Infectious Waterborne Disease in the United States

[Announcer] This program is presented by the Centers for Disease Control and Prevention.

[Sarah Gregory] Hello, I'm Sarah Gregory, and today I'm talking with Sarah Collier, a CDC epidemiologist. We'll be discussing the health burden of waterborne disease in the United States.

Welcome, Sarah.

[Sarah Collier] Hi there. It's such a pleasure to be here.

[Sarah Gregory] I do this weekly podcast about infectious diseases—and of course it's all scary stuff—but I've got to say that the thought of our water safety being compromised is terrifying. I know water safety is a global problem, but we in the U.S. have taken safe water for granted for more than 100 years.

Tell us a little bit about the history of water in the United States.

[Sarah Collier] Sure. So, I will start from the very beginning, but we can travel back in time a little bit to the turn of the 20th century. And at that time, typhoid fever and cholera were among the top causes of death in the U.S. (those are both waterborne diseases). And the first chlorination and filtration of a public water supply happened in 1908 in Jersey City, New Jersey. And, you know, soon after death rates from these diseases just sort of plummeted (essentially going to zero). And so, the end of the 19th century, the beginning of the 20th century saw the sharpest decrease in death rates in recorded history. And treating drinking water was probably responsible for at least half of that decrease. So...so, it kind of just shows you how...how important safe drinking water is.

And then if you fast forward to today, we have one of the most reliable, safest drinking water supplies in the world in the U.S. and that's thanks to the hard work of a lot of people that developed water treatment methods and there are, you know, lots of laws that protect our water supply. So what that means for us is that our mental picture of waterborne disease is a little bit outdated. I'm a...I'm a child of the 80s, so I think of it as sort of like the...the Oregon Trail picture of waterborne disease. We think it's...it's typhoid fever and cholera and that it's something that happened in the past. But you know, actually we....because...you know, partly because of our...our safe and reliable water supply, we've started using water in really complicated ways. So, we use it to heat and cool buildings, we use it to produce food, and we use water in medical equipment (like ventilators and dialysis machines). So in our work we wanted to update people's mental picture of what waterborne disease looks like in the U.S. now and figure out where we can get better at preventing waterborne disease.

[Sarah Gregory] I did my last podcast with Dr. Elizabeth Beshearse about sickness transmitted by food and water, and she mentioned your study. How are they related?

[Sarah Collier] Oh, sure. Dr. Beshearse's study was really important for our work. We...we couldn't have done our study without hers. And so she brought together a group of experts to figure out for this long list of diseases, how much disease was waterborne, foodborne, and so on. And we were able to take those expert estimates and then apply them to the total amount of various diseases to figure out the...sort of the chunk of disease that's waterborne. So you know,

for example you can take giardia (which is a parasite which causes diarrhea) and if there are a million cases of giardia each year and 40% is waterborne, then we estimated that 400,000 cases of giardia were transmitted through water annually and all of that is due to the...the estimates that Dr. Beshearse named.

[Sarah Gregory] As you said, in the United States, outbreaks associated with large public drinking water systems have sharply declined—and apparently more so in the past 40 years. You say in your article this is likely the result of improvements in regulation and operation. However, transmission of disease still occurs, with certain types actually increasing. Can you tell us what's going on?

[Sarah Collier] Sure. You are absolutely right. Big, public drinking water systems are subject to lots of laws and regulations that are aimed at making water safe to drink. And so, we have seen big declines in...in people getting sick from their municipal water systems. But we still see people getting sick from their drinking water in a couple ways. One is if you think about the pipes that bring water to our taps, many of those systems were designed about 100 years ago, and so we have millions of pipes in the U.S. that are decades past their lifespan. And so, these pipes can...they create kind of continuous maintenance issues that can develop into emergency situations like a water main break, and sometimes these...these water main breaks can allow germs to get into the pipes and contaminate the water. So that's one way that we see illness.

Another way that we see illness is from private wells. So, big public water systems have drinking water engineers (so, people whose job it is to make sure that your drinking water is safe). But if you think of a person that has well water at their house, that person has to be their own drinking water engineer. And so having a private well requires some maintenance, just like any other part of a house. And so, we do get outbreaks from private wells reported to our system. And what I think a lot of people don't realize is that there are actually about 45 million Americans that get drinking water from a private well. So, those are some of the ways that we see people getting sick from drinking water.

[Sarah Gregory] So along those same lines (sort of) is pipes. Is one type of pipe better or worse for collecting pathogens, say the plastic pipes or metal pipes or…? We know lead pipes are bad.

[Sarah Collier] That's a great question. Actually, let me...let me talk a little bit about...about pipes and how that might relate to waterborne disease. So, there actually are 6 million miles of indoor plumbing in the United States. We have a...a, you know, complicated buildings and complicated plumbing network in our communities and lots of the...these complex systems that we've built over the last few decades had been added to the existing piping systems that were designed in the early 1900s, right? So, it's a really complicated network and it can sometimes be hard to maintain the right disinfection and temperature levels in these millions of miles of piping. And there can also be, like, stagnant areas within the pipes where the water sits for long periods of time, and so that makes a good environment for germs to grow. If you've ever seen sort of the, like, black slime that may come out of the faucet or be down the drain, that's known as biofilm. And that's...that's pretty common in plumbing. And so, plumbing that's not well-maintained can provide hiding spots in this...in this biofilm where germs can hide and avoid disinfectant. And if water with these germs in it gets misted into the air or if people drink it, you know, people can get sick. And so you're wondering, you know, are there...are there different types of pipes that are...that are better or worse for preventing this kind of illness, and the answer is we don't really

know. This....this idea that biofilms in pipes can cause illness is kind of a new....it's kind of a new concept for us and we're only just starting to appreciate the importance of it. And so I think what I would say is, you know, we're not really sure but we do...we have some evidence that, you know, all types of pipes can harbor these biofilms. It's just kind of inevitable wherever you have water, you'll have a biofilm if things aren't properly maintained.

[Sarah Gregory] And what is the scope of the problem now in pathogens and water? What are all the different ways that water can infect us (recreational, drinking, everything)?

[Sarah Collier] Sure. So as we talked about a little earlier, scientists have known for a long time that germs in drinking water can cause gastrointestinal disease. But today we have a better understanding that germs in water can cause illness in lots of parts of the body. Obviously we don't just drink water, but we bathe and swim in water and we breathe in water in the air. You know, we clean wounds with water, we use...we use water in lots of medical procedures. So we're really surrounded by water. And if there are germs in water, then they can cause illness in lots of different systems in the body and that includes respiratory illness, wound and bloodstream infections, skin problems, even neurological illnesses.

[Sarah Gregory] So as we said earlier, a lot of the water issues have gone away over the last hundred years. But there's been some increase in some types. How did this happen and what changed and what are they?

[Sarah Collier] Sure. And you know, it's a little bit hard to tell whether these illnesses have always been around and we're detecting them better. But we...what we do know is that we're definitely interacting with water in ways that are different than in the past. So we've talked about indoor plumbing and that's actually part of, you know, ventilation systems in large buildings, including buildings with sick people in them like hospitals. And so, you know, we have this complicated plumbing in buildings and if it's not well-maintained, you know germs can kind of grow on biofilm. And so in addition to seeing people getting sick from drinking water—as we did, say, at the turn of the 20th century—what we see now is that people also get sick with severe pneumonias caused by breathing in contaminated water. So, if...you know, if there are....if there are germs in...in plumbing or in, say, in a hot tub or something that sort of gets misted into the air, people can breathe them in and get sick. And you can get mists of contaminated water from air conditioning systems, from industrial processes, from decorated fountains. So you can kind of start to get the idea of how complicated our interactions with...with water are these days. It's sort of...it's all around us, it's...it's surrounding us. And there are lots of different ways that people can get sick.

And there's, you know, one...one other thing that's changed is that we have more leisure time to swim. And we see people getting sick from swimming in the complicated, you know, pools, hot tubs, water parks that are more common now and we don't just see swimmers getting sick from gastrointestinal disease. We see people getting sick with these diseases related to breathing in contaminated water and, you know, wound infections as well. So, those are some of the ways that we see waterborne illness in our...in our more modern world.

[Sarah Gregory] How many people get sick and how many people die each year from these waterborne germs?

[Sarah Collier] We estimated that about 7.2 million people get sick from waterborne germs every year in the U.S., so that's about 1 in 44 people every year. And 6,600 of these people die. And we also estimated that these germs are responsible for 600,000 emergency department visits and about 120,000 hospitalizations.

[Sarah Gregory] That's staggering. Can you repeat the number of people who died? I'm not sure I heard you correctly.

[Sarah Collier] Sure. 6,600 people die each year from waterborne disease in the United States.

[Sarah Gregory] 6,000....yeah, I thought you said 6 or 2,000. Well, that's a terrible number.

What are the most common waterborne causes of illness and what are the most common reasons for hospitalization and death?

[Sarah Collier] Sure. The, you know, the most common illnesses are...are swimmer's ear (which is an outer ear infection caused by swimming in contaminated water) and norovirus (which is a diarrheal illness). But when you look at the types of illnesses that cause hospitalization, it's a little bit different. You start to see these germs that cause more severe respiratory or systemic disease. So the....two of the diseases that we saw causing the most hospitalizations are nontuberculous mycobacterial infection (which I'm going to call NTM infection because it's a lot easier to say), and *Pseudomonas* pneumonia, which is a....both of these are sort of severe lung infections caused by breathing in contaminated water that's in the air.

[Sarah Gregory] So, recreational water is a big problem. I mean, we read about this in the news a lot. Why? Why is this increase so much and is there a way to stop the increases, rectify, treat water better.....I don't know.

[Sarah Collier] Thanks. That's a great question. And you know, it's a little bit hard to tell whether it's...that we're...we're better at detecting these illnesses or that illnesses have actually increased, isn't it? You know, it's a little bit hard to tell. I can say that one of the illnesses that we see a lot with swimming (with recreational water contact) is cryptosporidiosis, and that's a....*Cryptosporidium* is a parasite that's resistant to chlorine. It has sort of a hard, outer shell and so it's a lot harder to disinfect it with using chlorine. And so, you know, not surprisingly that....that can be a real problem for these...for pools and things that are disinfected with chlorine. And so that is one...one of these that we've seen quite an increase in. And there certainly are things that people can do to protect themselves and others from illnesses when they swim. Some of the key things to do are not swallow the water (if you have young kids, you know, I know this is hard, but try and work with them to...to not swallow the water); you can stay out of the water if you have diarrhea or an open wound; you can make sure that the water that you're swimming in is properly chlorinated; and a thing that you can do to help prevent swimmer's ear (which is still surprisingly common) is to dry your ears thoroughly after getting out of the water. So, that's one of the biggest prevention steps for...for preventing swimmer's ear.

[Sarah Gregory] In the last bunch of years, I know a lot of pools have switched to saline instead of chlorine, which I prefer because chlorine tends to make me feel terrible. Is saline better, no better, worse? What's the deal with that?

[Sarah Collier] Sure, that's a good question. So, I think you're talking about the…sort of the saltwater pools, which actually do....you know, folks may not know this, but those pools actually

also are disinfected with chlorine. It's just that they use...they use table salt (you know, sodium chloride) and have machinery to split the table salt into sodium and then chlorine, and then the chlorine is used for disinfection. But I absolutely agree with you. They are very pleasant to...to swim in. The water has a little bit of leftover salt in it and so you feel a little bit more buoyant and it feels really nice on your skin. But I think folks don't realize that those pools also do have chlorine, and that's...that's one of the ways that....one of the really important things that help keep us safe when swimming. Because when you...when you really think about swimming, it's sort of...it's sort of shared bathing. You know, you're in this water with everybody else and so germs on your skin are kind of shared with everybody else's that's in the pool. So it's important to...to one, obviously not swim when you have diarrhea and not swim if you have an open wound. And then also, you know, not swim the water....excuse me, not swallow the water. Those are all things you can do to kind of keep yourself safe when you're swimming.

[Sarah Gregory] What's the total burden of all these water dangers to public health?

[Sarah Collier] Not only do we know that not…that over 7 million people are getting sick and that over 6,600 people are dying every year, but the cost to our healthcare system is also really significant. Waterborne diseases are responsible for more than $3 billion in healthcare costs for hospitalizations and emergency department visits, and that's the...that's something that we were able to calculate in this...this paper that came out recently.

[Sarah Gregory] Was there anything that surprised you about this study?

[Sarah Collier] We were surprised. We had an inkling that waterborne germs that were...that are causing these respiratory illnesses and systemic illnesses were a problem, but I think getting a full understanding of the overall costs and the number of hospitalizations and deaths from these particular illnesses was really, really striking to us.

[Sarah Gregory] How many pathogens were looked at and which were the most notable ones?

[Sarah Collier] We looked at 17 pathogens for this study, and the most notable ones from our perspective were the four pathogens that typically grow in pipe slime or biofilm. So...so the diseases caused by those pathogens are Legionnaire's disease, nontuberculous mycobacterial (NTM) infection, and then *Pseudomonas* pneumonia and septicemia. And so these pathogens caused less than 5% of the illnesses, but they were actually responsible for 94% of the deaths and over $2.3 billion of the total healthcare cost.

[Sarah Gregory] How did you go about doing this study? What kind of data did you use?

[Sarah Collier] Thanks, I'm so glad you asked because this...this effort was actually sort of more than a decade in the making. It...it turns out it's actually really hard to answer these kinds of questions about, you know, how much waterborne disease is there in the United States. And so we had to kind of think creatively about data sources that would tell us more about these...these respiratory or systemic germs that we thought were, you know, an emerging problem. And so, we had to use a big data approach. There…CDC doesn't have dedicated disease surveillance systems for....for example, for NTM infections, and so we had to look to these giant healthcare...these health insurance billing databases to kind of get some information on how common these...these infections were. And so we used a combination of surveillance data and health insurance data, and then estimates that had been previously published in, you know, in the scientific literature. And we had to kind of limit our...limit our scope a little bit, just to kind of

get an initial estimate out there, and so we didn't include illnesses caused by toxins or chemicals (like lead) just to kind of carve out a manageable question for...for us to answer.

[Sarah Gregory]Well, let's take a minute for you to tell us about your study.

[Sarah Collier] Sure. So we....we combined those data sources that I...that I just talked about. And then we used Dr. Beshearse's work that told us how much of each disease was waterborne. And that allowed us to come up with estimates of how much waterborne disease there is in the U.S. And we also worked really hard to come up with uncertainty intervals for each estimate. So, we had an indication of how certain or uncertain we were about each number.

[Sarah Gregory] In what ways is your study unique?

[Sarah Collier] Until now, we didn't have an estimate for the...the total magnitude of infectious waterborne disease in the U.S. There had been previous estimates for illness from drinking water...you know, a few estimates for illness from recreational water contact. But this is the first study to kind of put together all of the pieces, the full picture of how people get sick from water in the U.S. now, and it includes these respiratory and systemic illnesses that haven't been studied as much. So that's one thing that...that's unique about our study.

[Sarah Gregory] You already mentioned several challenges. Are there any other challenges to this research you'd like to tell us about?

[Sarah Collier] Sure. I mean, I think one of the...one of the hardest things was just kind of figuring out what a manageable research question was. You know, it's....figuring out how much waterborne disease there is in the U.S., it's just a really wide question. And so we had to go through a little bit of a process of figuring out, you know, ideally we would like to sort of include all of these things. But what's possible, you know? What do we have adequate data to look at and how can we make estimates that are useful and, you know, grounded and solid data with existing data sources? And so, one of the things that really stood out to us was how hard it was to get information on these diseases like NTM infections or *Pseudomonas* where there isn't dedicated disease surveillance. And so for us that really underscored the importance of using a flexible approach where we could incorporate lots of different data sources to come up with, with estimates that are informative.

[Sarah Gregory] What to you are the most important issues of your study that you found?

[Sarah Collier] For me, the most important issue that we found was the serious health impacts of the germs that are found in biofilm. And so, you know, as I've mentioned despite being responsible for only a small percentage of the illnesses, when people do get sick from these germs the health outcomes can be really severe. So we saw, you know, lots of hospitalizations and deaths from these diseases. And that's not a thing that we see from, you know....we certainly didn't see deaths from...from cholera or from typhoid in the way that you would have at the beginning of the 20th century. You know, obviously because we...we've developed effective prevention for...for that sort of waterborne illness. But this to us is sort of the new frontier, the area where we really need to kind of figure out better ways to prevent waterborne disease.

[Sarah Gregory] So what can public health do? Are there ways to deal with this? To stop or slow the transmission of these new, old, emerging pathogens?

[Sarah Collier] Sure. I mean, there's lots of...lots of things that we can do. We can certainly work to better understand how to control and prevent these pathogens. We could increase surveillance (having dedicated disease surveillance for some of these germs would be quite helpful). We can, you know, continue to do research and analysis. And we can also work on creating best practices for waterborne disease prevention. So some of these biofilm-associated germs...you know, obviously it's sort of a really complicated issue and it involves complicated plumbing systems or, you know, recreational water venues. And so these are things that really benefit from sort of bringing together, you know, the latest research and helping building managers or pool managers create a plan so that...so that they can prevent these diseases. And so to do all of this, we started the process of working with policymakers, industry partners, building managers, lots of other stakeholders to kind of...sort of build some momentum to start developing ways to prevent the disease that we're seeing more effectively.

[Sarah Gregory] And how about individually? I know you mentioned some things about what not to do swimming-related, but what are other kinds of things people can do to protect themselves? Like particularly in your house? I've been hearing more and more lately like if you have pipes like I do (I have a spare bathroom I never use), should I be running the water every few days just to clear things out or…? Give us some advice here.

[Sarah Collier] That's such a great question. I'm so glad you asked. We actually have a new webpage that kind of lists some of the things that people can do to prevent waterborne germs in their home. And so if you Google 'waterborne germs at home,' it should come right up. But some of the things that people can do include...you know, as you were mentioning, you can sort of flush your faucets and showerheads. So like if you have a guest bedroom where…or bathroom where things, you know, the water hasn't run in a while, you can kind of open the faucet and let it run for a few minutes just to kind of clear out what might have accumulated.

And then another thing that you can do is follow the manufacturer's instructions for devices that use water, like humidifiers or folks who use CPAP machines. And so you can clean and disinfect and maintain all of those devices in the way that the manufacturer recommends. And you could also...you know, one other thing that I think people might not think of is you can sign up to receive alerts from your water utilities (you know, what's happening with your water) and making sure to get in touch with your utility if you notice a change in water pressure or water color. And then for people who get water from a private well, it's really important to maintain that well and have the water tested at least once a year.

[Sarah Gregory] What about refrigerator filter, water filter lines? I wonder about that, you know? You change the filter in the refrigerator, but what about the line? I mean, is it okay if this is used regularly? I was thinking about that the other day.

[Sarah Collier] Good! So that's a great question. I have never thought about that. You're talking about the line that goes from...you know, from the plumbing to the filter?

[Sarah Gregory] Right. Or from the filter into your glass. Yeah, that line. Either one or both.

[Sarah Collier] Yeah. I mean, I think, you know....I think that people might not realize about their refrigerator filter. And, you know, I for one am certainly guilty of not changing mine (my filter) as often as I ought to. But...but a thing that folks might not realize is that those filters are there really to sort of improve the taste of your water. Most filters that are in refrigerators aren't

actually capable of removing germs from the water. And so it's just there kind of to enhance the...the taste. It takes out a little bit of the chlorine. Maybe, you know, if you have any iron in your water, it will take that out maybe and it just sort of makes it taste a little bit better.

So, you know, really when you're thinking about safe drinking water, that's what comes either from your...your private well or from your utility. And that's why, you know, it's so important that folks have safe drinking water. And I think that's one of the...the reasons why so much has been invested in building these drinking water systems in the past.

[Sarah Gregory] Well, I've got to say that makes me really sad to hear that that filter isn't actually protecting me from all the things it lists that it says it's protecting me from.

[Sarah Collier] I'm sorry, Sarah. Have I ruined swimming and also drinking water from your refrigerator? I apologize.

[Sarah Gregory] It's not just you. Yeah…my daughter from the time…she was an avid swimmer when she was tiny, but you couldn't get her to go into a lake. And I was like, "Oh no, no. Lakes are wonderful, they're safe." Now I'm like, "Oh, she was so right."

Are there any actions or further surveillance or research that you would like to see done?

[Sarah Collier] Yes. We're in the initial stages of our follow-up analysis. And, you know, what we're planning on doing is creating more detailed estimates of exactly how much disease can be linked to drinking water, to recreational water, and then to other types of water. And having these data should be really helpful as we work to better understand the...the best ways to control and prevent waterborne germs.

[Sarah Gregory] Tell us about yourself. Where did you grow up, what you studied and how you ended up at CDC?

[Sarah Collier] Sure. I grew in Ohio. I'm a proud Kalamazoo College graduate. And I came to public health because I wanted to make a difference in people's lives. I started out working in the birth defects area and then came to waterborne.

[Sarah Gregory] So you studied public health as for your....not undergraduate degree? What did you study for your undergraduate degree?

[Sarah Collier] My undergraduate degree was in chemistry, and then I actually worked as a…as a chemist at a pharmaceutical company for a few years after I graduated before...before going to public health school for my master's degree.

[Sarah Gregory] Well, tell us about your work at CDC and what you enjoy most about that?

[Sarah Collier] Oh sure. I have a great job. I get to do all sorts of data analysis with the waterborne group, and I do a lot of teaching and mentoring to new epidemiologists. And I've been working on waterborne disease for more than 10 years now, and I just love working on a topic that touches everyone's life in one way or the other.

[Sarah Gregory] Well I've got to say it's certainly, as I said at the beginning, scary but so important. What do you enjoy doing in your personal time?

[Sarah Collier] Well Sarah, these days I spend most of my time chasing around after my two young children. But I have been working on improving my baking skills, and my latest project has been perfecting pie crust. So, some progress in that area, I'm happy to report.

[Sarah Gregory] Pie crust, that's great. My daughter makes puff pastry from scratch. She's the only person I've ever seen in my life do it. It's an arduous....

[Sarah Collier] Oh my gosh.

[Sarah Gregory] Yeah, it just pains me just watch her do it.

[Sarah Collier] That is impressive.

[Sarah Gregory] It's the only real baking she does. I don't know...well, it's a long story...never mind.

[Sarah Gregory] Well thank you for taking the time to talk with me today, Sarah.

[Sarah Collier] Oh Sarah, this has been delightful. Thank you so much for the opportunity to chat with you. I really appreciated it.

[Sarah Gregory] And thanks for joining me out there. You can read the January 2021 article, Estimate of Burden and Direct Healthcare Cost of Infectious Waterborne Disease in the United States, online at cdc.gov/eid.

I'm Sarah Gregory for *Emerging Infectious Diseases*.

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