed (EPA 2020a)		3.6%	

Source of "Homes exceeding": HBBF analysis of tests from 785 homes across the country, 2016-2020

*1 ppb is AAP's recommended limit for school-age children and is therefore especially relevant for formula-fed infants, who receive a far higher dose of lead in water on a body weight basis, compared to older children (see Appendix A for details).



UNRESOLVED ISSUES IN RED BANK, NJ:

Two water sources, one of them corrosive

"Through this process I have only recently discovered that our city, Red Bank, NJ, has been in a political dispute for two years to address proper and transparent testing of lead pipes within the city. This is how I found out about the testing.

Only last month has the city been forced to come up with a proper action plan with NJDEP to test residences properly… it could be years for the town to remediate issues outside of our service line."

ANTHONY • RED BANK, NJ

Lead at nearly 30 times the action level

6 OLDER HOMES ARE RISKIER, BUT NEW HOMES CAN ALSO HAVE LEAD ISSUES.

Our study confirms that older homes are more likely to have high lead levels that could trigger regulatory action. But we also found many newer homes with "legal" levels that are still risky for formula-fed infants (Figure 4).

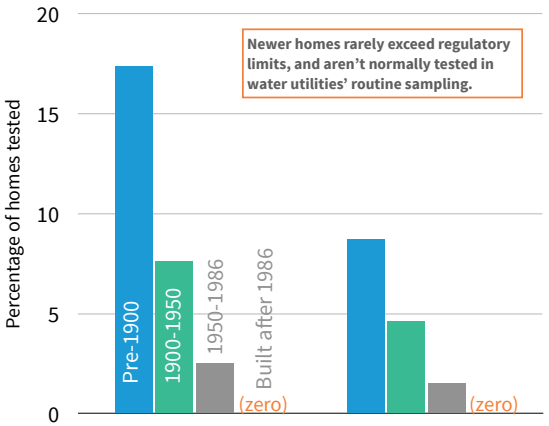
Lead pipes were common before World War II, and lead solder was used until 1986. In newer homes lead can leach from older city pipes or even from new lead-containing brass- and chrome-plated fixtures.

Testing shows that some new brass faucets that meet existing standards and are labelled "lead-free" will leach significant amounts of lead into water in the first month of use (EDF 2018).

Fig 4. Lead levels in older homes vs. newer homes

Older homes are more likely to have high lead levels that could trigger regulatory action.

Homes exceeding *regulatory* limits



Lead > 10 ppb

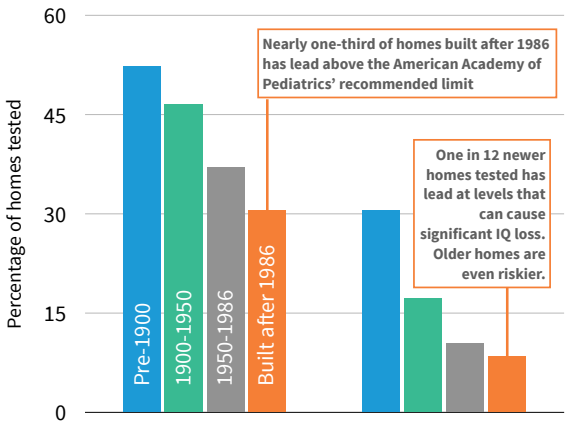
EPA trigger level that requires water utilities to prepare corrosion control plans (EPA 2020a)

Lead > 15 ppb

EPA action level that requires water utilities to implement corrosion control plans, if 10% of tested homes exceed (EPA 2020a)

But many newer homes have "legal" levels that are still risky for bottle-fed infants.

Homes exceeding *health-based* limits



Lead > 1 ppb

Upper limit safe for children, American Academy of Pediatrics (AAP 2016)

Lead > 3.9 ppb*

Limit that causes up to 1% loss in lifetime economic productivity for exposed infant/child, due to IQ loss (Abt 2020)

Source: HBBF analysis of tests from 785 homes across the country, 2016-2020.

7 SOME OLDER CITIES, LIKE NEW ORLEANS, HAVE ESPECIALLY SERIOUS LEAD PROBLEMS.

Ninety-seven families from New Orleans tested their homes in our study, adding to the many homes participating in Dr. Adrienne Katner's Lead Exposure Assessment for Drinking Water Study at Louisiana State University (LSU Health 2020, 2017).

New Orleans is a hot spot for lead. In our study, 95 percent of homes had detectable levels, versus 79 percent for homes tested in other locations. Seventy-one percent of New Orleans homes had levels over the American Academy of Pediatrics' recommended limit for children, versus 40 percent for other homes tested.

The city's water utility says the water is safe (NOSWB 2020), but Virginia Tech's Dr. Marc Edwards, a nationally recognized lead expert, has questioned that assertion. "New Orleans residents are being told their water is safe when there's no evidence that's the case… This is just repeating the mistake made in Flint" (Subbaraman 2019).

Lead in water:

79%
of homes **nationally**

95%
of homes **in New Orleans**

Lead above pediatrians' recommended limit:

40%
of homes **nationally**

71%
of homes **in New Orleans**

CONSUMERS TAKE ACTION IN NEW ORLEANS:

Whole-house filter installed when trust in the city is lost

"After receiving our results showing an unacceptable level of lead in our water, we contacted the New Orleans Sewerage and Water Board who conducted their own 'tests' and told us that the level was acceptable. We disagreed of course. We ended up installing a whole house water filter. The filter and plumber cost us about $2,000. At the time, we felt incredibly fortunate that we had the means to do this knowing that many families in New Orleans did not have the resources we do and would have to be exposed to lead in their water. It is completely unacceptable.

We are in a new house in New Orleans now and I won't even bother testing, we are just getting a whole house filter because I don't trust the City of New Orleans to keep our water safe and not to lie to us about it. We have an infant, and we only give her bottled water until we install the filter."

MARCIE • NEW ORLEANS, LA

8 CITY AND WATER UTILITY TESTING CAN EASILY MISS LEAD PROBLEMS, AND STANDARD HEALTH AGENCY ADVICE CAN INCREASE RISK.

Our tests suggest that utilities' compliance testing programs – which can include only a "first-draw" sample in the 50-100 city homes selected for testing – could miss the high lead levels that compel regulatory action. **First-draw tests would have missed 39 percent of the homes in our program that exceeded EPA's trigger level of 10 ppb in one or more samples.** In those homes, it was the second or third samples, not the first-draw sample, that topped the trigger level.

Our tests also show that common exposure reduction advice from water utilities and public health agencies, to flush water from the tap for up to 2 minutes before using, may be inadvertently increasing lead exposures. Seven percent of homes tested in our program had higher leadlevels after flushing, by at least 1 ppb, compared to the first-draw sample. And 4.6 and 2.0 percent of homes had lead increases of at least 2 ppb and 5 ppb, respectively, after flushing. LSU's New Orleans-based testing program suggests that the odds are much worse in cities where lead service lines are common. Fully 47 percent of New Orleans homes had higher lead levels in water after up to 45 seconds of flushing (LSU Health 2017).

Many of our tests also suggested that water was likely contaminated with lead in the city pipes before it flowed into lead service lines and homes. We found 68 homes (8.7 of homes tested) with lead levels above 2 ppb in the water main sample (the 5-minute flush sample), and 24 homes (3.1 percent of homes tested), including 5 homes in Newark NJ, with lead above 5 ppb in that sample.

With ineffective compliance testing and standard advice that can worsen lead problems, families and water utilities can remain in the dark even as lead exposures escalate, whether from city-wide changes in water quality (e.g., Flint, Michigan), or when lead spikes at an individual house when pipes are disturbed by maintenance.

9 INFANTS' DAILY EXPOSURES TO LEAD IN WATER HAVE SIGNIFICANT IMPACTS.

Lead is a developmental neurotoxin (Project TENDR 2016). It can harm a baby's developing brain and nervous system, both in utero and after birth, for impacts that include the permanent loss of intellectual capacity and behavioral problems like attention-deficit hyperactivity disorder (ADHD). It causes IQ loss from exposures early in life.

HBBF commissioned a new analysis from Abt Associates, a nationally recognized toxicology and economic research group, to accompany our water tests. The work included an assessment of IQ loss attributed to lead in tap water for bottle-fed infants drinking powdered formula reconstituted with tap water. Abt's findings show, for example, that **water lead levels between 5 and 15 ppb cause IQ loss in the range of 1 to 2 points for a formula-fed infant.** One of every 8 homes we tested had water lead levels above 5 ppb. Details of Abt's methodology and what it means for formula-fed infants are in Appendix A and Abt (2020).

MULTIPLE TESTS LEAD TO RESOLUTION IN COS COB, CT:

New lead-free service line, high marks for water utility

"When we brought [the tests] to the attention of the water company, we were asked to confirm that our supply line (on our property) was NOT lead. If it was NOT, then they would agree to replace their section of the line that leads to our house's supply line (in the street)... I used your report to show that the results indicated the issue was likely their line, not ours…

The company was extremely cooperative with their resolution. They provided instructions for flushing lines after the work was completed and followed up with additional water testing after they performed their work. They also agreed to do the same work for any of our neighbors who also requested this fix and had similar types of pipes."

AARON • COS COB, CT

10 EXPOSURES AND IMPACTS ADD UP, INCREASING URGENCY FOR ACTION.

Lead in water is not the only exposure source raising the specter of IQ loss and other neurodevelopmental deficits for babies. Among many recent examples, a study by HBBF found lead and three other toxic heavy metals, arsenic, cadmium, and mercury, in 95 percent of baby foods tested (HBBF 2019). Apples and spinach are often tainted with organophosphate pesticides, cheeses including mac 'n' cheese powder contain phthalate plasticizers, and a wide range of breakfast cereals, grains and beans are contaminated with the pesticide glyphosate (Roundup).

All of these pollutants and pesticides are neurotoxic or linked to babies being born small, with resulting risks for lower IQ and other neurological or behavioral impacts (e.g., Flensborg-Madsen 2017, Parvez 2018, Gillam 2017, FOE 2019, EWG 2019 and 2020, CSFPP 2017).

Formula itself, before water is added, is contaminated with low levels of lead. Infant formula appears on a list of the top 10 foods contributing to early-life IQ loss, not because of high metals levels – arsenic and lead concentrations are relatively low in both compared to some other types of baby food, according to HBBF and FDA tests – but because American children drink so much of it (HBBF 2019). FDA action to set limits in formula for arsenic and lead – and cadmium as well, which is often detected – would create benefits extending to millions of children.

As part of our work to ensure healthy futures for all babies, HBBF is a member of the Baby Food Council, a group of infant and toddler food companies, supported by key stakeholders, seeking to reduce heavy metals in the companies' products to as low as reasonably achievable usage best-in-class management practices (BFC 2020). While the Council's work doesn't address lead in tap water, it will help reduce children's exposures to lead and other neurotoxic heavy metals commonly found in both food and water.

HEALTH RISKS – THE SCIENTIFIC EVIDENCE

Research continues to confirm widespread exposures and troubling risks for babies exposed to lead, including studies revealing IQ loss, attention deficits, and other learning and behavioral impacts among children who are exposed through water, food and other sources. Lead is also a potent human carcinogen.

Widespread exposure to toxic heavy metals like lead shifts the population-wide IQ curve down. It nudges more children into special education, and drives down the IQ of the most creative and intellectually gifted children. For an individual child, the harm appears to be permanent (e.g., Grandjean and Landrigan 2014, Abt 2020).

Instead of overt poisoning, the low, daily exposures children face from neurotoxic pollutants like lead create "subclinical decrements in brain function" with impacts on a global scale. Scientists write that the exposures "diminish quality of life, reduce academic achievement, and disturb behaviour, with profound consequences for the welfare and productivity of entire societies" (Grandjean and Landrigan 2014).

Over the past 40 years lead has been restricted in children's toys and phased out of gasoline, pesticides, and paint. But lead that lingers in homes, soil, and water remains a festering problem. The toxic metal continues to contaminate the blood of nearly every child tested. Although exposures are lower now than in the past, lead-induced brain damage still accounts for an estimated 23 million IQ points lost among children under five (Bellinger 2012). Even very low exposure levels cause lower academic achievement, attention deficits and behavior problems. No safe level of exposure has been identified.

Evidence of lead's toxicity spans decades. Among recent studies are two that included 80,000 Detroit and Chicago school children, 3rd grade through middle school, whose standardized math and reading tests were correlated to their blood lead levels measured at birth or early childhood. "Early childhood lead exposure is associated with poorer achievement… even at very low blood lead levels," concluded one of the research teams (Zhang 2013, Evens 2015).

BEYOND WATER: OTHER SOURCES OF LEAD EXPOSURE

For many children, the biggest source of lead exposure is not water, but lead paint in homes built before 1978. Lead from chipping and peeling paint builds up in house dust and sticks to children's hands. It also flakes off of a home's exterior to contaminate soil in the yard.

To learn if you have lead paint, have your home inspected by a licensed lead inspector. You can also use a simple test kit sold at many hardware stores. Learn more: https://www.epa.gov/lead/protect- your-family-exposures-lead

SOLUTIONS FROM SHOREWOOD, WI:

Two pregnancies and a reverse osmosis filter

"Since we got our results (which were extremely high) we installed a Reverse Osmosis filtration system for our drinking water. We got our water tested a second time and the lead levels were basically zero, so it definitely helped.

At the time we had our water tested, I was pregnant with our first child (she's now 3). We also have a second child who is 18 months. I didn't want to drink the lead-contaminated water while pregnant, nor did I want my kids to drink it – ever. Both have been drinking the RO filtered water since they stopped breastfeeding."

AC • SHOREWOOD, WI

Lead widely contaminates food in addition to water, from its long-time use as a pesticide, its presence in food processing equipment (in older brass, bronze, plastic, and coated materials), and its presence at elevated levels in soil, either natural or accumulated from industrial pollution.

In October 2018 FDA cut in half its maximum daily intake limit for lead in children's food. An estimated 2.2 million children six years or younger exceed the new intake limit (EDF 2019). A recent HBBF study (healthybabyfood.org) found lead in 95 percent of 168 baby foods tested (HBBF 2019).

WHAT PARENTS CAN DO

Nearly eighty percent of homes have lead in their tap water. It's not safe for anyone, but pregnant women, formula-fed infants, and young children are most at risk. Lead can harm the developing brain, and often builds up in children's bodies in greater amounts than in adults.

USE A WATER FILTER CERTIFIED TO REMOVE "TOTAL LEAD."

A water filter certified to remove lead is a good safeguard for almost every home.

If you already use a filter, check online or with the manufacturer to make sure lead is one of the contaminants it is certified to remove.

Use NSF International's "Certified Product Listings for Lead Reduction" Guide to find a filter that is NSF/ANSI 53 certified.

Try a pour-through pitcher like ZeroWater RedyPour or a filter that mounts to the kitchen faucet, like Pur or Brita models.

SOLUTIONS FROM PITTSBURGH, PA:

Pitcher filter and breastfeeding

"After getting the results, we obtained a 'Zero Water' water filter and started using this for all drinking and cooking water. My wife ended up getting pregnant in 2018, and our son was born in April 2020. He was breastfed."

PETER • PITTSBURGH, PA

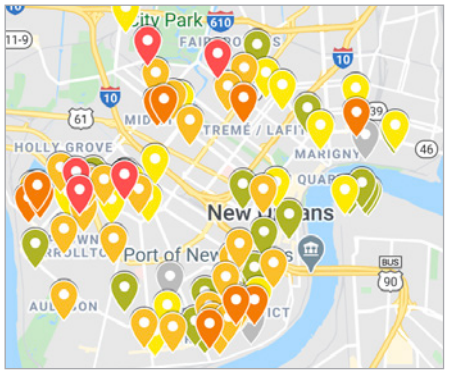
TEST YOUR WATER FOR LEAD.

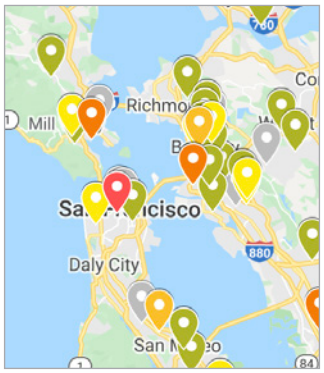
Your water utility may offer free tests. Make sure their test includes at least 2 sample bottles for lead. One-sample tests can miss lead sources in pipes further from your faucet.

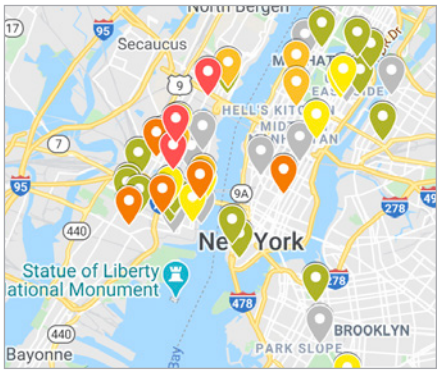
If you use their test, check your results against the American Academy of Pediatrics' recommended lead-in-water limit for children of 1 part per billion (1 ug/L, or 0.001 mg/L). Filtering will reduce your lead levels and is most important in homes with infants and young children.

HBBF and Virginia Tech offer an at-cost 3-sample test that you can order online at hbbf.org/lead-drinking-water. You'll get a personalized action report based on the test results.

Our study found high variability in lead levels across individual cities and neighborhoods, in both old and new homes. Testing is the only way to know how much lead is in your home's water.







RETEST YOUR WATER EVERY TWO YEARS OR WHENEVER THERE'S A CHANGE IN YOUR RISK.

Test results are a snapshot of lead in your water when you sampled. Retesting periodically a good idea. Retest when:

- You are planning a pregnancy or are newly pregnant.
- You plan to begin using water to make infant formula.
- There is road or pipe work on your block, or if you make changes to your plumbing. This can dislodge lead from pipes and valves.
- You learn that your utility has changed its water source or treatment process. Read your water bill inserts and yearly water quality report for updates.
- During summer. Warmer water can pull more lead from pipes.

Using a filter certified to remove lead can protect you from these unexpected changes.

UNSCREW YOUR FAUCET AERATOR AND RINSE OUT ANY TRAPPED PARTICLES AT LEAST EVERY SEASON.

Most faucets have a small screen or aerator at the open end (where the water comes out). Particles from lead pipes can get trapped there and put lead in your water. It's easy to unscrew and rinse out the aerator to remove any particles caught there.

KEEP YOUR WATER FILTER WORKING.

Replacing the filter cartridge is important. An old cartridge will let lead through and can also harbor bacteria.

SOLUTIONS FROM CHELSEA, MI:

Replacing home plumbing

72% lead reduction

"I retested after we installed a new kitchen faucet and the water lines right under the sink. That seems to have made a big difference. The faucet was original from 1960. We had [our two-year-old] tested for lead and he didn't have any in his system… phew! "

CYNTHIA • CHELSEA, MI

CONSIDER DISCONNECTING YOUR WATER SOFTENER IF YOU DON'T USE A WATER FILTER FOR LEAD.

Softened water can leach lead from pipes and fixtures. Use a water filter certified to remove "total lead" or consider disconnecting your water softener.

FOLLOW THESE STEPS TO CHECK FOR LEAD IN YOUR HOME'S WATER PIPES AND SERVICE LINE

Millions of homes in the U.S. have lead in their water pipes and solder that can leach into their tap water

You are at higher risk for lead in your water if you have any of these 3 risk factors:

- Brass fixtures installed before 2014, or a new fixture within the last month.
- A service line installed before 1986 (this is the outside pipe that runs from your home to the street).
- Pre-1986 copper pipes, which can have lead solder.

Homes with these items are at risk even if current lead levels in water are low. Lead-bearing plumbing can begin to release lead into the water when your water utility changes treatment methods or disturbs pipes during maintenance.

Water utilities add chemicals that coat the pipes to keep lead from leaching out, but sometimes it's not enough. Here's how to check if you have lead pipes or solder:

Copper water pipes installed before 1986. These can be joined with lead solder. Check if your solder is lead by carefully scratching with a key. It's probably lead if the scratch mark is bright silver. Don't use a knife or other sharp tool. Wash the key off when you are finished. A water filter will remove lead that leaches from solder.

Water service lines installed before 1986. The service line connects your house to the neighborhood's main water pipe. It normally comes through a wall of your home, often in the basement, and then connects to the rest of your home plumbing. Pipes installed before 1986 might be made of lead. Call your water utility to see if they have a record of your pipe type.

You can check the service line yourself with the steps below:

Lead service lines are a dull gray color and are soft. Check if your pipe is lead by carefully scratching with a key. If it's lead, the scratch mark will be bright silver. Don't use a knife or other sharp tool, and take care not to puncture the pipe. Wash the key off when you are finished.

If you have a lead service line, call your water utility to learn of any plans to replace it. Some utilities and cities have replaced all lead service lines city-wide. Replacement should involve the entire lead pipe from the water main to the home. Replacing only a portion of the pipe can disturb remaining lead pipes and increase the lead in your water.

DRINK AND COOK WITH WATER FROM THE COLD TAP, AND MAKE SURE IT'S NOT DISCOLORED.

- Always drink, cook, and make infant formula with water from the cold tap. Hot water leaches more lead from your plumbing than cold.
- Never drink discolored water or water with solid particles. This can be a sign of high lead levels.
- Boiling your water does not remove lead. Instead, lead levels can increase as water boils off and the lead is left behind.

FLUSH YOUR WATER LINES FOR 45 SECONDS BEFORE DRINKING.

If you can't use a water filter, running your water for 45 seconds before using it for drinking or cooking can reduce lead levels in many homes. **If you have a lead service line, run the water for 5 minutes instead.**

Studies show that lead can build up again in water within 10 minutes of flushing. To avoid having to flush frequently, you can flush once and then fill a container. Store it in the refrigerator and use that water for drinking and cooking.

Good ways to flush your water without simply running it down the drain include outdoor watering, showering, flushing the toilet, or running a dishwasher or clothes washing machine. You can then run your tap for only 45 seconds to clear any remaining water from that faucet.

An alternate, more expensive but safer solution is to use a home water filter certified to remove lead.

SOLUTIONS FROM BERKELEY, CA:

Tests show that flushing can help in some homes

"After we got the results, the main thing I did was make sure to run the water in the faucet for a little while before drinking from it any time it was left sitting."

BRENDAN • BERKELEY, CA

ASK YOUR DOCTOR ABOUT BLOOD LEAD TESTS FOR YOUR CHILDREN.

Any child can have high blood lead levels. You have to test to know. The tests help doctors and parents find children who have too much lead in their blood. Parents can then take action to get rid of lead sources where the child spends time.

A blood lead test is usually recommended for children at ages 1 and 2. It is especially important for children in these higher risk groups:

- Living in a home built before 1960 that has recently been renovated, repaired, or painted, or that has been poorly maintained.
- Living in a home or building where siblings or other children have had elevated blood lead levels.
- Arriving to the U.S. as immigrants, refugees, or through international adoption.

Even children who seem healthy may have dangerous levels of lead in their bodies. Some states require all children to be tested. Medicaid covers blood lead tests for children.

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APPENDIX A: METHODS AND DETAILED FINDINGS

This appendix describes assumptions included in the report's numeric findings, details on the percentages of homes with lead levels above health and regulatory thresholds, details of laboratory testing methodology, and basic steps in Abt Associates' analysis of IQ loss from lead in water.

ASSUMPTIONS IN REPORT FINDINGS AND STATISTICS

Assumptions inherent in the statistics given in this report are described below.

All statistics representing a national view of our water tests exclude the 97 homes from New Orleans, unless otherwise noted below. The New Orleans samples were assessed separately for most parameters because detection rates in New Orleans were significantly higher than the national average, which impacted many findings featured in the study.

New Orleans samples were included in the national statistics when their inclusion did not significantly influence the finding. This was the case for report finding #6, which shows exceedances of health and regulatory limits by age of home. HBBF's study includes 785 homes altogether, 97 from New Orleans and 688 from outside of New Orleans.

Statistics indicating the number of homes exceeding loss of IQ or lifetime economic productivity correspond to the model in Abt (2020) for Lanphear (2019) with EPA's 2007 adjustment to control for potentially inflated IQ estimates at lower exposure levels (see Figure 7). This model relies on the key seminal study (Lanphear 2019 - federally funded, free of conflict of interest), with an adjustment for exposures levels that were below those included in that study, a reasonable modification given the typically low lead levels in tap water found in our study. Future research may reveal more about IQ loss at these lower exposure levels. In the meantime, we've also presented results for two scenarios in Figure 5 – Lanphear (2019) with and without the EPA adjustment – to show a range of predicted IQ loss.

Statistics presented in this report rely on the maximum lead level measured in each home's 3 samples unless otherwise indicated.

Table 1 shows exposure factors and references for water consumption and body weight during infancy and childhood, including the estimates shown in Figure 2.

Table 1. Drinking water ingestion rate by age

Age	Ingestion rate (L/day)	Body weight (kg)	Dose (mL/day per kg of body weight)	Dose (mL/day per pound of body weight)	Ingestion rate source	Body weight (BW) or dose source
Birth - 1 month, bottle-fed (powder)	0.633	3.9	162	73.7	Abt 2020	CDC 2001 (BW)
Birth - 1 year, bottle-fed (powder)	0.843	7.3	115	52.4	Abt 2020	CDC 2001 (BW)
Birth - 1 year, bottle-fed (all formula varieties**)	0.640	7.3	88	39.8	EPA 2011	CDC 2001 (BW)
Birth - 1 year, all infants	0.526	7.3	72	32.7	EPA 2011	CDC 2001 (BW)
Children 1 - <2	0.308	11	27	12.3	EPA 2011*	EPA 2011 (dose)
Children 2 - <3	0.356	14	26	11.8	EPA 2011*	EPA 2011 (dose)
Children 1 - <3 (average)	0.330	13	27	12.0	EPA 2011*	EPA 2011 (dose)
Children 3 - <6	0.382	18	21	9.5	EPA 2011*	EPA 2011 (dose)
Children 1 - <6 (average)***	0.370	16	23	10.4	EPA 2011*	EPA 2011 (dose)
Children 6 - <11	0.511	30	17	7.7	EPA 2011*	EPA 2011 (dose)
Children 11 - <16	0.637	53	12	5.4	EPA 2011*	EPA 2011 (dose)
Children 16 - <18	0.702	70	10	4.5	EPA 2011*	EPA 2011 (dose)
Children 6 - <18 (average)***	0.595	46	14	6.2	EPA 2011*	EPA 2011 (dose)
Adults 18 - <21	0.816	74	11	5.0	EPA 2011*	EPA 2011 (dose)
Adult	1.227	77	16	7.3	EPA 2011*	EPA 2011 (dose)

* Table shows the intake rate for water consumers only (it excludes those who don't drink tap water)

** Average ingestion rate for babies drinking formula regardless of type (powder, concentrate, ready-to-feed), corresponds to EPA's proposed scenario for a health-based "household action level" for a bottle-fed infant (EPA 2017).

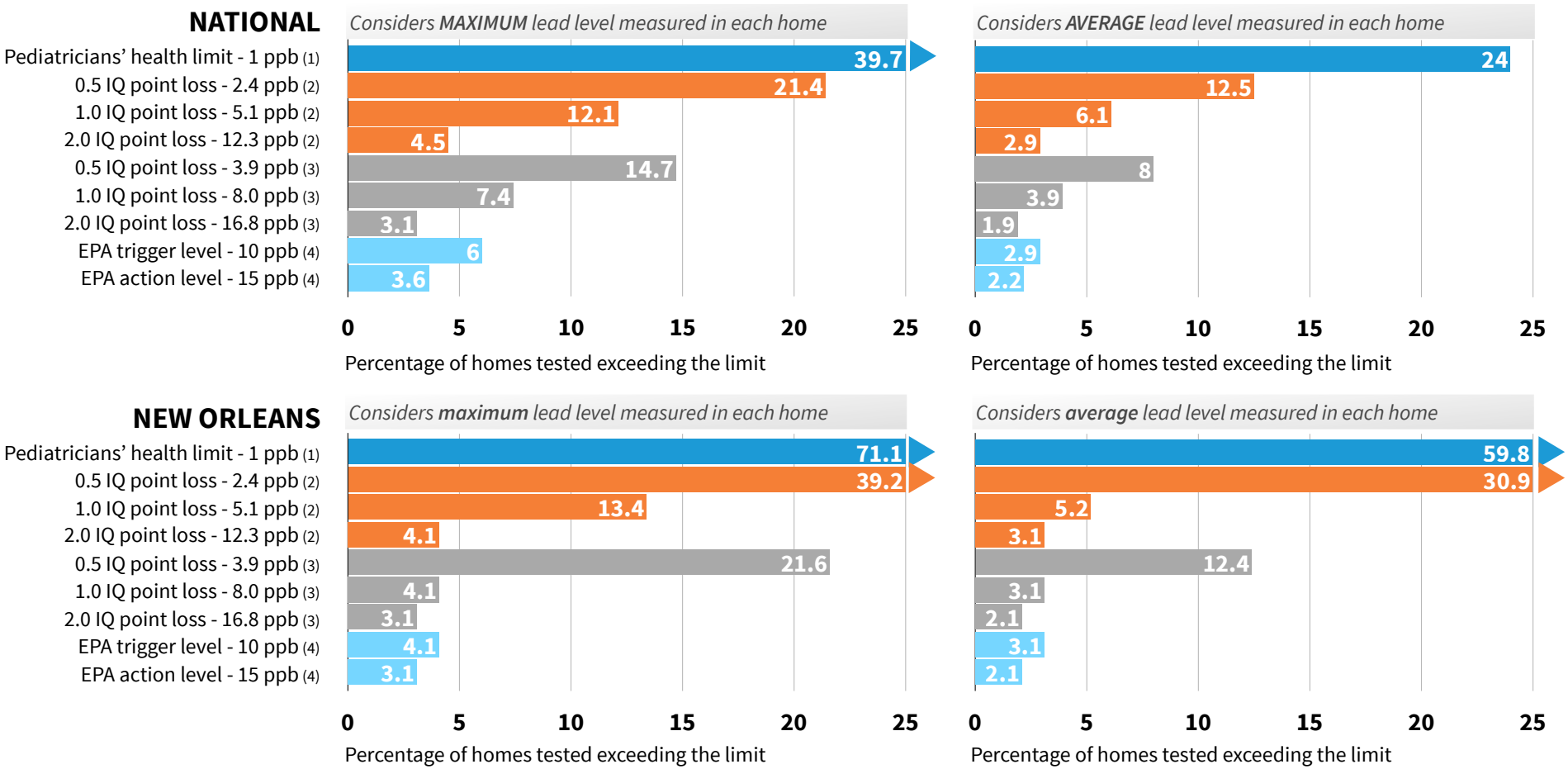
*** Time-weighted average derived from data in rows above

Data from highlighted rows is shown in report Figure 2.

PERCENTAGES OF HOMES WITH WATER LEAD LEVELS OVER HEALTH AND REGULATORY LIMITS.

The figure below shows the percentages of homes where maximum detected lead levels in water exceeded various health and regulatory thresholds. As described above, the "National" statistics reflect 688 homes nationwide (all homes tested outside of New Orleans) and the "New Orleans" statistics reflect the 97 homes tested in that city.

Fig 5. Percentage of homes with water lead levels over health and regulatory limits



Source: HBBF analysis of lead in water tests from 785 homes across the country, 2016-2020, relative to the reference levels shown.

References: (1) AAP (2017); (2) Lanphear (2005,2019), in Abt (2020); (3) EPA (2007), in Abt (2020); (4) EPA (2020).

▶ *Indicates bar is truncated*

ABOUT WATER TESTING METHODS

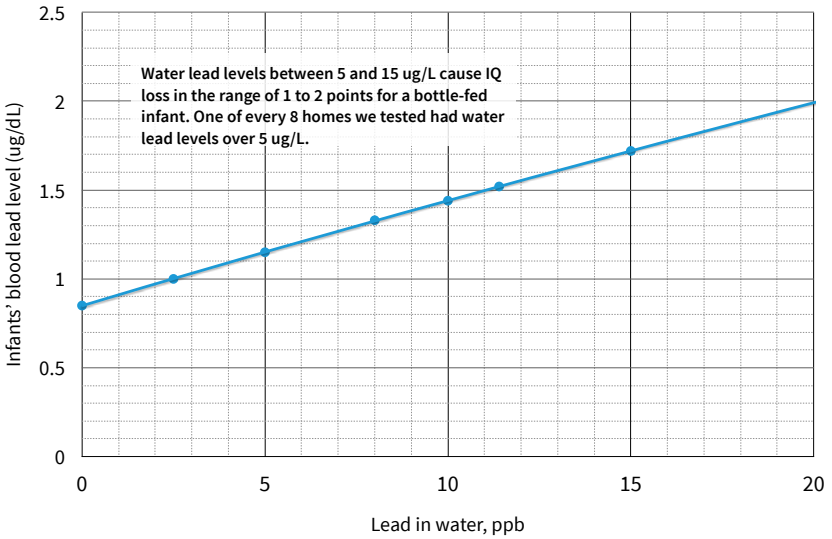
Water samples analyzed by Virginia Tech were tested for 28 elements including lead using a Thermo Electron iCAP-RQ inductively coupled plasma mass spectrometer (ICP-MS) per Standard Method 3125-B (APHA, AWWA, and WEF, 1998). Samples and calibration standards were prepared in a matrix of 2% nitric acid by volume. Only the lead results are given in this report. Families who tested were notified of other test results when levels exceeded health-based limits. Water samples analyzed by Waypoint Analytical were tested for lead according to the EPA (1994) ICP-MS protocol. The laboratories reported results above detection limits of 0.2 and 0.3 ug/L for Virginia Tech and Waypoint, respectively.

BASIC STEPS IN ABT ASSOCIATES' ANALYSIS OF IQ LOSS FROM LEAD IN WATER

HBBF commissioned a new analysis from Abt Associates, a nationally recognized toxicology and economic research group, to accompany our water tests. The work included an assessment of IQ loss attributed to lead in tap water for formula-fed infants drinking powdered formula reconstituted with tap water. Details are provided in Abt (2020).

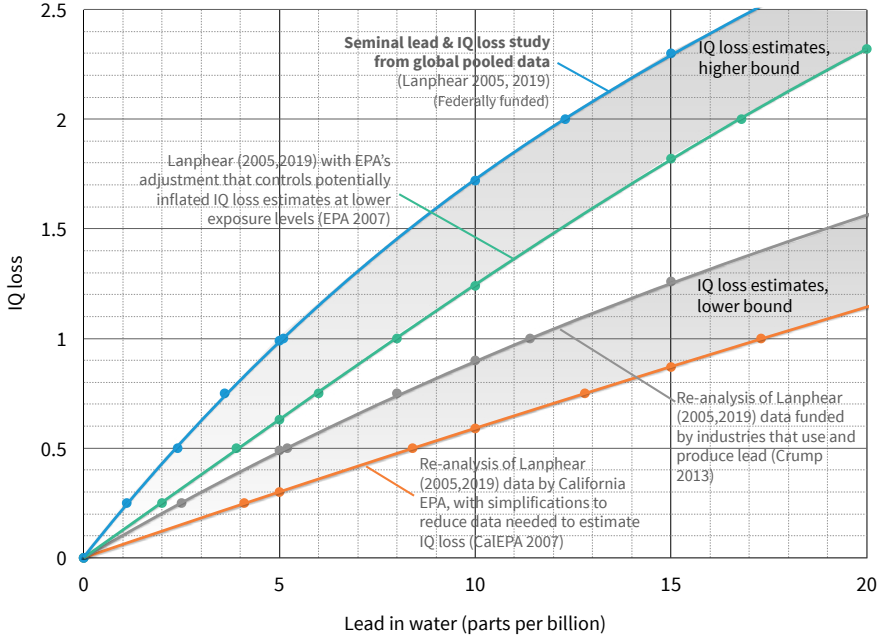
The method includes three basic steps. The first is to estimate lead exposures from all sources (e.g., food, dust, air) during infancy and early childhood, using standard government and industry references as detailed in Abt (2020). In the second step (Figure 6), Abt uses a standard EPA model to estimate children's blood lead levels as a function of lead levels in drinking water, for formula-fed infants (IEUBK, EPA 2016). In the third step (Figure 7), Abt uses four models from the peer-reviewed literature and government assessments to estimate IQ loss for children who during infancy were exclusively formula fed, drinking powdered formula made with tap water. This step uses as input the step 2 results from the EPA model. The full analysis is described in Abt (2020).

Fig 6. EPA's standard model used in Abt (2020) shows how lead in water impacts infants' blood lead level



Source: Abt 2020, results from EPA's standard model for estimating children's blood lead levels (EPA 2016)

Fig 7. Four methods are used in Abt (2020) to estimate infants' IQ loss from lead in water



Source: Abt 2020

To estimate IQ loss for bottle-fed infants drinking lead-contaminated water, Abt (2020) uses four methods from the peer-reviewed literature and health agency assessments, shown here. These produce a range of estimated IQ loss that varies by a factor of about 3 for any given lead level in water.

Healthy Babies Bright Futures

Healthy Babies Bright Futures (HBBF) is an alliance of scientists, nonprofit organizations and donors working to create and support initiatives that measurably reduce exposures to neurotoxic chemicals in the first thousand days of development.

Our efforts are inspired and supported by science and data, and designed to help restore the chance for a full life to children who would otherwise face brain-diminishing exposures to toxic chemicals beginning in utero.

Learn more at hbbf.org

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