Get the Lead Out!

Lead is a particularly toxic metal that has been used for everyday items from paints and makeup to coins and plumbing. Disease surveillance and regulations have dramatically reduced the amount of lead in our environment and in our blood over the last 50 years.

Terms to Know

Blood lead level	amount of lead in blood, measured in micrograms per deciliter (µg/dL) of blood; CDC currently recognizes 3.5 µg/dL as the level of concern for children
Corrosion	chemical reaction between a metal and its environment that causes it to break down into ions and dissolve
Environmental hazards	substance, state, or event which has the potential to adversely affect people's health, including pollution and natural disasters
Health disparity	a particular type of difference in health outcome that is closely linked with economic, social, or environmental disadvantage
ppb	parts per billion; measure of concentration equal to the mass units of a particular substance per billion mass units in a sample
Public health	science of protecting and improving the health of people and their communities
Service line	water pipe that directly connects a larger water main to individual buildings; service lines are privately owned and maintained at owner's expense

Background on Lead

Lead is easy to work with, abundant in the environment, and has many uses. The ancient Romans had a water and sewer system that used lead pipes extensively, giving us the word *plumbing* from the Latin word for lead, *plumbum*. They also used lead for weapons, medicines, makeup, and coins, among other uses. They even added lead compounds directly to food and wine. Unsurprisingly, chronic lead poisoning was common in the Roman Empire, though few connected gout, sterility, and stillbirths back to the lead they were constantly exposed to.

Lead poisoning occurs when a person's health or body functions are negatively affected by lead contamination in what they eat, drink, touch, or breathe. The dangers of lead poisoning have been known for centuries. Lead poisoning can cause learning disabilities, behavioral problems, and, at very high levels, seizures, comas, or even death. Research has shown that even small amounts of lead can cause neurological damage to people lo ng before any symptoms occur.

Think About It

1. What are some common reasons that **environmental hazards** are not addressed?
2. What kind of work do you think CDC's National Center for Environmental Health (NCEH) does to address **environmental hazards**?
3. Give two examples of health disparities that might result from **environmental hazards**.

Lead and the Centers for Disease Control and Prevention (CDC)

Children are particularly vulnerable to lead toxicity because their blood-brain barrier is not fully developed. This means that toxins like lead can enter the brain and cause neurological damage. Lead can also replace calcium in bones, meaning that it can be released from the bones into the blood slowly over time. Protecting children from exposure to lead is important to lifelong good health. No safe **blood lead level** in children has been identified. Even low levels of lead in blood have been shown to affect learning, ability to pay attention, and academic achievement. While the effects of lead poisoning may be permanent, if caught early there are things parents can do to prevent further exposure and reduce damage to their children's health. Efforts to protect children have resulted in the removal of many formerly common lead sources in the environment.

Lead in Gasoline

In 1923, automobile manufacturers and gasoline producers began producing fuel that contained tetraethyl lead to improve fuel combustion in the engine and reduce loud engine knock. By this time, the negative health effects of lead were well known. At the plants where the fuel was produced, dozens of workers died or went mad from acute lead poisoning. Without any government agencies to step in, the fuel continued to be produced. Car exhausts continued to emit lead and other pollutants into the environment for decades.

In 1970, the Environmental Protection Agency (EPA) was established to measure, set standards, and regulate pollutants in the environment. Because data showed that Americans had incredibly high **blood lead levels**, the EPA began issuing lead reduction standards in 1973, and ultimately banned the sale of leaded gas. CDC played an instrumental role in providing scientific evidence to Congress to reinforce the ban on leaded gas in 1980. Through blood samples collected by NHANES (National Health and Nutrition Examination Survey), CDC scientists demonstrated the parallel decreases in blood-lead levels and amounts of lead in gasoline from 1976-80.

Lead in Paint

Lead has been used as a paint pigment for thousands of years. Most interior paints before 1940 contained about 50% lead. The dangers of children eating lead paint from cribs, toys and walls were noted by **public health** officials as early as the 1930s, and were often linked to problems of people with lower incomes in substandard housing. During the activist 1960s, citizens called for increased government intervention, including community screenings and the banning of lead-based paints in government housing.

CDC Began to coordinate federal lead poisoning programs in the 1970s. In 1971, lead paint was prohibited in all federal buildings as well as those built using government funding. CDC began to coordinate federal lead-poisoning programs in the 1970s. By that time, **public health** officials realized that the problem was not just limited to people with lower incomes. Any place where lead paint was peeling or chipping from a surface put children at risk. Hand to mouth lead transmission was the most common way that lead entered the blood. CDC's Childhood Lead Poisoning Prevention Program was established in 1990, funding prevention programs nationwide and creating the Childhood Blood Lead Surveillance System to monitor children for potential negative health effects.

Lead from Mining

Mining operations can also produce increased amounts of lead in the air, water, or soil around mines. A team of experts from many **public health** organizations, including CDC, travelled to Zamfara State in northern Nigeria in 2010 to investigate an outbreak. First, animals had begun to get sick and die; then children began suffering from vomiting, abdominal pain, headaches, and seizures. Investigation showed unsafe levels of lead in most homes and in community wells. Hundreds of children died, and thousands had dangerous **blood lead levels**.

The team observed the communities and saw many unsafe practices that would expose adults, children, and animals to harmful levels of lead. Zamfara State was agricultural but was also rich in many minerals, including gold. In recent years, many villagers had started mining gold to earn more money. Since most villagers did not wear personal protective equipment while working with the gold ore, they would return home from the mines with lead dust on their clothing. Many villagers would bring rocks inside their homes to extract the gold. These rocks also contained lead, and when the gold was extracted, the lead dust spread throughout the house. Children often helped to grind the gold ore, exposing them to high levels of lead dust.

To treat the outbreak, all the contaminated soil in a village must be removed and replaced. This process is expensive, and many children are still awaiting treatment for lead poisoning because the environment has not yet been cleaned. Additionally, mining is an important part of the local economy, so it cannot be prohibited. **Public health** education and safer mining practices were introduced to help control the outbreak.

Other Sources of Lead

Take-home lead exposure may occur among workers who use lead as part of occupations, such as battery manufacturing, smelting, home renovation, pottery production, and metal recycling. In addition to potentially being exposed to higher levels of lead on the job, these workers can also carry lead home with them on their clothes, tools, hair, and skin, thereby exposing their families.

Drinking water can become contaminated by **corrosion** of older lead pipes or solder (a metallic substance that is melted and used to hold pipes together). Many water systems are taking action to remove all lead plumbing that is still in service, including many lead **service lines**.

Lead-based paint spills, leaded gasoline, or industrial sources can contaminate soils. Children who eat dirt or put their hands into their mouths after playing in dirt risk exposure to lead. Soil particles that are brought into the house on shoes, clothing, or pets may also increase exposure.

Imported goods can sometimes pose lead safety hazards. Lead paint is somewhat common on imported toys and jewelry. Food, candies, and spices containing lead have also been found.

Think About It

1. Why do you think lead poisoning is a **health disparity** linked to socioeconomic factors?
2. How was NHANES data useful in supporting the ban of lead from gasoline and fuel?
3. Why did the Zamfara team educate the villagers rather than shut down the mine?

From the Expert:

From April 25, 2014–October 15, 2015, approximately 99,000 residents of the City of Flint, MI, were exposed to lead when the drinking water source was switched from the Detroit Water Authority to the Flint Water System (FWS). In December 2015, lead contamination in the FWS was declared a state of emergency and by January 2016, CDC assisted the City of Flint and the State of Michigan to develop a response and recovery plan.

In the video linked below, Dr. Phoebe Thorpe interviews Dr. Mona Hanna-Attisha, whose research exposed the Flint, Michigan water crisis. Learn how lead poisoning in children remains a problem in the United States and how childhood lead exposure can be prevented.
https://youtu.be/XVMZCqCpYCQ

For follow up, check out Dr. Hanna-Attisha's 2019 rousing commencement speech at the Harvard School of Medicine. Listen for a special tribute to Dr. Alice Hamilton, one of the female pioneers of **public health** and industrial health and safety standards.
https://hms.harvard.edu/news/fresh-eyes

Call to Action

In order to understand the risk factors of lead poisoning, it is essential that people know about the historical and current sources of lead exposure. You can help people by following these three steps:

1. Examine historical lead data. Data from NHANES were used to convince Congress to allow the EPA to regulate the amount of lead in substances like gasoline and paint. Examine historical blood lead level data to see lead's environmental hazards.

2. Develop a plan to address a public health emergency. The Flint water crisis caused elevated lead levels in tap water. Examine the timeline of the disaster and make recommendations to address the long-term effects of lead in the tap water.

3. Share your findings. One of the ways CDC communicates information is through social media. Your demonstrations can help CDC communicate the work they have done and are doing to reduce the rates of lead poisoning in the population.

Why Participate? A Message from CDC

Human health and well-being are strongly affected by the environment in which we live — the air we breathe, the water we drink, and the food and nutrients we eat. CDC's National Center for Environmental Health (NCEH) plans, directs, and coordinates a program to protect the American people from **environmental hazards**. Visit their site at https://www.cdc.gov/nceh to discover the wealth of environmental health data and resources to help you monitor and improve your quality of life.

Think About It

1. It took 18 months for the people of Flint, Michigan to convince others that their drinking water was unsafe. Why might this be an example of a **health disparity**?
2. Elevated lead levels can affect learning, ability to pay attention, and academic achievement in children. How can these symptoms lead to inequality?
3. After examining the NCEH website, what environmental health topics surprised you? Why do you think these areas are considered part of **public health**?

Public Health Approach

The **public health** approach below is a general method that can be used to study and solve **public health** problems. While this is a simplified version, it provides a good general framework.

For more detailed information about the **public health** approach, check out CDC's Public Health 101 training course. https://www.cdc.gov/training/publichealth101/public-health.html

Surveillance

What is the problem?

Survey and monitor health events and behaviors among the population.

- How widespread is the problem?
- Who is affected? What are their symptoms?

Risk Factor Identification

What is the cause?

Determine if certain members of the population are more at risk than others.

- What risk factors do affected individuals have in common with each other?

Intervention Evaluation

What works?

Brainstorm intervention ideas that might work to solve the problem.

- What interventions have worked in the past?
- What interventions might work in this situation?

Implementation

How do we do it?

Implement the intervention selected.

- Which method will work best given the resources and limitations in this situation?
- What challenges might this program face?

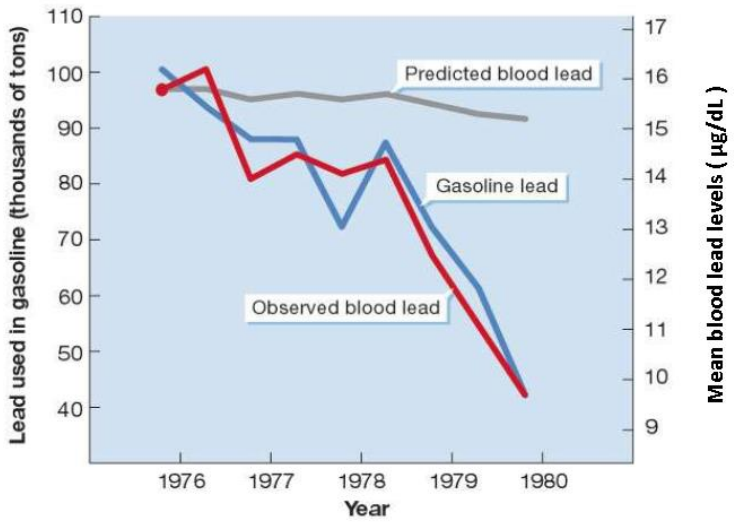
Examine Historical Lead Data

The National Health and Nutrition Examination Survey (NHANES) is a program of studies designed to assess the health and nutritional status of adults and children in the United States. The survey is unique in that it combines interviews and physical examinations. The survey is a major program of the National Center for Health Statistics (NCHS), which is part of CDC. It has the responsibility for producing vital and health statistics for the Nation.

DATA SET 1: BLOOD LEAD LEVELS, 1976-1980

Surveillance (What is the problem?)
The U.S. Environmental Protection Agency (EPA) issued regulations to gradually reduce the amount of tetraethyl lead over time, starting in 1973. CDC responded by adding **blood lead level** measurements to NHANES to collect surveillance data about its effects. The following data were collected and presented to Congress in hearings regarding the regulation of tetraethyl lead in gasoline. The "Predicted blood lead" line represents the scientists' prediction for how the **blood lead levels** of the community would change in response to the reduction of tetraethyl lead in gasoline.

Figure. Blood Lead Exposures in the USA, 1975-1980



Risk Factor Identification (What is the cause?)
Examine the relationship between gasoline lead and observed blood lead in the surveillance data above. What pattern do you see?

_____

_____

How does the line for predicted blood lead relate to the line for observed lead? What does this mean about the impact of gasoline lead on observed blood lead?

_____

_____

Based on this surveillance data, who is at risk for lead exposure?

_____

_____

Intervention Evaluation (What works?)
As of 2021, CDC recognizes 3.5 µg/dL as the level of concern for lead poisoning. Based on these data, what is the maximum amount of lead that should be in gasoline to reduce **blood lead levels** so that the entire population is below this level? Justify your answer using data.

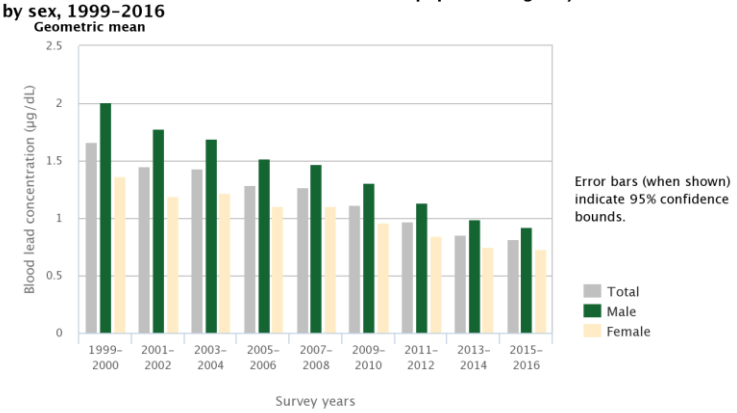
Implementation (How did we do it?)
Car manufacturers were ordered to begin building engines to run on unleaded gasoline by 1975, which led to the widespread use of the catalytic converter. Since lead damages catalytic converters, demand for leaded gasoline shrank. In 1996, EPA banned leaded gasoline from all on-road vehicles. The health effects of this ban can be observed through continuing surveillance.

DATA SET 2: BLOOD LEAD LEVELS, 1999-2016

Surveillance (What is the problem?)
NCHS has continued to record **blood lead levels** in the population through NHANES. The data below show blood lead concentrations for the U.S. population age 1 and older from 1999-2016, broken down by sex, race and ethnicity, and age group.

Risk Factor Identification (What is the cause?)

Exhibit 1. Blood lead concentrations for the U.S. population age 1 year and older by sex, 1999–2016

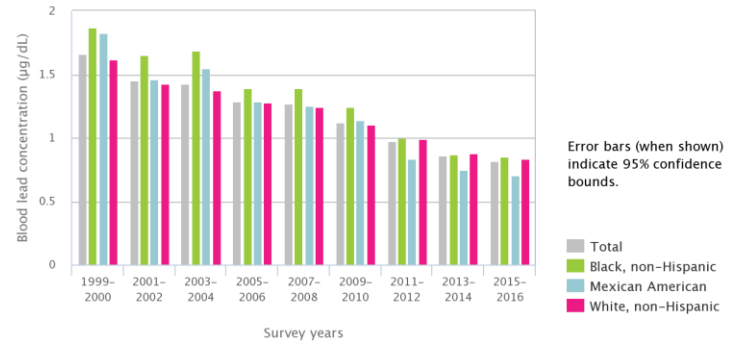


Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2018

Exhibit 1. What patterns related to sex did you notice in this graph? What risk factors may be responsible?

Exhibit 2. Blood lead concentrations for the U.S. population age 1 year and older by race and ethnicity, 1999–2016



Other racial and ethnic groups are included in the "total" only.

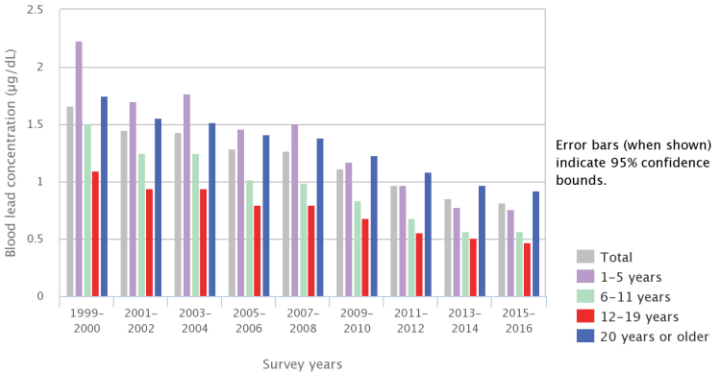
Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2018

Exhibit 2. What patterns related to race and ethnicity did you notice in this graph? What risk factors may be responsible?

Exhibit 3. Blood lead concentrations for the U.S. population age 1 year and older by age group, 1999–2016

Geometric mean



Information on the statistical significance of the trends in this exhibit is not presented here. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: CDC, 2018

Exhibit 3. What patterns related to age did you notice in this graph? What risk factors may be responsible?

Intervention Evaluation (What works?)

Think about the data and the risk factors you have identified. To improve the health of the public, you should start by addressing these health disparities. What are three interventions you would suggest to address these disparities?

1.

2.

3.

Implementation (How did we do it?)

Choose one intervention strategy that will be the most successful based upon your reading and data analysis. How would you implement this intervention?

What challenges do you anticipate in implementation?

Develop a Plan to Address a Public Health Emergency

During April 25, 2014–October 15, 2015, approximately 99,000 residents of the City of Flint, Michigan, were exposed to lead when the drinking water source was switched from the Detroit Water Authority to the Flint Water System (FWS). The levels of lead in Flint tap water increased over time as the lead pipes slowly corroded and lead dissolved into the water. CDC – led by the U.S. Department of Health and Human Services (HHS) – assisted the City of Flint and the State of Michigan to develop a response and recovery plan. Here is a brief timeline of events:

Apr 2014	Water in Flint, Michigan is switched from Detroit Water Authority to Flint Water System (FWS) as a cost-saving measure. Residents notice water smells, tastes, and looks funny. Normally, **corrosion** control chemicals are added to the water, but Flint did not have a proper plan in place when the switch occurred.
Jun 2014	An outbreak of Legionnaires' disease kills 12 and sickens 87. Legionnaire's disease is caused by *Legionella* bacteria and is a symptom of inadequately treated water.
Aug 2014	Fecal coliform bacteria are detected in the water system, and a boil water advisory is issued. This is another sign of poorly treated water. FWS increases the chlorine levels in the water to correct the bacterial contamination.
Oct 2014	General Motors stops using Flint water, as it is corroding engine parts in their factory.
Jan 2015	Flint officials announce the level of trihalomethanes (TTHM) is too high in the water system due to overchlorination, putting them in violation of the Safe Drinking Water Act. The state starts buying bottled water for its government offices.
Apr 2015	Michigan's Department of Environmental Quality (MDEQ) notifies EPA that FWS did not have **corrosion** controls in place. EPA warns Flint that its anti-**corrosion** methods are not sufficient and that they may be underestimating lead levels in the water due to poor sampling methods.
Jul 2015	MDEQ spokesperson says, "Let me start here — anyone who is concerned about lead in the drinking water in Flint can relax" in response to growing concern. Officials deny the water is unsafe to drink.
Sep 2015	A team of researchers from Virginia Tech examines water samples from around Flint and finds 17% are above the federal maximum standard of 15 **ppb** (parts per billion). They also find the water to be 19 times more corrosive than Detroit water. Dr. Mona Hanna-Attisha, working with the researchers from Virginia Tech, examines 1,700 blood samples from Flint children and finds nearly double the numbers of high **blood lead levels** since the switch to Flint River water. The city recommends use of water filters and begins offering lead tests.
Oct 2015	Further testing shows elevated lead levels in Flint, and the governor offers funding to help address the issues. The city is reconnected to Detroit water. However, the damage to the pipes is done, and they continue to leech metals into the water.
Dec 2015	A state of emergency is declared in Flint by the mayor, governor, and president. Federal agencies can now begin to offer support in the area.
Jan 2016	Bottled water and filters are distributed to all city residents to remove lead and other contaminants.
Jul 2016	Flint's water tests below the federal action level of 15 **ppb** for the first time.
Dec 2016	The U.S. Senate authorizes $100 million to address lead contamination in Flint.

After the water crisis, the City of Flint started a program to replace all lead **service lines** with new copper pipes at no cost to residents using $97 million in funding from state and federal governments. They also continued to supply water and filters to buildings awaiting replacement. Between the improved water quality and repairs to the plumbing infrastructure, the source of lead in Flint's water has been addressed. However, the problem is not over.

There is evidence that childhood exposure to lead can cause long-term harm. The effects of lead poisoning may be permanent. No safe level of lead exposure in children has been identified. Exposure to lead can seriously harm a child's health and cause adverse effects such as:

- Damage to the brain and nervous system
- Slowed growth and development
- Learning and behavior problems
- Hearing and speech problems

This can cause:

- Lower IQ
- Decreased ability to pay attention
- Underperformance in school

Develop a Plan

Given what occurred with the water in Flint, Michigan, what support does the community need to address the issues brought about by the elevated lead levels in the water? Design a **public health** intervention strategy that would address the long-term effects of elevated lead levels in Flint's water. You may find useful resources here: https://www.cdc.gov/nceh/lead

Surveillance (What is the problem?)

What type of data would you like to collect? How will you collect it?

Example: You could conduct phone interviews with people in Flint to assess their needs.

Risk Factor Identification (What is the cause?)

What group would you want to address with your intervention?

Example: You could design an intervention for third graders with low reading or math test scores.

Intervention Evaluation (What works?)

Propose 3-5 intervention strategies that you think could address the issue you have identified.
Example: Provide increased Medicare benefits so that residents of Flint can get medical care.

Implementation (How do we do it?)

Come up with a plan to implement the intervention that you think would be most effective.
Ex: You could secure government funding to open free preschool for all Flint kids.

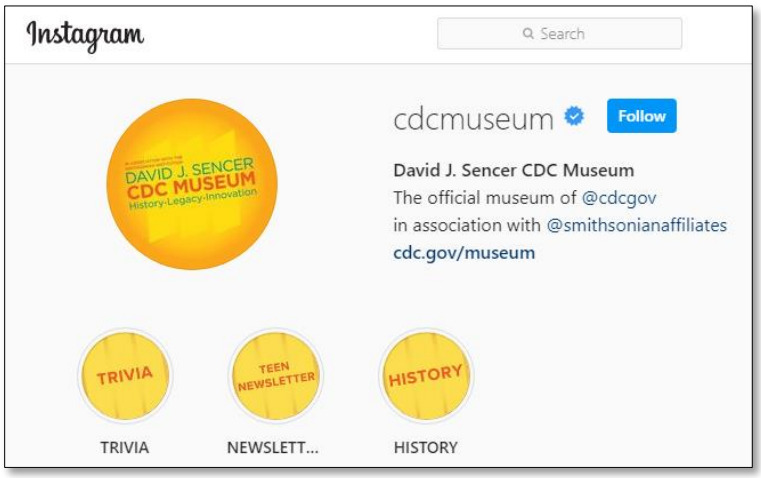
Success Story: Newark, New Jersey

After elevated levels of lead were found across 30 public schools in Newark, New Jersey, the city began evaluating its water system. The threat of lawsuits and warnings from the EPA pushed the project into quick action. Between March 2019 and August 2021, the city replaced all 23,000 **service lines** with copper at no cost to homeowners. Listen to Kareem Adeem, the Acting Director of the Newark Department of Water and Sewer, explain the process and how this monumental feat was accomplished so quickly. https://youtu.be/V8hEYFpYsv4

Share Your Findings

The David J. Sencer CDC Museum uses award-winning exhibits and innovative programming to educate visitors about the value of **public health** and presents the rich heritage and vast accomplishments of CDC. Your demonstration could be a valuable contribution! Share your demonstration with the CDC Museum on Instagram using **@CDCmuseum**.

CDC's National Center for Environmental Health (NCEH) plans, directs, and coordinates a program to protect the American people from **environmental hazards**. They promote a healthy environment and prevent premature death, avoidable illness and disability caused by non-infectious, non-occupational environmental and related factors. They are especially committed to safeguarding the health of vulnerable populations – such as children, older adults, and people with disabilities – from certain **environmental hazards**. Share your work them on Twitter using **@CDCEnvironment**.



Name: _____

Reflections

Now that you have completed this investigation, think about what you learned from the information presented. Answer the questions below.

1. How have the sources of lead in the environment changed over the last hundred years?

2. Why are small children so much more at risk for lead poisoning than adults?

3. How has the amount of lead in Americans' blood changed since the 1960's? Use the data from the graphs provided to justify your answer.

4. In interviews with long-term NHANES team members, many cited the **blood lead level** data as the organization's proudest achievement. Why do you think this is the case?

5. When designing **public health** interventions, why is it so important to consider the specific needs of the community and the resources available to solve the problem?

6. The Clean Air Act of 1976 gave EPA the right to regulate substances whose emission products endanger the **public health** or welfare. Ethyl Corporation sued for the right to continue producing gasoline with lead after the EPA banned it, claiming that there was no proof of harm from lead. If you were the judge in this case, how would you rule? Why?