

illUminate Blog Transcript: Muzhe Yang on Lead in Our Drinking Water

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- ANNOUNCER: 00:01 [music] This podcast is brought to you by illUminate, the Lehigh business blog. To learn more, please visit us at business.lehigh.edu/news.
- JACK CROFT: 00:13 Welcome. I'm Jack Croft, host of the illUminate podcast for Lehigh University's College of Business. Today is January 27th, 2023, and we're talking with Muzhe Yang about his research examining the connection between prenatal exposure to lead-contaminated drinking water in Newark, New Jersey and adverse birth outcomes. We'll also talk about the policy implications of his research findings for other cities across the nation who are confronting similar contamination in their tap water from aging lead pipes. Dr. Yang holds the Charles William McFarlane Professorship in Economics in Lehigh's College of Business. His research aims to provide empirical evidence on causal relations that have policy implications. Examples in recent years that we discussed in a [March 2021 illUminate podcast](#) include fetal health effects of long commutes to work during pregnancy, maternal and fetal health effects of working during pregnancy, and the effects of power plant emissions, air pollution, noise pollution, light pollution, and water pollution on fetal and infant health. So welcome back to the illUminate podcast, Muzhe.
- MUZHE YANG: 01:32 Welcome. Morning, Jack. Thank you for giving me this opportunity to share my study with your audience.
- CROFT: 01:37 Great. Now, from public schools in Delaware to California and from Flint, Michigan to Washington, D.C. to Chicago to Newark, New Jersey, and many other cities and towns, lead in drinking water continues to be a critical public health issue. So let's start with the big-picture perspective: How prevalent is lead in drinking water throughout the United States today? And what are the main adverse health effects it poses?
- YANG: 02:08 Good questions. And let me answer them one by one. First, about the prevalence. I would say it is high and also at an alarming level. Just between 2018 and 2020, about 30 million people received their drinking water from their community water systems that were in violation of the EPA's regulation about the maximum level of lead that can be allowed in drinking water. And that regulation threshold is 15 parts per billion, which is 15 micrograms per liter of water. Among those violations, one important source is the use of water service line that is made of lead. The service line is the pipe that connects a house or a building to the water main. The water main is the main line in a water supply system. So let me use this road system as an analogy. A water main is just like an interstate highway, such as I-95. And the service line is just like a local street that gets to each home. Water mains are typically made of copper. But a lot of service lines are made of lead, especially for old homes. I think, back then, people had a preference for lead, which is very understandable. This is because lead is not only durable, but also malleable. So you can bend it, twist it, or make it into many shapes very easily without breaking it. So not surprisingly, lead had been a very popular choice in the old days, not only for service lines, but also for in-home plumbing features.

YANG: 04:04

Now, about the total number of lead service lines, it is estimated to be somewhere between 6 and 10 million nationwide. But I want to say that this is possibly an underestimate. Why? Because those numbers were based on the numbers reported by the water systems within each state. We may not have the full counts. And this is because some of those numbers depend on the reports from homeowners. Some or maybe a lot of homeowners do not really know whether their water service lines located on their private properties are made of lead or made of copper. As I mentioned earlier, people in the past had a preference for lead probably because lead is durable and also malleable, so very understandably, old houses are more likely to have lead plumbing fixtures and lead service lines. For plumbing materials that are made of lead, a thing called corrosion can happen. And this will happen when the pH level of water inside the pipe drops below a certain threshold, that is when the water becomes too acidic. We need to keep this in mind that this practice of increasing the acidity level by the water treatment plant can happen with very good reasons why, because doing so is for the purpose of reducing carcinogens, that is, the cancer-causing byproducts which can be generated during the process of treating water using disinfectants.

YANG: 05:54

Now, about the second part of your question which is about the health impacts of lead, let me answer it more concisely here. Simply speaking, lead is poison. When lead enters our body into the blood, it will affect all organs including the brain. What I want to emphasize here, which is very relevant to our own study, is that lead is stored in our bones alongside calcium. And it can be released as a substitute for calcium. And this substitution will happen when there is a calcium deficiency. And this deficiency can happen during pregnancy. In this case, lead instead of calcium will be used in the formation of the bones of the fetus. Also, lead in a mother's blood can cross the placenta, directly exposing the fetus to lead. So there will be severe health consequences of lead exposure for the fetus. In our study, we focused on the fetal health impact of prenatal lead exposure during pregnancy.

CROFT: 07:15

OK. Now, as you mentioned, your study looks at the lead-in-water crisis in Newark, New Jersey. And how did the water contamination there first come to light, and how bad was it?

YANG: 07:29

OK. The very first indication of the water contamination happened in March 2016. At that time, routine water testing found 30 public schools in the city of Newark had lead levels in drinking water above the EPA regulation threshold, which is 15 parts per billion. After that event, and throughout the year 2017, more testing results in the city revealed high levels of lead in drinking water. One statistic showed that more than 22% of drinking water samples exceeded the EPA regulation threshold. Now, with more testing results coming out, a pattern also emerged. And the pattern is that the violations were concentrated in the western part of the city. And then later on, the city commissioned an engineering firm called CDM Smith to conduct an independent investigation about the water crisis. The report was released in October 2018, and it found that the city, specifically the western part of the city, had continuously violated the EPA regulation about lead in drinking water. I read that report and the report helped me figure out my research design for identifying a causal effect of lead exposure on health.

YANG: 09:11

And here I also want to say that there are many, many studies that have already found a strong correlation between lead exposure and health, but I need to clarify

that the findings of a causal link still has been lacking in the literature. Without confirming this causal link, we can always argue that lead health outcomes are driven by other factors that coexist with lead. What makes causal inference very difficult is that identifying a causal effect in principle requires random assignment of lead exposure to people. Now, as humans, we have ethical standards and we just simply cannot do that kind of randomization on purpose to real people. Nevertheless, in reality, things do happen in a way out of our control and there can be cases where people got their lead exposure in a way without their awareness. When this happens, it means that the lead exposure is almost randomly assigned. And this is the idea we used in our study to identify a causal effect of lead exposure.

CROFT: 10:29

Now in your study, you discuss how the water crisis in Newark provided, and I'll quote here, "a unique natural experiment," unquote, to study prenatal exposure to lead-contaminated drinking water on fetal health. So what was it about the crisis in New Jersey's largest city that made it a unique natural experiment?

YANG: 10:52

Yes, it is unique in the sense that we have two groups of people where one group was exposed to lead in drinking water in an unexpected way while the other group was not. In other words, the Newark water crisis provided an exogenous variation in the lead exposure. So we economists often use the phrase called natural experiment just to describe an empirical setting where the exogenous variation is not obtained through any purposely designed randomized controlled trials, but resulting from certain events that happened in the real world. Now, what makes Newark's water crisis unique is that the city is served by two, not by one, water treatment plants. And this allowed us to do a within-city, not cross-city comparison. And here, the argument is that, well, it is possible for people to choose where to live. It is not very possible for people to choose where to live based on what water treatment plants they get. If this is true, then we can say that people living close to the border separating the service areas of the two water treatment plants can be very similar only except for the water treatment plant they get. This is similar to a randomized controlled trial, but it happens just naturally in the real world. The border separating the service areas of the two water treatment plants essentially plays the role of randomly assigning city residents into two groups.

YANG: 12:40

Back in 2015, there was a significant drop in the pH level of the water treated by one of the two water treatment plants, and this plant served the western part of the city. The lowered pH level caused lead to leech into the tap water of that plant's service area, which is the western part of the city. So at this point, you may wonder, why lower the pH level? This goes back to what I have just mentioned earlier. So sometimes it is necessary for a water treatment plant to lower the pH level to make the water more acidic in order to reduce the cancer-causing byproducts generated during the water treatment process. And another unique feature in the Newark water crisis is that the two water treatment plants use two different chemicals to treat their water. Those chemicals were approved by the EPA, but it turned out that one chemical lost its effectiveness in preventing lead from seeping into the tap water when the acidity level became too high. So in the end, we argued that city residents' exposure to lead in their drinking water was essentially randomly assigned.

YANG: 14:09

To the west of the border, people were unfortunate and they were exposed to lead in drinking water. To the east of the border, people were fortunate, but probably only initially. As the crisis unfolded over time, and with more and more media reports,

people living to the east of the border could also be affected because of the increased stress level, worrying about their drinking water also being contaminated. In our study, we did confirm the adverse effect outcomes for women living to the west of the border, such as increased likelihood of having babies born with low birth weight or preterm. And we also found some evidence of the information spillover effect, that is, people living to the east of the border were also adversely affected possibly due to increased stress level.

CROFT: 15:10

Over the years, several of the studies that I mentioned in the introduction were also conducted using data from New Jersey to examine factors including light pollution, air pollution, residential noise pollution, and adverse work conditions and how they affect prenatal, maternal, and infant health. So what is it about New Jersey's record-keeping policies that make it a prime state to do that kind of research?

YANG: 15:41

New Jersey is rather unique because it allows researchers to get access to birth records with information on mothers' home addresses. Even mothers' employers' addresses. One of my papers use both addresses to study the health effects of long commutes. The studies you have just mentioned all depend on home addresses. The New Jersey Department of Health has established a standard application process for such data access for all researchers. This is great. This is great because other researchers should be able to get the same data I used to do cross-validation studies. Here, let me give a clarification about the other popular data source, which is the U.S. National Center for Health Statistics, and that center has data on vital statistics such as birth records for the entire country, for the whole country. You may wonder why I didn't expand the scope of my study to the whole country using that center's data. Here's the reason. The National Center for Health Statistics allow researchers to get geographic identifiers for the vital statistics data, but with a big limitation. That limitation is, for those vital statistics data, the most detailed geographic identifiers that researchers can get are only at the county level or for large cities that have more than 100,000 residents.

YANG: 17:24

As I explained earlier in this interview, a lot of the time, researchers need to use exogenous variation to identify causal effect. And a lot of the time, exogenous variation happens only at a very local level. So let me give you one example here. We can choose exactly which neighborhood to live in. And in this case, the variation of the neighborhood's quality is not exogenous because we choose that quality ourselves. But by comparison, within a neighborhood that we can choose, we typically cannot choose exactly which neighbors we live with. So in this case, the variation of the neighbor's quality is exogenous. And this is the kind of exogenous variation researchers need most. So in the end, I will say that I feel very fortunate to have gotten the access to the New Jersey data. And I hope my work will also help other researchers to get to know the New Jersey data.

CROFT: 18:33

You've talked about the New Jersey data on where the houses are, the two treatment plants, so how did you put all this information together to analyze the effects of lead contamination in Newark's tap water on birth outcomes?

YANG: 18:50

Yeah, I put these two pieces of information together. So one is the exact home addresses of pregnant women living in the city. The other information is the spatial boundaries, so basically just a map of the two water treatment plants. So the former was obtained from the New Jersey Department of Health. The latter was obtained from a website and that website is about the Newark's lead service lines. By

combining these two pieces of information together, I was able to tell exactly who lived to the east of the border separating the two water treatment plant service areas and who lived to the west of that border. Now, if we believe no one chose where to live based on the two water treatment plants' service areas, then we can say people living to the west of the border were exposed to the lead in their drinking water randomly. And this is the randomization that allowed me to identify the causal effect of lead exposure on health.

CROFT: 20:06

And what were the key findings of your study then?

YANG: 20:09

We find that the prenatal lead exposure increased the chance of low birth weight by about 18% and also increased the chance of preterm birth by about 19%. These numbers do not represent correlations, but rather causal relations, that is, the effects due to lead exposure alone, not due to other factors. So these are the key findings of the study.

CROFT: 20:43

Now, as you've mentioned, your research is primarily focused on that causal relation and even more specifically causal relations that have policy implications. So what are the main public policy implications of your research on Newark's lead-in-tap-water public health crisis?

YANG: 21:05

I would say what happened in Newark may be just the tip of an iceberg. The main policy implication of our study is that replacing all lead water pipes being used in the U.S. water system should be done as soon as possible. It is not a question of whether we should do it or not, but a question of how quickly we can do it. In our study, we mentioned that high levels of lead had already been found in the tap water in cities other than Newark. We listed a few in our paper and they are Baltimore, Chicago, Detroit, Milwaukee, New York, Pittsburgh, and Washington D.C. So in summary, replacing all lead water pipes should be done as soon as possible.

CROFT: 21:59

Now, there are those who say that the cost to replace old lead pipes across the country is just too expensive. So how does that cost compare to the lifetime cost for society associated with preterm births?

YANG: 22:14

We did a cost-benefit analysis in our study taking the lifetime cost of preterm birth into account. Our analysis is only for the city of Newark, so all the numbers I'm about to mention are just for this city alone. According to our calculation, the cost savings from avoiding increased preterm birth because of the lead exposure can be somewhere between \$90 million and 160 million dollars. This benefit is roughly the same order of magnitude as the replacement cost of lead water pipes. And the cost was estimated to be somewhere between \$90 million and a 180 million dollars. Here, I also want to emphasize that the cost-saving estimates we did could be an underestimate. This is because we only considered the benefit from avoiding bad health outcomes. There are other benefits. There are other benefits coming from avoiding other undesirable outcomes. For example, lead exposure among children has been found to reduce their school performance, increase their antisocial behaviors, and even increase their criminal behaviors. If we take those benefits into account, then the total benefit is likely to exceed the total cost of replacing all lead water pipes. So here, I want to say that the cost of replacing the lead water pipes shouldn't be viewed only as an expenditure, it should also be viewed as an investment. And it is also an investment for our children's future.

- CROFT: 24:04 And finally, what should politicians, policymakers, and the public—who are the, the people who live in places where they have lead in their tap water or may develop lead in their tap water as it continues to age—what should they all take away from your study?
- YANG: 24:26 The infrastructure bill passed by the Congress, I would say, really gave hope for finally solving the problem of lead water pipes. The bill was passed in November 2021, and it includes a funding of [\\$15 billion for lead pipe replacement](#). It is a concrete step, but still, it is just the first step. So what I really want to emphasize is this: Policymakers and the public, especially at the local level, probably want to pay close attention to the actual progress of the replacement work. And we just cannot wait too long. Time flies. The bill was passed in November 2021 and more than one year has already gone. We are now in 2023. I really hope we can get work done soon. And I hope the study we did can help those decision-makers understand the importance and also the urgency of replacing all water pipes that are made of lead as soon as possible. As I have just said, the replacement cost shouldn't be viewed only as an expenditure. It should also be viewed as an investment. And it is also an investment for future generations. And this is all I want to emphasize at the end of my talk today.
- CROFT: 26:07 Muzhe, thanks again for sharing this important research with our listeners on the ilLUMinate podcast today.
- YANG: 26:14 I thank you for giving me this opportunity to share my study's findings with your audience. Thank you.
- CROFT: 26:20 Happy to do it. And as you continue to work in this vein on the effects on birth outcomes of various factors, we'll be happy to talk with you again.
- YANG: 26:32 Thank you. And I will keep you posted.
- CROFT: 27:30 Okay. Among other examples of Muzhe Yang's research are peer effects in physicians' new drug prescription behaviors; the impact of publicly reported provider quality information on coronary artery bypass graft markets; the impact of exposure to food advertising on purchasing behaviors; the roles of nationality and ethnicity in international and inter-regional trade; effects of signaling behaviors on college admission outcomes; and effects of paid maternity leave on breastfeeding practices. This podcast is brought to you by ilLUMinate, the Lehigh business blog. To hear more podcasts featuring Lehigh business thought leaders, please visit us at business.lehigh.edu/news. And don't forget to follow us on Twitter, @Lehighbusiness. I'm Jack Croft, host of the ilLUMinate podcast. Thanks for listening.