Beth

My name is Beth and I got caught up in a salmonella outbreak. I was volunteering on a tall ship and usually in exchange for volunteering you get your meals for the weekend and a place to sleep and hang out with the crew at the festival and all of that. So we'd been working the festival for a couple of days and spent all Saturday out in the sun all day, grabbed dinner real quick, hung out with my friends, hopped a couple of bars in Cleveland, evening out on the town. And the next morning got up, did the same thing over again, ate breakfast, I was out working in the head rig out in the sun all morning and again, it's another hot day but nothing out of the ordinary. When we took a break for lunch I noticed that I was really feeling just hot and tired and dehydrated. I sat down in the shade, I grabbed a water bottle, drank a bunch of water. And I just assumed I'd been out in the sun too long.

The festival ended that day, I was supposed to get a ride back to my car so I could go home. The woman that was supposed to give me a ride to my car wasn't there because she had actually taken a couple of my crewmates to urgent care, found out later that they were kind of feeling the same thing. They were dehydrated, some of them had upset stomachs. I eventually got a ride back to my car and headed home. It's about a 45 minute drive from downtown Cleveland to where I was living at the time. And as I'm driving all of a sudden it hits me just like stomach cramps, stomach pain. I really felt like I had to fart. I almost made it that last couple of miles, well some parts can't be trusted. So I got home, I had actually pooped my pants a little bit and so I just took off my clothes, threw them in the washing machine and started a load to wash, took a shower, put on pajamas, and went to bed.

Woke up a couple times in the middle of the night again with just an urgent need to go to the bathroom, just watery diarrhea every time. Whatever was inside of my intestines was just on the fast track out. And that's how I spent Sunday night, that's how I spent Monday, and as I recall that's how I spent Tuesday too. I mean I tried to eat bland food like Cheerios or instant mashed potatoes but every time I put something in my mouth, it was just on the fast track, clear through. I started getting messages from some of my friends who were on the ship still and it wasn't just me. At first it was 8 or 10 of us and then 20 of us and then all of a sudden almost 40 of us were sick and not getting better. Probably Tuesday I stopped trying to eat. I'm like I'll just let my entire digestive system empty out, reset itself, and we'll try food again in a day or two. That didn't fix the illness but it did let me control my bowels well enough that I could actually go to urgent care.

So I did that. They collected a sample and sent it to the lab and I went back home and lived on Gatorade the next couple of days. Urgent care called me back and they're like, Ooh you have salmonella, it should resolve itself, if not follow up with your primary care doctor.' And that's really all they said about it. But a week into this I still can't eat solid food. So finally 8.5 days later I finally got in to see my primary care physician and she walked into the exam room, first thing she says is you look terrible. And the next question she asked me was did you finish your antibiotics? And I said what antibiotics? So it turns out that the lab results from urgent care had actually said you should treat this patient with this antibiotic. Urgent care never prescribed that. So my doctor started me on the antibiotics, four days later all of a sudden I can eat food again. It was a minor miracle.

But in that time, it was about 10 or 11 days between when I got sick and when I started feeling better, I dropped about 16 lbs. That took me from being a healthy weight to being underweight. And at the same time this was happening to all of my crewmates too. So we knew that something had gone on in the ship that weekend. When the health department actually started doing surveys and talking to all the people who were and were not sick, we figured out that the people that were sick were not vegetarians and they'd eaten dinner onboard the ship on Saturday night. Saturday dinner was Mexican casserole, so there was a version with chicken in it and there was a version that didn't have chicken in it.

	An interview with one of the guys that helped in the galley, he says he thinks that chicken had been cooked about six days earlier and it was put into a wood stove after dinner one night as the stove cooled off. So the cook who has to start the fire the next morning for breakfast and finds room temperature chicken and he throws in the refrigerator. And that Saturday night it ended up in that casserole. They also took a look around the equipment and took a lot of measurements of how hot the wood stove got, how cold the refrigerator was, how cold the freezer was, things like that. And one of the things they discovered is there actually was not a food thermometer onboard.
	One of the things about these ships is they have a black water tank and so whenever you flush a toilet on the ship, it actually doesn't flush like a toilet, you actually pump the wastewater into the black water tank, that tank gets emptied basically with a septic hauler truck, so those big tank trucks that have the vacuum pumps. So as soon as the ship got back to Erie, they scheduled that truck to come in and empty the black water tank because so many people had been using the heads that the black water tank was full. So first thing on Monday morning, his first stop of the day was the ship. He pulls in, hooks up to all the connections so he can suck the poop out. When he emptied the truck the day before he hadn't flipped the pump from pumping the blackwater out of his truck to sucking it into his truck. So what he actually did was he pushed a bunch of air into the black water tank which pushed salmonella-contaminated poo water up through the vent and all over the place where most of the crew sleeps. And they sanitized what they could but several people got caught that way too. So we actually have a little secondary outbreak because the vac truck was set to blow, not suck.
	At the end of it all. I believe there were 37 of us in the outbreak, it was a large enough percentage of the crew that the ship actually had to miss some of our contracted sales and events. But it managed to take a bunch of young healthy people and pretty much ruined an entire summer for us. Even though you started feeling better because you didn't have uncontrolled diarrhea anymore, for some of us it was months before you could just eat whatever you wanted without thinking about it. And then a lot of us still to this day a decade later don't eat chicken. And several of us have sworn off Gatorade too. Just both of those things are things that remind us of that awful week that we all spent not being able to do anything more than 5 ft away from a toilet and that was enough to lead to some regulatory changes in that community. And that's my story.
TPWKY	(This Podcast Will Kill You intro theme)
Erin Allmann Updyke	Oh my.
Erin Welsh	Oh my gosh. The number of times that I went, 'What?'
Erin Allmann Updyke	Right.
Erin Welsh	Are you kidding me?
Erin Allmann Updyke	Like I'm sorry, what?
Erin Welsh	That is one of the most outrageous stories. The old chicken, I can't, I cannot.
Erin Allmann Updyke	I don't know that I'm ever going to be able to eat chicken again.
Erin Welsh	I don't know that I'm going to be able to eat so many things again. Well thank you Beth so much for sharing your story. Oh my gosh, what an unbelievable, horrible experience.

Erin Allmann Updyke	Yeah.
Erin Welsh	Hi, I'm Erin Welsh.
Erin Allmann Updyke	And I'm Erin Allmann Updyke.
Erin Welsh	And this is This Podcast Will Kill You.
Erin Allmann Updyke	Welcome, we're talking about poop today.
Erin Welsh	We are. I love these days, I truly do.
Erin Allmann Updyke	Me too! We talk about poop in my house a lot lately and so this is just like another day.
Erin Welsh	I feel like it's an important thing to talk about.
Erin Allmann Updyke	It is.
Erin Welsh	And people get real squeamish about it but literally every person produces fecal waste.
Erin Allmann Updyke	Yeah. Everybody poops.
Erin Welsh	Everyone poops.
Erin Allmann Updyke	It's important. We have books about it.
Erin Welsh	Yeah. I guess we're not going to get that much into it.
Erin Allmann Updyke	Yeah, we're not going to Bristol Stool Scale it over here.
Erin Welsh	Okay, adding that to my things to google later list.
Erin Allmann Updyke	We can post a picture of it. Anyways.
Erin Welsh	Anyways. Yeah, this is going to be an interesting episode. So this is not our first salmonella episode.
Erin Allmann Updyke	No, it isn't. It isn't. Yeah.
Erin Welsh	But the last time we did salmonella we did typhoid.
Erin Allmann Updyke	Which is different.
Erin Welsh	Very different and there's a lot of complexity in salmonella and a lot of diversity in salmonella. And it's going to be interesting.
Erin Allmann Updyke	Yeah, it definitely is.

Erin Welsh	And another thing that's going to be very interesting is that in this episode we also get to learn how you determine things like the difference between the salmonella that gives you typhoid vs a slightly maybe less scary salmonella serovar.
Erin Allmann Updyke	Yeah. We are so excited to be joined later on in this episode by Sara Zaucha who is a medical laboratory scientist that's going to give us a behind the scenes look at this fascinating and so important career. Like what is medical laboratory science? We've never talked about it on this podcast. So we'll talk about it today and we'll talk about how you choose which tests to run on various samples and what are some of the strangest samples that have shown up in the lab. But we'll get to all of those questions and more later on in the episode.
Erin Welsh	I am so excited. It's gonna be so much fun.
Erin Allmann Updyke	Yeah, it will be. But first...
Erin Welsh	Is it time for quarantinis?
Erin Allmann Updyke	For quarantinis? I think so. What are we drinking today, Erin?
Erin Welsh	We're drinking The Chicken Or The Egg? Question mark.
Erin Allmann Updyke	Get it? Because they could both give you salmonella.
Erin Welsh	Yeah. Along with many other things.
Erin Allmann Updyke	Yeah, yeah.
Erin Welsh	What is in The Chicken Or The Egg?
Erin Allmann Updyke	It's a very tasty concoction without any chicken or eggs in it.
Erin Welsh	Yep, yep. We decided against an egg white foam for this one.
Erin Allmann Updyke	Considered and discarded. But it has gin and blueberry syrup, lemon juice, some club soda, a little fizz for you. It's fantastic.
Erin Welsh	And if you want to have a foam, there are many different foaming alternatives. One of them is the water from chickpeas, aquafaba.
Erin Allmann Updyke	Aquafaba.
Erin Welsh	You can turn it into a foam, a non egg white foam topper for your cocktail.
Erin Allmann Updyke	And I don't think that you can get salmonella from canned beans. Maybe just botulism.
Erin Welsh	Yeah, don't quote us on any of that.
Erin Allmann Updyke	Yeah. I don't know.

Erin Welsh	Any of this.
Erin Allmann Updyke	Moving on.
Erin Welsh	Moving on.
Erin Allmann Updyke	We'll post the full recipe for that quarantini and are non alcoholic placeborita on our website thispodcastwillkillyou.com and all of our social media channels.
Erin Welsh	We will. And on our website, I have a post-it note, check it out. You can find the sources for all of our episodes, you can find transcripts, you can find links to our bookshop.org affiliate account or our Goodreads list.
Erin Allmann Updyke	I'm loving your dramatic positives here, Erin.
Erin Welsh	You can find music by Bloodmobile, you can find links to our merch, our Patreon.
Erin Allmann Updyke	Can't read your own handwriting?
Erin Welsh	I can't. I cannot read my own handwriting. And alcohol-free episodes. That'll do it.
Erin Allmann Updyke	Fantastic. Well done. Well shall we get into this, Erin?
Erin Welsh	Let's do it, I'm excited about it.
Erin Allmann Updyke	Me too. We'll take a quick break first.
TPWKY	(transition theme)
Erin Allmann Updyke	Like you said Erin, we've already become somewhat familiar with the genus Salmonella during our typhoid fever episode. Today we're going to focus on all of the other serovars of Salmonella enterica. So you may or may not, listeners and Erin, remember from our typhoid episode that typhoid fever is caused by a very, very specific bacterium. It's Salmonella enterica subspecies enterica serovar Typhi. Okay?
Erin Welsh	Oh I forgot about the subspecies part of it.
Erin Allmann Updyke	Yeah, exactly. And I also mentioned during that episode that there's another serovar Paratyphi and there's a couple different versions of that. And together those serovars cause what are known as enteric fevers or the typhoid fevers.
Erin Welsh	Okay.
Erin Allmann Updyke	So let's re-familiarize ourselves with salmonella and talk about all of the rest of them, shall we?
Erin Welsh	I'm excited, let's do it.

Erin Allmann Updyke	Let's. So salmonella enterica is a gram-negative facultatively intracellular anaerobe which means it can live and grow both inside and outside ourselves and both with or without the presence of oxygen. So it's quite versatile I guess. And it is present worldwide. It's absolutely everywhere. And today we're focusing on all of the non enteric fever-causing serovars. These are often called NTS, non typhoid salmonella. So there are over 2500 serovars of Salmonella enterica that are in six different subspecies.
Erin Welsh	Okay, so quick question.
Erin Allmann Updyke	Oh gosh.
Erin Welsh	And I don't know if we covered this on typhoid. What makes a serovar a serovar?
Erin Allmann Updyke	I knew that you were going to ask that and I still don't really know.
Erin Welsh	Did I ask that on typhoid?
Erin Allmann Updyke	You might have. I can't remember. I still don't fully understand because it gets into the very confusing genetics of bacterial species and how you define a species and how you define a subspecies. I don't know the answer. But we can at least narrow it down a little further.
Erin Welsh	Okay.
Erin Allmann Updyke	Because of those six different subspecies of Salmonella enterica, we're focusing on Salmonella enterica subspecies enterica. So all of the serovars that cause disease in humans and other animals are in this very specific subspecies and there are over 1500 different serovars just in this subspecies alone.
Erin Welsh	Yeah, wow.
Erin Allmann Updyke	Yeah. Basically all of these different serovars have differences between them obviously that lead for them to have differential host specificity. So some of these serovars infect and cause illness in a really wide range of host species and others have a relatively narrow host range, like for example Typhi, right, which really only causes disease in humans. But luckily for what we're talking about today, most of the non typhoid subspecies, the pathogenic ones, cause pretty similar disease. They cause enterocolitis or diarrhea. So that's why they often get lumped together as the non typhoid salmonella group. They definitely have a range in their severity and like I said their host specificity. So some might really only cause disease in birds or in reptiles and only rarely in humans where others are much more common in humans, etc.
	And they can range in their severity and they can also differ in their susceptibility to antibiotics for a number of different reasons we'll get into a little more later. But an important thing to keep in mind is that when characteristics that make a particular serovar more invasive or more likely to cause an invasive disease, a more serious disease, combined with characteristics that confer antibiotic resistance, those two things combined can make for a pretty dangerous serovar.
Erin Welsh	Yeah.
Erin Allmann Updyke	Yeah. Okay. So let's get into how we get this, shall we? I think everybody knows at this point.
Erin Welsh	Yeah.

Erin Allmann Updyke	Just like typhoid, other strains of Salmonella enterica, I might refer to them as just NTS or salmonella.
Erin Welsh	I say salmonella throughout, I think the whole time. Yeah.
Erin Allmann Updyke	Cool, cool. These are transmitted primarily fecal-oral in some capacity. Poop is where these bacteria come from and poop has to somehow make it into your mouth. Salmonella is really a gut pathogen, it's found as a commensal organism in the guts of a lot of different animals. So salmonella can make its way into the soil or the water wherever there is fecal contamination. But even if they're naturally in the gut of an animal, that doesn't mean that they should be in anywhere that they would come into contact with the food supply.
Erin Welsh	Right.
Erin Allmann Updyke	Okay, they're in the gut, they shouldn't be in the breast, they shouldn't be in the meat, they shouldn't be in the feathers. They shouldn't be anywhere else except for in the gut.
Erin Welsh	Right.
Erin Allmann Updyke	Yeah. And also like Salmonella typhi that we talked about, the other serovars of salmonella do tend to require a relatively large infectious dose upwards of 50,000 bacteria in order to establish an infection.
Erin Welsh	That's a lot.
Erin Allmann Updyke	It is a lot. But these bacteria can grow to be in really high numbers as we'll talk about in just a second. So when you get exposed to a pathogenic serovar of salmonella, you eat it right, on your chicken casserole or whatever. It travels through your stomach, through your intestines and generally establishes an infection in the terminal ileum which is the last bit of your small intestine or in your colon, the large intestine. Those are the two areas that salmonella likes. Asterisk, I'm talking about human infection, I know nothing about the guts of other animals.
Erin Welsh	Why does it like those areas?
Erin Allmann Updyke	I think that's just where it makes a great home in the epithelium.
Erin Welsh	Okay.
Erin Allmann Updyke	The epithelium is different throughout your whole rest of your gut and your small intestine prior to that has a lot of villi and all these little things that I don't know exactly why, but that's not where salmonella likes to make its home.
Erin Welsh	Okay.

Erin Allmann Updyke	Now once it's there they sort of grab onto that epithelium and they have a number of different virulence factors that what they do is induce a huge amount of inflammation, especially neutrophils which are often one of our first responders, one of our first white blood cells to rush into the scene. And they induce a ton of this. So you have tons and tons of neutrophils and other inflammatory cells, cytokines rushing to the area. And this all starts to happen within 1-3 hours of an infection, you see massive amounts of inflammation coming in to try and fight off these bacteria. We start making a whole bunch of proteins, we start secreting things to try and fend off these bacteria, and then within a few more hours is when the diarrhea starts.
Erin Welsh	Okay.
Erin Allmann Updyke	So symptoms start within 6-12 hours after exposure but after the development of this intense amount of inflammation.
Erin Welsh	Right.
Erin Allmann Updyke	So typically the symptoms are a pretty acute onset of really painful crampy, crampy abdominal pain and watery diarrhea. Sometimes this diarrhea can be bloody, especially more common in kids who tend to have even more severe inflammation. And then it's also not uncommon to have a lot of nausea and vomiting because your whole colon and that last part of your small intestine are just full of inflammation and makes your whole guts really angry.
Erin Welsh	So your body is just like get everything out of me now.
Erin Allmann Updyke	Exactly. And the good news is that without any treatment whatsoever, salmonella enterocolitis, salmonella-related diarrhea tends to be a self-limited infection that does clear up over the course of about a week, which is a really long time to be having massive diarrhea and nausea and vomiting.
Erin Welsh	Right. And not being able to keep anything down.
Erin Allmann Updyke	Yeah. So as long as you can keep something down, as long as you can stay hydrated and avoid electrolyte imbalances from this diarrhea, then you're going to be okay. And in general antibiotics are actually not recommended. The CDC, the World Health Organization, it's generally agreed upon that for this type of self-limited diarrhea, you generally don't give antibiotics and the only times that you do are if there are specific risk factors that make you think that this is likely to become an invasive infection or you have very high risk of it just being a really severe diarrhea, like in our firsthand account. If you're not keeping anything down then of course something is wrong. Or if you're very, very young or very elderly or immunocompromised, especially with something like HIV.
	And one of the reasons that it's generally recommended not to use antibiotics in the setting of diarrheal disease is that antibiotic administration in some cases can actually prolong the illness and it can prolong the shedding of the infectious bacteria in the stool, which I find absolutely fascinating. But now the question of course is how often does this become a more severe infection? And by more severe what I mean is that while in general these salmonella enterocolitis infections are just limited to this diarrhea, if these bacteria enter through the wall of your colon or your small intestine and make it into your bloodstream, they can cause a systemic infection, right. And that can be really severe, just like typhoid.
Erin Welsh	What does that systemic infection look like?
Erin Allmann Updyke	Great question, Erin. It looks a lot like typhoid or enteric fever.

Erin Welsh	Okay.
Erin Allmann Updyke	It can be a really, really high fever, you can see enlargement of the liver and the spleen as the bacteria travel there and begin to replicate within our white blood cells, it can even invade the lungs in some cases, it can cause respiratory symptoms. If these bacteria traveled to the heart and infect the heart or our large arteries like our aorta it can cause endocarditis, that's inflammation of the heart or endarteritis, that's inflammation of our arteries. This can very quickly become a systemic bacteremia, so people can then go into shock, they can get very sick very quickly. And what's interesting is that often people who end up with invasive salmonella that's not typhoid tend to not really have as much of the diarrheal type symptoms.
Erin Welsh	At the beginning.
Erin Allmann Updyke	Throughout their infection.
Erin Welsh	Interesting.
Erin Allmann Updyke	Yeah.
Erin Welsh	Because the body is not just shedding that as much or what?
Erin Allmann Updyke	Yeah, I don't fully know and I really tried to get a handle on first of all how often does this happen? And from what I can tell, it's actually way more common than I realized because the papers that I found that cited an actual number said that it could be up to 5% of the time.
Erin Welsh	Wow.
Erin Allmann Updyke	Which seems really, really high.
Erin Welsh	Right.
Erin Allmann Updyke	And the mortality rate in these invasive infections can be as high as 20-25%.
Erin Welsh	So this is interesting because I think it calls into question two things in my mind. Number one is that the 5%, how accurate are the estimates that we have of salmonella cases, number one?
Erin Allmann Updyke	Exactly, yeah.
Erin Welsh	Number two, I think that this makes me ask the question about I understand that it's sometimes not recommended to give antibiotics for salmonella but sometimes it is. How do you know? That line seems like suddenly you cross it and this could be really bad, really fast.
Erin Allmann Updyke	Yeah. And so what I don't know the answer to, what I didn't quite see in the discussion of the invasive non typhoidal salmonella infections is whether people tend to have a salmonella enterocolitis, salmonella-related diarrhea and then progress to invasive disease or if these are kind of two different disease processes caused by the same infection or caused by the same bacterium rather.
Erin Welsh	Okay.

Erin Allmann Updyke	And it kind of seems like it's two separate disease processes.
Erin Welsh	That's very interesting.
Erin Allmann Updyke	Yeah. But that's not to say that people can't become severely ill from quote unquote "just diarrhea" right. You can end up with electrolyte imbalances, you can end up with weight loss, you can end up very, very sick even from just diarrhea. So it's not like nobody should get antibiotics.
Erin Welsh	Right.
Erin Allmann Updyke	It's just a matter of risk stratifying who's more likely to either have a really hard time with it and not be able to tolerate food and just have a really hard time with the infection and who is likely to go on to potentially have a risk for invasive disease.
Erin Welsh	And so beyond people who are immunocompromised, are there other risk factors for invasive disease?
Erin Allmann Updyke	Being very young, so under 5, being very old, so over 70 or 75. And interestingly... Okay, let me back up for a second. Remember how I said that salmonella causes a lot of inflammation in your gut?
Erin Welsh	Yeah.
Erin Allmann Updyke	So this is something that's totally different that these non typhoidal salmonella is do that typhoid doesn't do. So typhoid doesn't cause a lot of inflammation in your gut. All of the other serovars that cause infection in humans do. And so one of the things that we have seen is that there are inherited deficiencies in certain inflammatory systems, specifically if anyone cares it's certain interleukin systems, IL-12 and IL-23, that people with deficiencies in these systems are at much higher risk of invasive non typhoid salmonella infection and they're more resistant to typhoid infections.
Erin Welsh	That is fascinating.
Erin Allmann Updyke	Yeah. The other thing is that salmonella that we're talking about today, these serovars seem to be specifically adapted to survive in a highly inflamed environment. So it's thought that this actually lends it a competitive advantage to establishing an infection in our guts, right. They get into our guts, they stimulate a massive amount of inflammation that makes it harder for a lot of our normal gut flora to thrive, then ensues massive diarrhea wiping out all of their competitors, and then they can kind of flourish and take over.
Erin Welsh	I really enjoy thinking about the ecology of microbial interactions inside someone.
Erin Allmann Updyke	I know.
Erin Welsh	It's so interesting.
Erin Allmann Updyke	Yeah. And I wonder too how much could somebody's individual microbiome put them at risk or at less risk for not only having an infection but having a severe infection or an invasive infection?

Erin Welsh	Yeah, it's really interesting to think about. But also what about the people who get infected and then don't have any inflammation and the salmonella just hangs out in there? Is that what's going on with carriers?
Erin Allmann Updyke	So non typhoidal salmonella, the kind that causes disease, we don't tend to see carriers in humans at least the way that we see with typhoid.
Erin Welsh	Okay.
Erin Allmann Updyke	So people tend to shed for a month after infection, there's still salmonella there that they're pooping out and in kids it can be as long as 7 or 8 weeks which is still a fairly long time to be pooping out salmonella. But we don't see like we do in typhoid this carrier state of a year or 2 years or 10 years or your whole life which I think is really interesting and it kind of points to this really is a pathogen in humans and not a commensal.
Erin Welsh	Yeah.
Erin Allmann Updyke	Yeah. That's the biology, Erin.
Erin Welsh	Wow.
Erin Allmann Updyke	I mean that was kind of short.
Erin Welsh	How much do we know about... I mean this is probably way too much of a rabbit hole question.
Erin Allmann Updyke	Okay.
Erin Welsh	But how much do we know about different serovars and the frequency of them or the intensity of disease that they cause or which ones to keep an eye out for, which ones are associated with which food products? All those things.
Erin Allmann Updyke	It's a very good question. So I read a paper that was really diving into that kind of like the specific epidemiology of all of the different serovars. It's hard because there's like 1500 which is so many.
Erin Welsh	Yeah. I feel like we could spend the entire episode just listing the names of them and then we'd be like okay.
Erin Allmann Updyke	The end.
Erin Welsh	That's a two hour episode.
Erin Allmann Updyke	Yeah. So there are a few that kind of stick out as being the most common worldwide and therefore I guess causing the most infection, not necessarily the most severe infection but just the most common ones. Those are Enteritidis, I'm hoping I'm pronouncing that close to right, Typhimurium of which there are Typhimurium A and B, there's multiple kind of Typhimuriums.
Erin Welsh	Of course.
Erin Allmann Updyke	Newport, Javiana, and Infantis. Those are some of the top five.

Erin Welsh	There's also a Kentucky one that I saw.
Erin Allmann Updyke	There is a Kentucky one, yeah. Place name, love it. There are so many serovars and in general they do have different pathogenicity. So all of the different serovars that cause disease in humans and other animals have some similar virulence factors that tend to be clustered on what are often called these pathogenicity islands which I think is a hilarious term. But it basically is just in their genome they have these little clusters of genes that encode a number of different things like flagella and capsules and type three transport systems that blah, blah, blah, help them to infect us. But there are also a number of different plasmids that they have that encode not only other virulence factors that might make them more likely to say be able to infect a bird or your bearded dragon or your frog and other ones that might make it easier to infect humans. But also a lot of these plasmids are what end up conferring antibiotic resistance which of course is a huge problem when it comes to salmonella and I'll talk a lot more about it at the end of this episode. But that's kind of what happens next.
Erin Welsh	Yeah, yeah.
Erin Allmann Updyke	Because even though we don't use antibiotics to treat all human infections, you have to have antibiotics that work to be able to treat the severe infections.
Erin Welsh	Yeah.
Erin Allmann Updyke	Yep. So Erin, can you tell me a little bit about this bug? I can. Let's take a quick break and then we'll get started on that.
TPWKY	(transition theme)
Erin Welsh	Like we've talked about, we've covered salmonella before in the context of typhoid and even though I feel like that was a pretty big episode.
Erin Allmann Updyke	It was.
Erin Welsh	And we covered a lot of ground in that. There really isn't that much overlap between that history and the history of general salmonella food poisoning or at least in terms of what I decided to talk about today. And I have to say that I'm really excited about it because it is I think such a fascinating look into how food preparation and consumption has changed over the past 100 years or so and how food poisoning kind of grew as a concept during that time. But the thing that I am most thrilled to talk about is how salmonella was involved in the first act of bioterrorism in the US.
Erin Allmann Updyke	Stop it. What?
Erin Welsh	Yeah. I'm so glad you don't know anything about this because it's gonna be fun.
Erin Allmann Updyke	I know nothing about anything, Erin. I love it.

Erin Welsh	Okay. So let's get started. So in terms of evolutionary history stuff, the salmonella group that has been linked to food poisoning like we talked about is incredibly diverse and the number of serovars and all of that is just... I'm not going to go into the details about the origins of this or that serovar because there's just too much ground to cover. But I will say that understanding the evolutionary origins of certain serovars that are associated with food poisoning and which types of food poisoning, that's incredibly important in preventing outbreaks because that knowledge can influence control strategies.
	For instance, if one serovar is only present in the guts of diseased animals, animals that are actively showing that they are diseased, you might use a different strategy than if a serovar was a natural commensal of the guts of all cows are all pigs or something like that. And it can also help with identifying the source of contamination. So if you're dealing with a diseased animal only serovar and you find it in a bunch of meat, that could point towards fecal contamination in the meat processing aspect of it which is really bad. And really in a sense finding salmonella in any part of an animal product is bad but I also think that it might be dependent upon the serovar when you're like oh that is really alarming, how did it get all over here? Whereas there might be ones that you more commonly see.
Erin Allmann Updyke	Yeah. And especially because there are ones that infect different animals. So if you have one that's more common in chickens and it's all over your beef, how did it get there?
Erin Welsh	Right. What happened here?
Erin Allmann Updyke	Yeah.
Erin Welsh	Okay so salmonella food poisoning seems kind of ubiquitous nowadays and probably most people either know someone who has had it or has had it themselves. But has it always been this ubiquitous food poisoning presence, right? I mean probably. It seems kind of tricky to get estimates of the timing of when salmonella started infecting people based on molecular clock info but people have probably been getting sick with salmonella and other foodborne pathogens forever. And I think that this probably ramped up somewhat with the agricultural revolution. But even though the widespread practice of keeping livestock would have increased exposure to salmonella, the big outbreaks that we see today were still a ways away.
	Unlike in the typhoid episode where I talked about the Plague of Athens and the 400s BCE and the impact of typhoid on the residents of Jamestown in the 1600s, for more general salmonella food poisoning I'm going to jump ahead to the mid to late 1800s, so around the time germ theory was more or less established as a thing. By this point in history people had of course long recognized for hundreds of years that foods could make you sick with fever or diarrhea or vomiting. But before germ theory it seemed to generally be ascribed to chemical changes in the food as it decomposed or some element of rotting food specifically.
	It was around the early 1880s that people began to realize that food could look perfectly fine and unspoiled and smell fine but could contain microbes that would make you sick if you ate it. And one or rather many I guess of those microbes happened to be salmonella. In 1885 researchers Daniel Salmon - Sal-mon or Sam-on? I don't know. Because I'm realizing that we say sal-monella but not sam-onella. Anyway Daniel Salmon and Theobald Smith were the first to identify salmonella causing salmonellosis in pigs that were sick with hog-cholera. And they thought that this microbe that they had found was responsible for hog-cholera, which it wasn't, but they named it hog-cholera bacillus.

	In 1900 it and several other microbes were reclassified and renamed Salmonella in order of Salmon. But even though this taxonomy was a complete mess, the important thing was that there was now a name for these cases of food poisoning and it also kind of provided the ability to trace its source via microbiological techniques. Pretty soon after the first identification of Salmonella in those pigs in the 1880s, people began finding the bacteria in many different foods, especially pork, chicken, beef and milk, and also in people who fell ill after eating those foods right, making the link between food and illness. And this period marks a huge turning point in the history of food safety, not just because salmonella had been identified but also because it represents a shift in the way that people viewed foods that made you sick. So previously it had been specific foods themselves. Oh this one is spoiled, this one has undergone a chemical change.
	But the recognition of salmonella and other microbes as directly causing those illnesses meant that any food could be contaminated without appearing to be and more optimistically that those sources of contamination could mostly be eliminated through the way you handled the food. You could kill the bacteria through methods of cooking or preparation, especially heat. Food poisoning as a general term, like the term itself came into use around this time which I think is so interesting because it kind of represents the shift in thinking about microbes spoiling food rather than food just being spoiled on its own.
Erin Allmann Updyke	Yeah, I never thought about that.
Erin Welsh	Yeah. And I think this whole period also called for an infrastructure change in regulation of food safety, especially through testing, notification, and better food handling practices. But that was still a long way away and there was a lot left to be desired. Because as the global population continued to grow and people continue to leave the rural countrysides for cities, the way that people interacted with food increasingly changed. Food was traveling larger distances, refrigeration wasn't really necessarily a thing yet, and hand hygiene was far from universally practiced.
Erin Allmann Updyke	Yep.
Erin Welsh	As these things were going on, the rate of food poisoning just continued to increase, right. Our knowledge of this group of bacteria way outpaced our ability to do anything about it.
Erin Allmann Updyke	Yeah.
Erin Welsh	But it wasn't really until the first few decades of the 20th century that people begin to realize the true extent of just how prevalent these pathogens were. And that's simply because people weren't monitoring foodborne illnesses. The primary salmonella-related focus throughout the late 1800s and early 1900s was typhoid and so a lot of the efforts were centered more on improving water quality and identifying human carriers of the disease as we well remember from our typhoid episode. But salmonellosis kind of was just waiting for its moment to shine. In the first few decades of the 20th century, Salmonella seemed to be on the rise and this was shown to be the case by the 1930s or the 1940s which is around the time that several countries had adopted foodborne illness reporting systems.

	What these early reporting systems were finding was more and more salmonella. But was there an actual increase? Always an important question to ask. And it seems to be somewhat debated because screening tools weren't the greatest, although they did improve in the 1930s and 1940s when phage typing began to be used to distinguish among salmonella serovars. And so it's possible that one big part of the apparent increase in cases was due to improvements in screening or our increased ability to trace outbreaks or even that more mild illnesses like foodborne illnesses were finally coming into view as more deadly diseases were being treated or vaccinated against. But I also feel like it's hard to chalk all of the increase up to just those things.
	Because like I mentioned earlier, the way people were handling food and eating food was changing, especially during WWII and the years immediately after. So during WWII we saw a huge rise in communal feeding spots. Large numbers of people were being fed in canteens and cafeterias and so there was a greater potential for larger outbreaks rather than sporadic cases. And this communal feeding and rationing also led to people reheating food more often which when done improperly can of course lead to food poisoning. So there were more opportunities for a larger number of people to get sick if the salmonella was there. But was salmonella itself growing in its presence or prevalence? And that also seems likely. So let's consider things from the food production side.
Erin Allmann Updyke	Yeah.
Erin Welsh	Especially in the scaling up and the industrialization of many food products.
Erin Allmann Updyke	That's the key.
Erin Welsh	It is the key. So whereas previously people would mostly consume food that had been grown or produced in their near vicinity, even just within a town or city, the growth of cities and the demand for more food and a greater variety of food meant that every step along the way in food production, the operation had to expand, it had to grow larger and it had to become more specialized in a way, right. In the years after WWII, especially when wartime rationing restrictions were lifted, meat consumption increased in a big way. And to keep up with that, farming expanded and intensified. Small chicken ranches or dairy farms grew into or were largely replaced by huge industrial operations. And with bigger populations of livestock, salmonella could spread more easily and infect more animals and it would become much more difficult to control or identify. Not to mention that around the same time, post WWII, is when widespread antibiotic use started to come into play and antibiotic resistance was not far behind. And that also grew and grew and grew and grew and to be honest it's one of the most terrifying parts of this whole story. That's all I'm going to mention about it but yeah.
Erin Allmann Updyke	Yeah. Listen to our antibiotic resistance episode from season three for more.
Erin Welsh	Three, yeah.
Erin Allmann Updyke	Season three.
Erin Welsh	But another place where contamination became increasingly likely to occur, again thinking about sort of this chain of food production, is in slaughterhouses.
Erin Allmann Updyke	Yeah.

Erin Welsh	So slaughtering shifted from being mostly at or near the farms where these animals were raised to happening farther away because you needed to have more equipment to process more animals, you needed to have more specific equipment. It was difficult to be a jack of all trades as a farmer and make a living the way you used to, it became less and less feasible.
Erin Allmann Updyke	Right.
Erin Welsh	And so slaughtering began to be done mostly at these large slaughterhouses that processed many different types of meats in many different ways. So you can see how literally every step along the way of food production or preparation or consumption increased the potential for salmonella to spread. And in some cases these changes in practices led to some increase in virulence or difficulty in treating, like we talked about with antibiotic resistance. And also it's important to point out as I'm sure you will later on that salmonella was not and is not limited to just the pork or poultry or beef industries.
Erin Allmann Updyke	Right.
Erin Welsh	It's everywhere.
Erin Allmann Updyke	It's everywhere.
Erin Welsh	And an increase in salmonella in one area frequently leads to an increase in salmonella in all areas. The mid 20th century did see several new regulations put into place and testing had also become more refined but the cat was out of the bag. Sporadic cases or outbreaks of salmonellosis had just become kind of almost a regular thing, it wasn't that unexpected. So in September of 1984, when residents of a small community in Oregon began experiencing painful stomach cramps, diarrhea, nausea, fever, fatigue after eating at several restaurants in the area, local public health officials suspected salmonella was to blame naturally. And it was. Samples from several people who had sought care at hospitals in the area confirmed the presence of Salmonella Typhimurium which is like you said one of the most common causes of salmonellosis associated with the consumption of contaminated animal products. So by the end of that first week of cases, 13 of 28 employees at Shakey's Pizza, one of the restaurants suspected to be a source, had come down with food poisoning and dozens of customers had called the restaurant complaining that they had gotten sick after eating there. And that wasn't the only restaurant affected. By the time the outbreak was over at the end of September, nearly 1000 people had reported symptoms of food poisoning and 751 cases of salmonella had been confirmed.
Erin Allmann Updyke	That's a lot.
Erin Welsh	It's a lot. It was and I think remains the largest outbreak in Oregon's history. But fortunately this salmonella did seem to resolve for a lot of people pretty easily or pretty well or it was treatable with antibiotics. But people had missed work, they had these large medical bills, and their bodies had obviously been put through the wringer with this illness. And they were left with questions. What happened? Where did this come from? Why me? The big guns were called in to help the local public health department trace the source of the outbreak and EIS officers from the CDC arrived later that month. And they went around interviewing hundreds of patients and their families about what they had eaten, where, and when. And also they went to every restaurant in the area testing food, surfaces, and employees for trace of salmonella. They evaluated thermometers and ovens for any inconsistencies or faults. They tested cows, milk, septic tanks, city water, pond water, produce, literally everything they could think of for salmonella, expecting to find a common source linking all of these cases. The fact that the outbreak seemed tied to many different restaurants pointed towards a particular food item that was served at all of them but they couldn't pinpoint it, they couldn't find it.

Erin Allmann Updyke	What?
Erin Welsh	There was no single factor linking all of these cases. Which isn't to say that they didn't find salmonella because they did find it in a few places like in the coffee creamer at one restaurant and in the blue cheese dressing at another. But those items weren't eaten by everyone who had gotten sick and the blue cheese dressing was contaminated during its preparation, not before it got to the restaurant which pointed towards a human source. But no one person worked at all of the restaurants. As the investigation went on cases dwindled and leads dried up and the CDC was left with the unsatisfying conclusion that the outbreak was, I don't know, likely caused by employees at these different restaurants and a lot of them lived together or were roommates and so maybe that's what happened. And that's kind of how it goes sometimes with food poisoning outbreaks, there's no neat answer. But the people of Wasco County, Oregon would get their neat answer. They just had to wait about a year for it.
Erin Allmann Updyke	Oh my god, I'm loving this.
Erin Welsh	And when they got it it was not the answer that they were expecting although at least a few people had had their suspicions all along. The reason that the food poisoning investigation had such a hard time linking all the cases to one food or one person was because it was actually many foods poisoned by many people. People belonging to the Rajneesh, some say movement, some say cult. So there was one common source for the salmonella cases all along but the CDC investigators did not expect it to be intentional poisoning by a cult. Okay, so what? Why? What's happening?
Erin Allmann Updyke	Who? What? I'm sorry, this is a cult podcast now?
Erin Welsh	I know, I know. Let's get into it.
Erin Allmann Updyke	Okay.
Erin Welsh	And this is why I asked you whether you had seen Wild Wild Country, that documentary series.
Erin Allmann Updyke	No, I haven't.
Erin Welsh	It's so interesting. And everyone who's listening and hasn't seen it yet, um go check it out. And everyone who has already seen it and I suspect a great number of you out there have already seen it, watch it again or you this is just a refresher. So I don't know, I hope you enjoy it.
Erin Allmann Updyke	I'm excited.

Erin Welsh	Okay. So to get into the what and the why and the how of this massive salmonella poisoning, which this is like I said the first bioterrorism attack in the US, we have to go back to around 1981. That year a group of people from this religious movement, including its founder Bhagwan Shree Rajneesh moved to Wasco County, Oregon which is about 90 or so miles east of Portland, to a 64,000 acre ranch they had purchased. The group had left Poona, India for Oregon after a lot of political pressure and reports suggesting that the cult was basically a money-making scheme which exploited not only its wealthy members but also did other illegal things to make money. I don't know if it's been confirmed or not but they wanted out and they wanted to establish a utopia elsewhere. Ma Anand Sheela, the personal secretary and right hand Woman of the cult's leader Rajneesh, was charged with finding a place where they could build this utopia where the followers known as sannyasins or Rajneeshees could freely practice Rajneesh's teachings which involved a lot of love, beauty, guiltless sex, and capitalism. There was a store where you could become more enlightened by spending money.
Erin Allmann Updyke	Cool.
Erin Welsh	It's kind of genius. And so this is how she decided on this ranch, right. 64,000 acres, plenty of space to grow, beautiful land, all of that stuff. Their arrival was not really met with open arms by the people living in Wasco County, especially those living in the small town of Antelope. And when I say small, I mean like population a few dozen small.
Erin Allmann Updyke	Okay.
Erin Welsh	That was located really near the ranch. And tensions between the townspeople of Antelope and the ranch continued to mount as the Rajneeshees built up their community to essentially be a mini city complete with dozens of modular buildings and mobile homes and A frames, a 2.2 acre meeting hall, a 160 room hotel, a two block long shopping mall, a casino and a disco, a medical lab, a dam and a lake, water, sewage, and transportation systems, an airstrip for the five private jet planes and helicopter owned by the cult, new roads. I mean you get the picture.
Erin Allmann Updyke	Wow. They built a whole city.
Erin Welsh	A whole city. It was a massive undertaking. Yeah. And this happened within a very short timeframe, in just a matter of a couple of years which was terrifying for the people of Antelope who started to look for ways to kick these people out of the town or ideally out of the country. And when the legal way of doing things didn't look like it was going to work to get them gone, some open threats began to be made with a lot of gun carrying around town. Yeah. And the Rajneeshees, they met fire with fire. They began to stockpile weapons, make threats to the town people, and they also used the legal routes available to them. They ran for town council.
Erin Allmann Updyke	Oh okay.
Erin Welsh	And they won handedly because the Rajneeshees greatly outnumbered the other residents of Antelope.
Erin Allmann Updyke	Yeah.
Erin Welsh	This meant that the cult now controlled everything in the town, everything, the roads, the water, the police force, they renamed the town Rajneeshee. And this of course further escalated things because then residents of Wasco County and Antelope ramped up their fight to get rid of the cult. On both sides there was violence, there was threats of violence. It's a story of constantly mounting tensions where cause and effect is really difficult or almost impossible to disentangle.

Erin Allmann Updyke	Yeah.
Erin Welsh	And a big reason for this constantly mounting tension was at least in terms of the cult, Ma Anand Sheela. So Sheela, who was spokesperson for the cult and effectively its leader during Rajneesh's four year vow of public silence, she was determined to win, to just gain more power and that's what she viewed as her life's mission, this movement and making sure this movement had whatever it needed to grow and expand and any threat to the movement was a threat to her directly. So she announced that she wasn't going to stop at taking over Antelope. She had set her sights next on Wasco County, the entire county, after that Oregon, and then the world. The only problem was that the cult members who numbered like 2000-3000, estimates vary, they didn't have the numbers to outvote the other Wasco County residents which is around 20,000 at this time.
Erin Allmann Updyke	Okay.
Erin Welsh	But luckily Sheela had a strategy. She coordinated the bussing in of thousands of people who were experiencing homelessness into the ranch to then get them to register to vote so that in the next Wasco County election in the fall of 1984, they would have stronger representation. But that didn't work out as planned again with legal battles. At this point though Sheela's position was getting to be a bit tenuous within the cult and she felt increasingly threatened and desperate to not lose her status as the de facto cult leader. She had to win this. Registering thousands of recently arrived people to try to win an election didn't seem to be working out. But that's okay, Sheela had another plan.
Erin Allmann Updyke	Oh no.
Erin Welsh	In the spring of 1984, Sheela and one of her top lieutenants Ma Anand Puja, who was a nurse in charge of the Rajneesh Medical Corporation, they had a brainstorming session about ways they could ensure that they won the election. One of the ideas floated was poisoning people to make them too sick to vote. But make them sick with what? That was the question. Sheela and Puja began reading books like, I kid you not, 'How To Kill: Volumes I-IV'.
Erin Allmann Updyke	Stop.
Erin Welsh	And 'The Handbook of Poisons'. Which I'm sure that based on what we do for this podcast our google search history is also quite bizarre.
Erin Allmann Updyke	Yeah but still.
Erin Welsh	But still. And they also visited a local urologist to ask which poisons and bacteria would be difficult to trace but deadly. And they were like, 'Oh well we're worried about people poisoning the cult so we want to know what we should keep an eye out for.' And he was like salmonella. Kind of easy to trace but okay. It seems like they were more concerned about the logistics of it and how do we best do this. Sheela had tried to coordinate the assassinations of political enemies of the cult and she had also poisoned people who had wronged her within the cult.
Erin Allmann Updyke	Naturally.
Erin Welsh	Puja was apparently known by some in the cult as Nurse Mengele because of her obsession with using poisons and pathogens as a weapon, with one report of her trying to weaponize HIV.

Erin Allmann Updyke	I'm sorry, what?
Erin Welsh	I know. It's horrifying. And there's so much more to the story that's like this is just scratching the surface, it's kind of unbelievable. So at the ranch there grew to be increasing conflict between the Rajneeshees and these people that had been bussed in. And so Puja's and Sheela's solution was to tranquilize the people, the new arrivals, either with sneak injections or by putting it in the beer that they were given every day. But for their sicken the public to prevent voting scheme, they also toyed with the idea of hepatitis viruses, typhoid, and putting beavers for giardia or just dead rats and mice into the public water system, just dropping it in there to make everyone sick. But salmonella seemed the most promising, not to mention accessible. Because where do you get salmonella, right? You order it.
Erin Allmann Updyke	You can order it?
Erin Welsh	I don't know if regulations have changed but because back then they had a medical corporation and a lab, all they had to do was order samples from companies.
Erin Allmann Updyke	Yeah.
Erin Welsh	Salmonella Typhimurium wasn't the only one they ordered. They also got causative agents for typhoid, gonorrhea., tularemia, shigella, and others.
Erin Allmann Updyke	Yeah I mean you're supposed to have a medical lab that is biosafety licensed of a certain level to deal with certain pathogens and those are supposed to be inspected. However often to maintain their status. There's supposed to be checks and balances in place here.
Erin Welsh	Well but I think the thing is they had been inspected by the public health officials. Their operation, their medical lab operation was big. They had legit equipment and everything.
Erin Allmann Updyke	Yeah.
Erin Welsh	Which makes it all the more scary I think.
Erin Allmann Updyke	I know.
Erin Welsh	But to make sure that Salmonella Typhimurium was the one, they had to test it out of course. The perfect opportunity presented itself with a planned visit in late August 1984 by Judge William Hulse, Wasco County Executive and Raymond Matthew, Wasco County Commissioner. They got a flat tire during their inspection of the ranch and while changing the tire they were offered some cups of water which they drank.
Erin Allmann Updyke	Oh my goodness.
Erin Welsh	Within about eight hours they were both violently ill. And Hulse nearly died, he went to the hospital and it was touch and go.
Erin Allmann Updyke	Wow.
Erin Welsh	And the cause? Salmonella.
Erin Allmann Updyke	Salmonella.

Erin Welsh	So now we arrive at the big moment. The poisoning of Hulse and Matthew showed that those samples could make people sick but would it work on a big scale? For that a bunch of members from the cult dressed up in disguise, they put on wigs and they changed out their bright red clothes and robes for more neutral toned outfits and they went around to restaurants and grocery stores in The Dalles mostly, sprinkling salmonella on salad bars, in coffee creamers, in dressings, over produce departments, and so on. Like everywhere. They just literally seeded everything with Salmonella.
Erin Allmann Updyke	Okay, how did it come to light, Erin?
Erin Welsh	Okay. So at the time, like I said the CDC concluded that well we don't really know exactly what happened but we suspect it was this person. There were people who did suspect that it was the cult, it was the Rajneeshees that were behind it. But there was no apparent evidence at the time linking the Rajneeshees to the outbreak. The poisoning, which that was just sort of a dry run I guess because this was in September and the actual voting happened later on. And so when it came time to the actual election, there was as far as I'm aware no salmonella poisoning and the Rajneeshee candidates in this election lost by a landslide. There was a record 93% voter turnout.
Erin Allmann Updyke	Wow.
Erin Welsh	It's really high. Sheela's position I think with this loss continued to slip and her paranoia grew and on September 13th, 1985, which is about a year after that Salmonella attack began, Sheela and a few others fled to Europe. A few days later Rajneesh broke his four year vow of public silence. He came out on stage and was like I denounce Sheela and her allies, they betrayed my faith, they're responsible for all these criminal things, they're horrible people, they're no longer in the light, etc. She attempted murder of followers who challenged her authority, she mismanaged my money and left this commune $55 million in debt and so I have to sell my 90 Rolls Royces.
	She tried to poison my doctor and dentist, she did incredibly intensive wiretapping, experimented with different lethal poisons on mice to try to find ones that were untraceable, and had coordinated the salmonella attack. And so in the midst of all of this denouncing of Sheela, Rajneesh was like I demand a government investigation, this is on you now, you need to investigate what happened. And the investigation found glass vials containing salmonella bactrol discs that had been ordered from VWR Scientific. And sure enough that Salmonella was the same as the one that had made those hundreds of people sick in The Dalles. And Rajneesh of course denied knowing any of it. He was like I knew nothing.
Erin Allmann Updyke	Of course.
Erin Welsh	So was Sheela just a scapegoat for all of this? I mean she clearly was responsible for a lot and she clearly was completely without morals but yeah. So how does the story end? The story ends with a few of these key players getting some jail time, about four years, and had to pay some fines. So Sheela, if you are curious, now runs a couple of care homes in Switzerland for seniors and people with degenerative disorders. (laughs) Your face. I know.
Erin Allmann Updyke	Oh no. Fascinating, Erin. Erin!

Erin Welsh	I know. It's so interesting because I was trying to figure out what is the legacy of this bioterrorism attack? This was the first time when we were doing this episode that I had read about it and I was like what on earth? There's so much more to the story than I had any idea, this seems like it would have been huge news and of course it was in Oregon but from what I read it doesn't seem like it got a ton of national attention. And I think that part of the reason for that is because public health officials were like, 'Oh my gosh, this was so easy for them to do. We don't want people to know that this is possible. We don't want any copycats. This is disturbing.'
Erin Allmann Updyke	Oh dear.
Erin Welsh	And so as far as I could tell, it didn't really immediately result in any changes to regulations about who could order germs or for what purpose. I imagine and I hope that that has changed somewhat by this point.
Erin Allmann Updyke	Interesting.
Erin Welsh	In any case the 1984 Wasco County salmonella attack was not the last time that salmonella made headlines. There have been many unintentional outbreaks since including a huge one in Chicago from contamination at a milk processing plant and it led to 16,000 confirmed cases.
Erin Allmann Updyke	16,000 confirmed?
Erin Welsh	That's what it said in a news report I read, yeah.
Erin Allmann Updyke	Oh my god, that's gotta be a lot more than that actual cases. Ooh boy.
Erin Welsh	Yeah. And reports in the late 80s revealed the incredible extent to which salmonella is present on eggs, which was also I think the first time that food hygiene as it related to salmonella gained more widespread awareness. But I'm really curious Erin, what has happened in the years since? I know antibiotic resistance is an issue and reporting and tracing outbreaks is a little problematic. Can you bring me up to speed how many people get sick? What's the biggest problems? All that stuff.
Erin Allmann Updyke	I can't wait to. Let's take a break first.
TPWKY	(transition theme)
Erin Allmann Updyke	So I thought for this one I'd start as broad as possible and then dig down two more narrow. All right? That's my plan.
Erin Welsh	Okay, sure.
Erin Allmann Updyke	So globally if we just look at foodborne illness in general, the World Health Organization estimates over 600 million infections and 420,000 deaths associated with foodborne illness specifically. If we look just at the diarrheal foodborne infections, those cause an estimated 230,000 deaths worldwide, so over half. And salmonella is one of these principal agents that cause death among those foodborne diarrheal illnesses. So it's estimated if we now just look more specifically at salmonella that salmonella enteritis itself in 2017 is estimated to have caused over 95 million infections worldwide. And there's a really wide margin of error on that estimate.

Erin Welsh	Of course.
Erin Allmann Updyke	And over 50,000 deaths, again wide margin of error. If we now get even more specific and turn to invasive disease, so invasive salmonella, not typhoid salmonella, it's estimated that there were in 2017 over 535,000 cases of invasive non typhoidal salmonella with the highest incidents in Sub-Saharan Africa. And they estimated over 34 cases per 100,000 happened in children under age 5. So a huge burden in children. And they are of course some of the highest risk for severe illness and invasive disease. And this paper also estimated over 77,000 deaths in 2017 just from invasive salmonella, so that's separate from the salmonella enteritis.
Erin Welsh	Oh wow.
Erin Allmann Updyke	I know. Yeah. The all age case fatality rate for invasive salmonella was 14.5% on average, 14% death toll from invasive salmonella. I had no idea how severe and invasive salmonella infection.
Erin Welsh	Yeah. And so when you get an invasive salmonella infection, is it just that antibiotics don't always get there in time or is it antibiotic resistant infections? Like what's contributing to that high death toll?
Erin Allmann Updyke	It's a good question. I think it's a lot of things, I think it's probably a combination of all of that. It's also that the case fatality rate is even higher if you look at just the elderly or look at just those under age 5 or just those living with HIV. So that's even just the average. But I think it's a lot of things, I think it's how overwhelming the infection can be maybe by the time you identify it, I think it's that a lot of these are happening in areas that have a lack of access to good medical care or to rapid medical care with identification and quick treatment and that sort of thing. So I think it's a lot of factors that play into it. In the US alone, the CDC estimates that there are over 1.35 million cases of salmonellosis every year, over 26,000 hospitalizations, and 420 deaths in the US. And now here's where it gets even scarier. And this data I really only have for the US but this isn't specific to the US but this data is from the US. Of those 1.35 million cases, it's estimated that over 200,000 of them are due to antibiotic resistant salmonella.
Erin Welsh	Whoa.
Erin Allmann Updyke	Including an estimated 20,000 at least cases a year that are resistant to three or more of the essential antibiotics that we would use to treat salmonella. Antibiotic resistance, it's a really big problem obviously when it comes to so many infections not just salmonella. But in salmonella I think part of the reason that it's a particular problem is because of the way that antibiotic resistance can develop in our food system and then spread through that food system.
Erin Welsh	Yeah.
Erin Allmann Updyke	Right? So because salmonella can be found in so many guts of so many animals, especially domestic animals that we use for food, it can then like you were saying Erin enter our food system from a number of different ways from the processing to the water supply. It can end up on the boots of a farmer and then be transferred between locations, it can end up in the soil, it can be carried by rodents or even insects potentially. It can persist on shared equipment like you mentioned, it can be in these tanks where they're cleaning things that just then get filled with salmonella. It can be everywhere, it has a lot of points of entry into our food system, right. That's just salmonella. Now antibiotic resistance genes are present not just in bacteria of pathogen potential but antibiotic resistance genes are present in a lot of environmental microorganisms.

	So there's what's often called an environmental resistome that exists and these genes can then also make their way into bacteria of pathogen potential. It doesn't have to be that these salmonella making their way into our food system have to evolve, these resistance genes de novo. A lot of the times these genes already exist and in many cases are present on plasmids or if let's say other lactic acid bacteria in the soil break open, now these genes are in the environment. So bacteria like salmonella can then come into contact and pick them up via conjugation or transformation. See our antibiotic resistance episode for more. And that too is one of the reasons why the widespread use of antibiotics especially in our farm system and our domestic animal for meat production and things is so concerning and such a big part of the problem that contributes to antibiotic resistance, right. Because you're selecting for these resistance genes not just in the pathogens but in the environmental bacteria as a whole.
Erin Welsh	It is nightmarish.
Erin Allmann Updyke	It really is. It is. Yeah. Speaking of nightmarish-
Erin Welsh	Great.
Erin Allmann Updyke	Yeah.
Erin Welsh	Love that segue.
Erin Allmann Updyke	Right? That was a good one. Thanks for handing it to me. I want to give a shout out to a very great and thorough article that Erin, you sent me over. This article was published in ProPublica. It dives very deeply into an outbreak that perhaps is still evolving, perhaps has waned, it's hard to say. But an outbreak of salmonella, a serovar called infantis which I mentioned at the top, that started in 2018. And this is a particularly multi drug resistant and particularly infectious and tends to cause relatively severe disease serovar that really ran rampant and was found at extremely high prevalence in meat and poultry samples. And throughout this outbreak, according to the article, the CDC estimated that for every confirmed case of salmonella an additional 30 are never reported. So this outbreak likely had infected nearly 3000 people. I had never heard of it.
Erin Welsh	No.
Erin Allmann Updyke	Yeah. This was 2018, 2019. This just happened. And this article does a really great job of kind of highlighting some of the major flaws and this is US specific and they kind of compare to the way the regulatory system works in the US vs Canada and Europe and other countries. But we have in the US some pretty massive holes in how our regulatory system works in terms of what the CDC can do and require and investigate and what their investigations can then produce as a recommendation or product vs the FDA vs the USDA who oversees meat and poultry and that is separate from the FDA that does all of the rest of the food. Right? And essentially just this system which probably comes as no surprise to anyone who's listened to this podcast is not designed to protect the consumer.
Erin Welsh	No.

Erin Allmann Updyke	It's designed to protect the industry. You might hear about salmonella in your bag of spinach every once in a while, you might hear about it every once in a while in chicken from this one farm. But the problem is so much bigger than that and to really get a handle on it we have to truly in this country revamp the way that our food system works and the power that regulatory government bodies actually have to regulate that industry which essentially doesn't exist right now. Salmonella is pretty easy to kill, it's not like some of the bacteria that we've talked about that have very environmentally hearty spores or anything. So cooking your food properly does kill the bacteria and it does have a really high infectious dose, so that's also good. Yeah it is also the really easy to contaminate other parts of the kitchen.
Erin Welsh	Yeah.
Erin Allmann Updyke	So I think the knives, the cutting boards, the counter, your hands, everything has to be really well cleaned including things that you aren't going to cook like salad greens or fruits. These things need to be washed. And that can really be a challenge sometimes.
Erin Welsh	It can, it really can.
Erin Allmann Updyke	One of the biggest tools that we have to use in understanding the extent to which salmonella poses a public health problem is of course through testing but not just testing of environmental samples or of meat products or produce but also testing of humans when we get sick. Because while a lot of salmonella cases are never reported because the person who got sick maybe didn't get sick enough to actually go to the hospital or clinic. But there are a lot of people who do. So if for example you get quite sick, you have really bad stomach cramps, you absolutely can't stop pooping, and you decide to go to the hospital or a doctor's office.
	Once you're there what's very likely going to happen is that you might get asked to provide a sample of said poop or stool to figure out what the cause is of your symptoms. But the question is how exactly does all that information come to light? Where does that stool sample go? Who is the person who's having to sort through it and test it? And what else are they working with? We are really happy to have the help of medical laboratory scientist and TPWKY listener Sara Zaucha to help us answer some of these questions and to shine a light on a sometimes very overlooked but crucial field in healthcare, medical laboratory science. We'll let Sarah introduce herself right after this break.
TPWKY	(transition theme)
Sara Zaucha	Hi, I'm Sara Zaucha, I'm a medical laboratory scientist, I have been working in the field for about 12 years. I am a SCP certified as a generalist which means I can work in all areas of the clinical laboratory including blood bank, hematology, chemistry, and microbiology which is my primary focus and where I have been working for the past 10 or so years.
Erin Welsh	Awesome. Thank you so much for being here. Can you walk me through what happens in foodborne illness testing in general? What's the process from the doctor's office to test results and what are the other common pathogens that you look for?

Sara Zaucha

In any kind of laboratory testing there are three phases, there's the pre analytic phase which is what happens with the specimen before it gets to the lab, the analytic phase which would be the actual laboratory testing, and then the post analytical phase. So starting in the pre analytic phase, that's when the patient goes to the doctor, they're not feeling well. And the doctor will be asking about patient symptoms, when they began, what their symptoms are, specifically if they're suspecting a foodborne illness of course, where did they eat? What did they eat? Any travel history, things like that. The next thing they will do is they'll collect the specimen from the patient. So the doctor will give the patient everything that they need to do that and in the case of foodborne testing they're gonna need a stool sample.

So the analytical phase of testing is when the specimen is actually received into the lab. So the specimen is processed for testing and there's a couple of different ways that this can be done. Right now a lot of labs are moving to a more rapid kind of testing vs traditional culture. In traditional culture you have to wait 24 hours for the bacteria to grow before you can really do anything with it. With the new molecular test it's a panel that will test for the most likely suspects in foodborne illness, so it will give you a preliminary result right away. So the doctor kind of has a heads up the day that the specimen is received into the lab. And these panels typically test for salmonella, shigella, E.coli, aeromonas, plesiomonas, vibrio, campylobacter, and Yersinia enterocolitica. You can also get expanded panels for other things like parasites and certain viruses that may cause gastrointestinal discomfort depending upon the hospital and what they determine their needs are.

So once this molecular panel is run, if there is something that is identified in this panel what will then happen is that specimen is cultured out and grown in traditional bacterial culture for confirmation. And then this is done by different biochemical testing and other commercial laboratory instrumentation that will confirm the ID. Once this bacteria is identified then it is typically sent out to the local department of health or other state reporting agencies so they can do kind of their follow up investigation. And then this kind of leads us into the last phase which is post analytical where the results are reported out to the patient's chart, called to the clinician if it's considered a critical value, and then any contact tracing or patient follow up is performed.

Erin Welsh

So with cases of food poisoning you have your usual suspects that you're looking for. But what if you don't know exactly what you might be looking for in a suspected infection? Where do you start your search in that case?

Sara Zaucha

Actually how it works is we're supposed to be totally blind when we have a sample come into the lab, we're not supposed to really know too much about the patient in their history because that can bias the results. So when the specimen comes into the lab all we know is that the doctor wants this kind of test. So in the case of suspected foodborne illness, they're just going to send a stool culture. So we would just set up the testing and basically we have a list of what we're looking for and we're ruling everything out. If the culture is negative we're going to send out those results. But if the doctor does suspect that there is still something going on then that's when they would order more testing.

So they would know okay, this patient is exhibiting GI symptoms, it's not bacterial, maybe it's viral, so let me order a viral panel. If that's negative then they'll be like alright parasitic, let me order an ova and parasite panel. So it's really up to the doctor to kind of make that determination, we in the lab aren't really authorized to order testing as that constitutes treatment and diagnosis which is out of our scope. The only time we're able to order extra testing to rule things out is if it's something that's predetermined by the medical director and the clinician team where a test would automatically reflux.

Erin Welsh

As a medical laboratory scientist or a technician, what are some of the places you can work and what does the current job market look like for these careers?

Sara Zaucha	So the current job market is super excellent right now. There is a severe shortage. I went on the Bureau of Labor Statistics to find out how short we actually are. So according to the Bureau of Labor Statistics job growth between 2020-2030 is 11% faster than the national average for most other jobs. What's going on right now? If you graduate from college, you can get a job anywhere, anywhere you want, any city, any hospital. I mean everybody is hiring. So some of the places that people normally work, hospital labs are the most common but also there's reference labs like Labcorp, Quest, ARUP, a lot of times doctors offices or urgent cares will employ an MLS to run their small in-house laboratory, point of care which point of care is kind of maintaining the devices that the nurses would use at a patient's bedside like glucometers. Public health labs, pharmaceutical companies, medical device companies, and research are other areas that do employ clinical laboratory or medical laboratory scientists. However I feel like those are a little bit less popular and also harder to get a job in those industries.
Erin Welsh	What is the most unusual sample you've ever worked with?
Sara Zaucha	The most unusual sample I've ever worked with. Probably any amputated body parts. When you're testing something like that, generally it's a tissue culture. Let's say somebody has gangrene and so you're trying to figure out the cause of the infection. So what's really supposed to happen, the doctor is supposed to cut off a piece of the tissue and deliver it to the lab that way. But there's been times where I remember one time we got something that was like a tupperware container and I opened it up and it's like half a foot. And we've gotten fingers, we've gotten tips of penises.
Erin Welsh	Wow.
Sara Zaucha	Yeah, so those would be some of probably my more memorable ones where I'm just like did they really just do that?
Erin Welsh	Oh my goodness. I really cannot get over it. That is amazing.
Erin Allmann Updyke	It's amazing and hilarious. Thank you so much Sarah for taking the time to chat.
Erin Welsh	Yes, thank you. Well should we do sources?
Erin Allmann Updyke	Sources, definitely.
Erin Welsh	I will shout out a few. There were a couple of papers by Hardy, one from 1999, one from 2003 that kind of looked at this bigger picture of salmonella and the way that food production changed. And of course the documentary Wild Wild Country.
Erin Allmann Updyke	I had a number of papers. If you want to know more about the differences in the epidemiology of the serovars there was a paper in Applied and Environmental Microbiology from 2019 that went into a lot of detail on it. I really enjoyed a paper from Frontiers in Microbiology 2014 that was comparing and contrasting typhoidal and non typhoidal salmonella serovars. There was a bunch of really good ones and I will also link to that ProPublica article if you want to read more about that outbreak that happened in the US recently.
Erin Welsh	Thank you again so much Beth for sharing your story, we really appreciate it.
Erin Allmann Updyke	Thank you. Thank you also to Bloodmobile for providing the music for this episode and all of our episodes.

Erin Welsh	And thank you to you, listeners. We hope that you enjoyed this poopy episode.
Erin Allmann Updyke	Poopy episode.
Erin Welsh	Yeah.
Erin Allmann Updyke	It wasn't actually that poopy.
Erin Welsh	It actually wasn't, yeah.
Erin Allmann Updyke	And a special thank you to our patrons. We love you.
Erin Welsh	We love you. Okay well until next week, my gosh, please wash your hands and your fruits and vegetables and use a thermometer.
Erin Allmann Updyke	And your knives and your cutting boards and your kitchen counters. And what do you do about sponges? You filthy animals.