Catherine Hughes	My name is Catherine Hughes and 5 years ago I gave birth to the most beautiful, gorgeous little boy. His name was Riley and he had soft blond hair and gorgeous, piercing blue eyes. But when Riley was about 3 weeks old he started to get sick. I really thought it was just a cold at first, it was just a bit of a runny nose, a bit of a sniffle, and I wasn't too worried. But then a couple of days later I heard this tiny little cough. And I'll never forget the sound it made, it was so small, so innocuous. But it was really a sign of what was to come. My husband was away for work so I decided to call out a locum doctor to come visit our house one evening, Riley was about 4 weeks old at the time.
	And Riley appeared perfectly healthy. He was sound asleep and you just couldn't tell that there was anything wrong with him inbetween the coughing bouts. So the doctor looked at Riley, reassured me that I was probably worrying too much, that Riley seemed to be perfectly okay. That evening Riley slept and slept and slept and just did not wanna breastfeed, he didn't wanna wake up, he was so sleepy. I was feeling really uncomfortable at that stage so my husband flew back in from work and we took him to hospital the next morning. And at hospital he was admitted overnight because they were just a bit worried that he was not interested in breastfeeding anymore. But Riley didn't go home the next day. Each day that he stayed in hospital he just seemed to grow worse and worse and the coughing got more severe. It felt like every day there were just more tubes and wires and more doctors, everything just got worse and worse.
	On his fourth day in hospital we were moved into the pediatric intensive care unit. The doctors were concerned that hemophilia had developed pneumonia and they were pretty confident at this stage that he had whooping cough. When the doctors diagnosed Riley with whooping cough I actually felt a bit relieved because I thought they'd be able to cure him. But there is no cure for whooping cough, you just kind of hope and pray that they get better as they are cared for in hospital. And Riley didn't get better. His organs started to shut down by day 5, his heart was under a lot of strain. And on day 5 which was his last day in hospital he was unconscious, they put him on life support and they tried to use ECMO to save his life. And I just remember looking at his body on the bed, it was a big bed, a tiny little 4 week old baby on there, but he was so swollen and just covered in so many wires and tubes it was really the most traumatic thing to see.
	And that afternoon we watched as this pink foamy stuff started coming out of his lungs and the doctors told us that there was nothing more that they could do. We'd asked about organ donation but unfortunately I think his organs were just too ravaged from the toxins released by the whooping cough bacteria. So at 2 in the afternoon after 5 days in hospital we took Riley off life support and he was just hot and swollen and so sick. And they took all the tubes and wires out and we had to say goodbye to our little baby because he had caught this horrible, preventable whooping cough. And he was too young to be vaccinated, he was only 32 days old when he died. And at the time pregnancy vaccination hadn't been routinely recommended or funded in Australia. So newborn babies like Riley were extremely vulnerable to whooping cough and it cost him his life.
TPWKY	(This Podcast Will Kill You intro theme)
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	Yeah, today it is.

Erin Welsh	Today it is. Yeah. So you just heard from Catherine Hughes who was kind enough to come onto the podcast and share with you her story. And you're gonna hear a little bit more from her later on in the episode as well. So thanks again Catherine, that was...yeah.
Erin Allmann Updyke	Yeah, it's a horribly depressing story that unfortunately isn't the only one out there. So today we're obviously talking about pertussis.
Erin Welsh	Whooping cough. To get us through this episode we are drinking-
Erin Allmann Updyke	A very strong quarantini.
Erin Welsh	Yes, it's basically all alcohol. It is called Three Women & A Baby and it's called that because the first really successful vaccine that was in widespread use was developed by three awesome women.
Erin Allmann Updyke	Woo-woo! Girl power.
Erin Welsh	Yeah. So what is in Three Women & A Baby?
Erin Allmann Updyke	Well it's rye whiskey of course because whiskey as we all know is the cure for all children's ailments.
Erin Welsh	Of course. (laughs) Don't do that at home, it's not true.
Erin Allmann Updyke	Not evaluated by the FDA or this podcast.
Erin Welsh	We're not being serious.
Erin Allmann Updyke	No.
Erin Welsh	It also has Luxardo liqueur.
Erin Allmann Updyke	And Cynar.
Erin Welsh	Which is an artichoke liqueur.
Erin Allmann Updyke	Which sounds weird but it's quite tasty in context.
Erin Welsh	It's bitter and delicious. Also my band name.
Erin Allmann Updyke	(laughs) Bitter & Delicious?
Erin Welsh	Yeah.
Erin Allmann Updyke	That's a good band name actually.
Erin Welsh	Garnish with a cherry and enjoy.

Erin Allmann Updyke	And we'll post the full recipe for this quarantini as well as our nonalcoholic placeborita on our website thispodcastwillkillyou.com and all of our social media channels.
Erin Welsh	Making the placeborita is gonna be a challenge for this one.
Erin Allmann Updyke	You'll figure it out.
Erin Welsh	I'll come up with something.
Erin Allmann Updyke	I have total faith.
Erin Welsh	Glad you do.
Erin Allmann Updyke	I say you'll figure it out. I'll just be like, 'Nice job'.
Erin Welsh	Thanks. (laughs) Now this feels like a group project again.
Erin Allmann Updyke	I also wanna give a quick shout out and thank you to Akeai - I'm sorry that we might've just pronounced your name wrong - but for sending us the most adorable gift package from Texas, y'all.
Erin Welsh	Oh my gosh, it's adorable!
Erin Allmann Updyke	I can't even handle it.
Erin Welsh	There's so many great things.
Erin Allmann Updyke	Did you guys know something called Texaroni existed? It's macaroni in the shape of Texas, okay? It's everything I needed in life and I love it.
Erin Welsh	I feel like that should be sold in stores across the US but Texaroni version, not like Illinois version.
Erin Allmann Updyke	Not like Illinoisaroni?
Erin Welsh	Yeah.
Erin Allmann Updyke	No. I wouldn't eat that.
Erin Welsh	Texas is a great shape for pasta, who knew?
Erin Allmann Updyke	It really is. I can't wait. We'll need to make mac and cheese together or something, Erin.
Erin Welsh	Oh my gosh, yeah.
Erin Allmann Updyke	Anyways thank you so much, that was really sweet of you. And sorry it took forever for me to check our PO box.
Erin Welsh	We should post pictures.

Erin Allmann Updyke	Yeah we should. Of us eating macaroni and cheese?
Erin Welsh	Yes.
Erin Allmann Updyke	Okay, cool.
Erin Welsh	Cool.
Erin Allmann Updyke	Okay.
Erin Welsh	All right.
Erin Allmann Updyke	Shall we jump right in?
Erin Welsh	Let's do it. Should we take a quick break first?
Erin Allmann Updyke	I think we need a breather, right?
Erin Welsh	Yeah.
TPWKY	(transition theme)
Erin Allmann Updyke	So pertussis aka whooping cough. Let's talk about what these symptoms are. So pertussis is caused by a bacterium and the name of the disease, the colloquial name 'whooping cough' tells you the most characteristic part of these symptoms and that is this very distinctive whooping sound that is not actually during the cough but it's as people try and take a breath of air in after an episode of coughing.
Erin Welsh	And so is the whoop, is that all ages that have whooping cough or is that mostly younger children?
Erin Allmann Updyke	Good with. We'll talk a little bit more in a bit about the differences in symptoms. It can happen in people of any age.
Erin Welsh	Okay.
Erin Allmann Updyke	But it's most typical in younger age groups.
Erin Welsh	Okay.
Erin Allmann Updyke	And we'll talk about why in a bit. That's a really good question, though. All right so the bacterium that causes pertussis is called Bordetella pertussis, it's a little gram-negative rod, so again gram-negative means it's pink when we stain it. However while Bordetella pertussis is the most common cause of whooping cough, there are a couple of other very closely related bacteria species including Bordetella parapertussis and Bordetella bronchiseptica that can in some cases cause a very clinically similar disease. But Bordetella pertussis is the one that for example we have a vaccine for and kind of the most important of these species.
Erin Welsh	Are you ready for questions? I feel like this is the earliest I'm getting into...

Erin Allmann Updyke	I can tell that you have them already.
Erin Welsh	Okay. So about these different bacterial species, are they as globally prevalent as just Bordetella pertussis?
Erin Allmann Updyke	Good question. I know that parapertussis is pretty widespread globally. I would guess that bronchiseptica is as well. One of the big differences is that these other species are found in many other species of animals as well whereas Bordetella pertussis is a human-specific disease. Side note though, Bordetella bronchiseptica causes kennel cough in dogs.
Erin Welsh	Interesting.
Erin Allmann Updyke	So anyways. Pertussis is transmitted via respiratory droplets. I've seen estimates that the R0 which if you'll remember from previous episodes is the number of secondary infections that a primary infection can cause, I've seen estimates ranging anywhere from 5 to 15.
Erin Welsh	Wait.
Erin Allmann Updyke	I know! That's bigger than measles!
Erin Welsh	I was gonna say...
Erin Allmann Updyke	Which doesn't seem right.
Erin Welsh	Well but I guess the R0 is an average.
Erin Allmann Updyke	Yeah. But anyways, in any case this is a highly, highly infectious disease. It spreads very easily.
Erin Welsh	Yeah.
Erin Allmann Updyke	In general the incubation period, so the time between when you first get exposed and when you start to show symptoms on average is about a week, maybe 10 days but it can be quite a bit longer and I think the reason that the range can be longer is twofold. Partly it has to do with infectious dose, how much are you exposed to at the outset but also it's very difficult to pinpoint when exposure might be in relation to symptoms because the onset of symptoms for this disease is kind of insidious. Which means it's slow and you might not recognize at first for like a week or more that what you're dealing with is actually pertussis.
Erin Welsh	Oh okay.
Erin Allmann Updyke	Yeah. So let's talk about how this little bacterium gets into you and causes disease, okay? And then we'll talk about those insidious...
Erin Welsh	Okay.
Erin Allmann Updyke	That's one of my favorite words, insidious symptoms.
Erin Welsh	Yeah. Also it's going to end up convincing a lot of people that they have whooping cough, isn't it?

Erin Allmann Updyke	Probably, I mean I convinced myself that my baby had whooping cough so you're not alone if this convinces you that you have whooping cough. Okay.
Erin Welsh	We just apologize in advance.
Erin Allmann Updyke	Yeah, we do. So unlike many of the other diseases that we've talked about recently including syphilis and E. coli, even dengue, this is a highly, highly specific bacterium. So it doesn't just go throughout your whole body wreaking havoc. Bordetella pertussis replicates only in association with the ciliated epithelium of your lungs.
Erin Welsh	How does it only reproduce there?
Erin Allmann Updyke	How? Okay, so pertussis has a lot of different virulence factors on its surface.
Erin Welsh	Yeah.
Erin Allmann Updyke	That allow it to colonize our body and then cause the symptoms that it causes. It also has a number of different toxins which are really ultimately responsible for a lot of the symptoms that we see. And so these virulence factors very specifically allow it to bind to the epithelium of our respiratory tract.
Erin Welsh	Okay.
Erin Allmann Updyke	And so those are the only cells that they bind to. Now Bordetella does not invade our cells but it binds to these respiratory cells and then it replicates in association with those cells, so like next to those cells.
Erin Welsh	What? This is so weird. Okay.
Erin Allmann Updyke	I know, isn't it? So this is a very... I don't know how much you're gonna talk about the evolution of this pathogen.
Erin Welsh	A little bit, yeah.
Erin Allmann Updyke	But it seems to me based on this, we've had a long association with this pathogen. Am I right?
Erin Welsh	I'm going to withhold comment until the history section.
Erin Allmann Updyke	(laughs) Okay. Excellent. That would be my guess based on the fact that this is a bacterium that is highly specialized to these cells in our respiratory tract. And it's a human-specific pathogen so it's not found in a bunch of other animals.
Erin Welsh	Right.
Erin Allmann Updyke	Okay, cool.
Erin Welsh	So are human respiratory cells that much different than any other mammal respiratory cells?

Erin Allmann Updyke	Oh, than any other mammal? I have absolutely no idea. I mean I guess they're specific enough that the virulence factors that Bordetella pertussis has doesn't allow them to easily colonize other animals.
Erin Welsh	Yeah. I'm just wondering what it is about the specificity that's like... I don't know.
Erin Allmann Updyke	Yeah, great question. I mean it makes sense, if it's gonna specify on any cells, respiratory epithelia are great because it's gonna cause you to cough and sneeze and that's gonna spread the pathogen really far.
Erin Welsh	Yeah.
Erin Allmann Updyke	So from that perspective it makes sense. But the specificity to humans, I don't know, man. How does that ever happen? Right? And again, Bordetella has a number of different toxins that it releases that result in a lot of the damage and symptoms that we see. So in addition to pili which we've talked about before, those sticky things that allow it to attach to the respiratory tract, two of the important toxins that it has are number one, a toxin called pertussis toxin, it's a really good name for it, that actually blocks the ability of our white blood cells to get back into our lymph system.
Erin Welsh	Ooh.
Erin Allmann Updyke	So what that means is that you have white blood cells coming because they recognize bacteria, right? They're like, 'Oh man, we need to come in and help out.' But then what those white blood cells want to do is then go back to our lymph nodes and regroup so that they can figure out a plan of attack kind of. So pertussis toxin blocks their ability to do that so you end up with a ton of white blood cells in the bloodstream because they've all come out to try and figure out what's going on with these bacteria but then they can't get back where they wanna be.
Erin Welsh	Oh my gosh.
Erin Allmann Updyke	Does that make sense? Yeah.
Erin Welsh	Okay, that's really interesting.
Erin Allmann Updyke	It is. And it's one of the only systemic symptoms of a Bordetella pertussis infection is this what we call lymphocytosis, a lot of white blood cells in your bloodstream.
Erin Welsh	Okay, so that's pretty indicative.
Erin Allmann Updyke	It is, yeah. I mean you can get that in tons of other diseases, so it's certainly not specific at all but it's one of the only systemic manifestations. Because this is a very respiratory-specific pathogen. And then it has other toxins which I forgot to write the name of down of course, I think tracheal toxin is one of them actually, that cause direct damage to the cilia of our respiratory epithelia. And so cilia are these little - what do you call this, Erin?
Erin Welsh	Fingers?
Erin Allmann Updyke	What I'm doing with my fingers.
Erin Welsh	Undulating anemone kind of things?

Erin Allmann Updyke	Yeah, exactly. Little projections on these cells that help to sweep mucus and debris up and out of our respiratory tract. We talked a lot about them in our cystic fibrosis episode.
Erin Welsh	Yeah.
Erin Allmann Updyke	Anyways so these other toxins, tracheal toxins and other that Bordetella produce cause damage to that system so you're gonna get a buildup of gunk in your lungs when you get infected with pertussis. Now we know what it does in your body, how it's infecting you, so what does it look like when you get infected?
Erin Welsh	Not good.
Erin Allmann Updyke	It's not good. So there are three main phases to pertussis. What's called the catarrhal stage - I think that's how you pronounce it - the paroxysmal stage, and then the convalescent stage aka recovery. So the catarrhal stage is this very insidious, nondescript illness. And this is what can make it difficult to pinpoint exactly when you might have started showing symptoms. And what I think is worst about this phase is that the symptoms are quite mild in a lot of cases. So these include something like a runny nose, not a gunky nose, just kind of a watery, runny nose. Coryza, so tearing from your eyes kind of like a viral eye infection might be.
Erin Welsh	Okay.
Erin Allmann Updyke	Okay. Watery eyes, maybe your eyes get a little red, maybe they're itchy like maybe you think it's allergies. You might have some sneezing. And at first it starts off with a pretty mild cough and that's how it begins. And in tiny kids actually across the board, if there is a fever which often there isn't a fever at all, even if there is a fever it's usually pretty mild, like we're talking maybe like 101 which is a pretty low grade fever. If you're talking about a kid who's over age 2, you mostly wouldn't even be concerned about a fever that low because kids get fevers from everything. Like every infection is gonna give a kid a fever so if a kid has a very low fever, you probably aren't going to be like, 'Well this kid is clearly very sick.' You'll be like, 'Oh it's a little fever, they'll get over it.'
Erin Welsh	Right.
Erin Allmann Updyke	But that's it, those are the symptoms. This lasts for 1-2 weeks, it's super mild. The coughing sort of starts to get worse but at this phase it doesn't have anything that makes it stand out, it's not more frequent at certain times of day, it's not super productive, it's just kind of a normal cough. Okay? And again, no fever. Then comes the paroxysmal phase and this is the whooping cough of whooping cough, okay. So the cough that starts out as mild in that catarrhal phase becomes paroxysmal, paroxysmal means a sudden recurrence. So all of a sudden out of the blue people will have a massive coughing attack. These usually are between 5 or 10 but they can be up to 30 coughs in a row and they become also, these paroxysms, these coughing attacks become more frequent at night and overall increase in frequency both throughout the day and the night. And each one becomes more severe than the last.
Erin Welsh	Okay.

Erin Allmann Updyke	And it's kind of almost hard to describe how terrible these coughs are so I actually found a paper from 1975 that's a really nice overview of pertussis and I'm gonna just read this. "The child possessed of the coughing fit is a pitiful sight, all the more so as the observer is helpless to alleviate or terminate the attack. Each attack consists of 10-30 forceful coughs per spasm and into each cough the patient appears to concentrate all his energy. He leans forward or if standing, stands with legs spread, grasping the nearest object and leaning far forward, tongue protruded to the utmost, saliva and mucus streaming from nose and mouth, eyes bulging with tears streaming, his entire body wracked with the total exertion of each cough. The coughing continues in a staccato series, the face becomes more and more cyanotic," which means blue. "The neck bulges with venous congestion and still the attack continues. Finally when it seems certain that death is imminent, a final cough appears to clear offending secretions or mucus from the upper airway and the first opportunity to inspire is offered. With a massive effort inspiration ensues, air rushes into the lungs against a still narrowed glottis and the characteristic whoop is produced."
Erin Welsh	Oh my gosh.
Erin Allmann Updyke	Yeah.
Erin Welsh	I'm just taking a second to breathe.
Erin Allmann Updyke	Right?
Erin Welsh	Wow.
Erin Allmann Updyke	Yeah. And so that's kind of a very classic description of what these paroxysms look like. They're horrible, I don't recommend googling them but you can find a lot of videos of them online.
Erin Welsh	Yeah. Are the coughs productive? are you coughing up mucus or gunk from your lungs?
Erin Allmann Updyke	So yes and no. There is a lot of mucus in your lungs and so it's thought that these coughing spasms are because of that mucus, it's like you trying really hard to get that mucus up. But especially because this is often a disease of very young infants, they're not good at coughing stuff up so they may or may not actually cough anything up. But there is a lot of mucus there that could potentially be coughed up, yeah.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah. One of the sort of other characteristic things that happens after these paroxysms is what's called posttussive vomiting, so it's really common to cough so hard that you end up vomiting.
Erin Welsh	Oh gosh.
Erin Allmann Updyke	Yeah. It's horrific. And these episodes are so exhausting, I mean imagine you are literally unable to breathe this whole time which is why that inspiratory whoop is so powerful, you're trying so hard to get air back into your lungs that as these progress and become more and more frequent throughout the ensuing days and weeks, this can last for weeks, people tend to become very, very exhausted. So they might be sleeping most of the day and only awaken when they have these coughing fits and then fall kind of right back to sleep.
Erin Welsh	It sounds so utterly exhausting.

Erin Allmann Updyke	Yes.
Erin Welsh	Oh my gosh.
Erin Allmann Updyke	And so especially in babies and in older children and adults this can lead to weight loss because people might stop eating because they're just sleeping through inbetween every coughing episode.
Erin Welsh	Right.
Erin Allmann Updyke	You can also get a lot of complications from the actual force of the coughing, you can burst blood vessels in your eyes or under your skin, you can cough out a hernia-
Erin Welsh	Oh my god.
Erin Allmann Updyke	You're coughing so hard that you result in a hernia through your belly button.
Erin Welsh	Ugh.
Erin Allmann Updyke	You can crack ribs.
Erin Welsh	Yeah.
Erin Allmann Updyke	And often your chest wall will get really sore and tender even if you don't break a rib just because you're working those muscles so, so hard to cough so much. And then there are a couple of really important complications that can happen on top of this, the most deadly of which is a secondary pneumonia.
Erin Welsh	Okay.
Erin Allmann Updyke	So that's lie usually it's a secondary bacterial infection because you've been sick with pertussis for so long and that often causes the most deaths. It's not the only way that you can die from pertussis. Because these paroxysms can be so severe that you can have prolonged hypoxia which means your brain isn't getting enough oxygen, that can result in encephalopathy, so brain damage, which can cause either long-term brain damage or can cause death, especially in young infants. Yeah. There's a number of other complications that you can get. You can rupture your trachea or your esophagus and get air that goes into your subcutaneous tissue or you can collapse one of your lungs and get a pneumothorax from coughing so hard.
Erin Welsh	Is the air in subcutaneous tissue, is that in the 1918 flu, the pockets of air?
Erin Allmann Updyke	Yeah, the crackles.
Erin Welsh	The crackles and pops. Oh my gosh.
Erin Allmann Updyke	Yep, yeah. Snap, crackle, pop under your skin. So this phase overall, the paroxysmal phase, can last anywhere from 1-4 weeks. But even as it starts to improve and you enter the convalescent phase, it's a very gradual improvement. Another name for pertussis is actually the 100 days cough cause symptoms can continue for up to 6 months.

Erin Welsh	Yeah.
Erin Allmann Updyke	So that's pertussis.
Erin Welsh	Wow.
Erin Allmann Updyke	Yeah. It is technically treatable with antibiotics but the antibiotics work best if you can get treatment during that catarrhal phase.
Erin Welsh	Okay.
Erin Allmann Updyke	Which again I mean a lot of people are never even gonna seek treatment during that phase cause that phase alone can last 1-2 weeks.
Erin Welsh	Right.
Erin Allmann Updyke	Yeah and so treatment with antibiotics works best if you can get treatment during that initial phase. After that the problem is that the bacteria has already started releasing all those toxins. So while antibiotics are still effective at eliminating the bacterium, they don't really help with symptom treatment.
Erin Welsh	Okay.
Erin Allmann Updyke	So yeah. What they do do is help to prevent further spread of the disease so it is still really important to treat with antibiotics even if you're not treating til later in the disease course.
Erin Welsh	Right. Is there any antitoxin available?
Erin Allmann Updyke	As far as I know, no. Like there's no antitoxin treatments that we have or anything like that.
Erin Welsh	Okay.
Erin Allmann Updyke	Yeah.
Erin Welsh	Like there was for diphtheria before?
Erin Allmann Updyke	Yeah.
Erin Welsh	Well I guess still is, but yeah. Okay, interesting.
Erin Allmann Updyke	Yep.
Erin Welsh	This is making me feel a lot like the diphtheria episode.
Erin Allmann Updyke	Like you can't breathe?
Erin Welsh	Yeah, sort of like the...
Erin Allmann Updyke	Do you have a pseudomembrane covering your throat?

Erin Welsh	Yeah.
Erin Allmann Updyke	Yeah. It's a horrible illness.
Erin Welsh	It's really horrible. But vaccine preventable.
Erin Allmann Updyke	I think we should specify that at the outset of this episode. This is a horrible illness and it is vaccine preventable.
Erin Welsh	It really is.
Erin Allmann Updyke	No kids should be dying from pertussis today and unfortunately they are.
Erin Welsh	In theory it could be a target for eradication.
Erin Allmann Updyke	Yes because it's a human-specific disease. So Erin, how did we get here? Where did this horrible thing come from?
Erin Welsh	I will answer that as well as I can just after this break.
TPWKY	(transition theme)
Erin Welsh	So if you think back to last year during our vaccines episodes, I talked a little bit about pertussis particularly in the second episode, part II, where I talked a little bit about the rise of vaccine hesitancy or the anti-vaccine movement nowadays. And how the pertussis vaccine actually played a pretty central role in that.
Erin Allmann Updyke	Yeah.
Erin Welsh	And back then I remember promising, 'Oh I'm not gonna go into this too much because we're gonna do a full episode on pertussis.' And here I am! Making good on that promise. So since I've already talked a lot about the history of pertussis when it comes to the rise of the vaccine hesitancy or anti-vaccine movements, I'm not gonna go into too much detail on that so I'll just refer you to part II of vaccines.
Erin Allmann Updyke	Good call.
Erin Welsh	But even before I can get to that part of the story of pertussis there's so much to cover beforehand. So let's go back to the beginning. Throughout history pertussis has been somewhat overshadowed I would say by some of the other big name diseases like smallpox, plague, cholera, tuberculosis, etc, sort of the ones that did really come through a population or a city and just wipe a lot of people out.
Erin Allmann Updyke	Yeah.
Erin Welsh	But that doesn't mean that it was minor or easily ignored. Pertussis has been one of the biggest killers of children throughout history and as I'm sure you're going to talk about it remains a huge problem around the world today.

Erin Allmann Updyke	Yeah.
Erin Welsh	I've talked before about the difficulty in retrospectively diagnosing a disease based on historical accounts.
Erin Allmann Updyke	Is this one easy?
Erin Welsh	(laughs) Especially if there's no physical evidence like skeletal damage or something like that.
Erin Allmann Updyke	Right.
Erin Welsh	But yeah, pertussis doesn't have that problem as much as some of the other ones. Cause the symptoms as you described, this whoop, the intake of air that's so restricted, it's pretty characteristic and very noticeable and it also has a tendency to just infect children. And so descriptions of a disease that mostly impacted children and was accompanied by a horrific cough that then breath in afterwards sounded like whooping, it's probably whooping cough.
Erin Allmann Updyke	Yeah. Safe assumption.
Erin Welsh	Safe assumption. This is where I think it's gonna get interesting, I think so anyway.
Erin Allmann Updyke	Okay.
Erin Welsh	So most historical reviews that I read of pertussis say that the first definitive or most likely definitive epidemic of the disease happened in 1578 in Paris.
Erin Allmann Updyke	All right.
Erin Welsh	So 1578. That's not that long ago.
Erin Allmann Updyke	No, especially not for a human-specific pathogen that is so well suited just to our one cell type.
Erin Welsh	Yes.
Erin Allmann Updyke	So?
Erin Welsh	Interesting.
Erin Allmann Updyke	Interesting.
Erin Welsh	Okay so the physician who wrote about this epidemic called the disease 'quinta' or 'quintana tussis' probably to indicate that the severe coughing fits that you mentioned occurred every four or five hours.
Erin Allmann Updyke	Oh okay.

Erin Welsh	And he also described it as being a new disease or only referred it to a couple other outbreaks. And he noted that it occurred mostly in children between the ages of 4 and 10 with a violent cough that ended in vomiting, cyanosis, and often death. However there are a couple of other possible outbreaks of pertussis that date back even further. So in and ancient Chinese medicine treatise dating back to the 600s there is mention of something called the 100 day cough which is the colloquial name for pertussis in China today. And in this treatise it says that the cough will last 100 days and if not cured, 80-90% of people will die.
Erin Allmann Updyke	Whoa!
Erin Welsh	So that's very high.
Erin Allmann Updyke	Very high.
Erin Welsh	And so because of that extremely high reported mortality rate, many researchers dispute this inclusion as whooping cough saying that it seems to be too lethal to be whooping cough and there was also no mention made of the fact that it mostly happens in children. So even though it is a 100 day cough now, it might have just changed names, like it might have just changed diseases, rather.
Erin Allmann Updyke	Right. Yeah. They used to call this thing 100 day cough and now they call pertussis 100 day cough.
Erin Welsh	Exactly. There are also a few other possible earlier - not earlier than the 600s but earlier than Paris - pertussis epidemics in Persia around the 15th and 16th centuries. And so around this time, just for reference cause I didn't really know this, Persia spanned from modern day Iran into parts of central Asia and India.
Erin Allmann Updyke	Okay.
Erin Welsh	And so in the late 1400s which is almost a century before the Paris pertussis outbreak, there were two epidemic coughs that led to vomiting and unconsciousness and death in many people, both children and adults. And the fact that adults were affected could suggest that this was a new disease for the population and hadn't fallen into this pattern of childhood illness yet. And there are a few other epidemics in 16th century Persia that seem even more conclusively to be whooping cough but the take home from all of this I think is that the disease seems to be first recognized in humans only 500 or 600 years ago.
Erin Allmann Updyke	Whoa, that's the opposite of what I guessed, Erin.
Erin Welsh	Yeah! So that leads to the question, is this bacterium really only 500 or 600 years old? Is that when it evolved?
Erin Allmann Updyke	No. (laughs) No, right?
Erin Welsh	No. Definitely not. Definitely not. So there was a research article from 2005 that investigated the evolutionary history of Bordetella pertussis and found that it likely evolved from a human-specific lineage of the related species Bordetella bronchiseptica around 2.5 million years ago.
Erin Allmann Updyke	I'm sorry.
Erin Welsh	Yeah.

Erin Allmann Updyke	So we go from 2.5 million to 500. What's happening?
Erin Welsh	Yes. Yeah. I mean does that mean that humans have been living with this bacterium since before humans were humans?
Erin Allmann Updyke	And then it just all of a sudden started causing disease?
Erin Welsh	Yeah. I mean honestly I don't have a satisfying answer and I couldn't find one in any of the things that I read. So I think what a few of the articles mentioned is that the most likely scenario is that the bacterium probably circulated in a relatively nonvirulent state in parts of Asia, possible Southeast Asia, for most of its history and then it evolved these virulence factors that allowed it to become super prevalent and highly contagious and also lethal.
Erin Allmann Updyke	You know I bet that is the biggest difference between when you asked about parapertussis and bronchiseptica and why those at least aren't as prevalent.
Erin Welsh	Yeah.
Erin Allmann Updyke	I think it is likely just that they don't cause disease as much and it is because of those toxins. Like bronchiseptica doesn't produce pertussis toxin and neither does parapertussis.
Erin Welsh	Yeah.
Erin Allmann Updyke	And it's thought that that's one of the main toxins that causes these symptoms that we see.
Erin Welsh	That's interesting.
Erin Allmann Updyke	Yeah.
Erin Welsh	One of the things that I thought was really interesting is in these papers it's harder to get a sense of historical genetic diversity for some of these bacteria that have had vaccines used against them because you can imagine certain lineages or certain strains or subspecies or whatever have been wiped out in some places.
Erin Allmann Updyke	Right.
Erin Welsh	And so the genetic diversity that we're left with now isn't necessarily representative of its historical diversity.
Erin Allmann Updyke	Yeah, that's a good point.
Erin Welsh	I thought that was really interesting. But yeah I mean it probably emerged or started causing epidemics 500 or 600 years ago because that's when widespread trade and global travel really kind of got up and running. So yeah.
Erin Allmann Updyke	Fascinating.

Erin Welsh	And another point in the column of this being a relatively new disease or recently evolved virulence is that physicians around the time when it first started appearing, they were also baffled by the disease and seemed to make important notes of it.
Erin Allmann Updyke	Okay.
Erin Welsh	One physician said in 1894 that, quote: "It is singular that a malady so distinctly marked as whooping cough should figure so little in the records of disease from former times." So no mention of it in Ancient Greece or Ancient Rome, sorry, which I had to mention Ancient Greece and Rome.
Erin Allmann Updyke	Right! It can't be an episode-
Erin Welsh	No mention in the Ebers Papyrus.
Erin Allmann Updyke	Oh my gosh, was this even an episode of TPWKY?
Erin Welsh	I dunno, it's gonna have an asterisk next to it for sure. And the sudden appearance or apparent sudden appearance of whooping cough caused other problems as well. Because it kind of popped up all over and in such severity, it gained all these different names even within the same language and didn't even get its scientific name until 1906, like for the bacterium.
Erin Allmann Updyke	Wow. Okay. Wow.
Erin Welsh	Okay but before we get to that, let's talk about a few of these names cause I know that you're gonna be excited for it.
Erin Allmann Updyke	Are they good? I love them.
Erin Welsh	They're fine.
Erin Allmann Updyke	Oh, okay.
Erin Welsh	Yeah. We've had better ones.
Erin Allmann Updyke	Okay. (laughs)
Erin Welsh	There's no 'mad staggers' or whatever...
Erin Allmann Updyke	Dandy fever?
Erin Welsh	Dandy fever. So there were several English names for the disease including hooping cough, no 'w'.
Erin Allmann Updyke	Okay.
Erin Welsh	Chincough, kink-cough, and others. Kink-cough was apparently the popular name for the disease in Scotland and the word 'kink' I guess was also used as a convulsive fit of coughing or laughter, a gasping for breath caused by coughing, laughing, or crying, the 'whoop' in whooping cough. That was from a definition somewhere.

Erin Allmann Updyke	Interesting.
Erin Welsh	Yeah. In France it was known as quinta, in Italy it was called tosa farina or tosa canina.
Erin Allmann Updyke	Ooh, like dogs?
Erin Welsh	Because the cough could sound like the barking of a dog.
Erin Allmann Updyke	Ah, okay.
Erin Welsh	Yeah. And all these names kind of slowed down the accumulation of knowledge about the disease or made it more difficult because it took a while for someone to go through and say, 'Ah yes, the chincough here is known as hooping cough there which is the same as quinta there.' Something like that.
Erin Allmann Updyke	Yeah.
Erin Welsh	And so throughout this time though the disease itself did not slow down. After its first appearance in Europe in the 16th century it would continue to cause epidemics until it fell into this childhood illness pattern, so appearing every year or every few years, often at a particular time of year and then impacting mostly children. Let's talk about that impact.
Erin Allmann Updyke	Yeah.
Erin Welsh	The numbers of infected kids per year are more difficult to get a sense for but we do have some census data for a couple of places that can give us an idea of the number of deaths.
Erin Allmann Updyke	Oh no.
Erin Welsh	In Sweden for example in the mid 1700s, Sweden seems to be particularly hard hit by whooping cough which I think is interesting historically. And so in the mid 1700s there was a death rate of about 151 per 100,000 people every year which is really high.
Erin Allmann Updyke	That's very high.
Erin Welsh	Really high.
Erin Allmann Updyke	150 per 100,000 just from whooping cough.
Erin Welsh	Yes.
Erin Allmann Updyke	Wow.
Erin Welsh	So that calculates to about 2700 children per year in a population of 1.8 million which is what it was in Sweden then.
Erin Allmann Updyke	Oh god.
Erin Welsh	And so as I mentioned these numbers are on the high end for deaths due to whooping cough.

Erin Allmann Updyke	Right.
Erin Welsh	But it was still a really bad problem in other places as well. So in London the annual death rate was around 29 per 100,000 around that same time in the mid 1700s calculating to about 238 deaths per year in that population of 700,000.
Erin Allmann Updyke	Okay.
Erin Welsh	And these numbers for London though would increase over the course of the 18th century, so the next 100 years, almost doubling.
Erin Allmann Updyke	Whoa.
Erin Welsh	And even occasionally surpassing the numbers of deaths caused by measles.
Erin Allmann Updyke	Whoa.
Erin Welsh	Yeah. So this trend in increasing virulence was repeated across a wide geographic range which is kind of interesting because I think we have this idea that diseases tend to decrease in virulence over time, as we saw syphilis do for instance after its first appearance in Europe in the late 15th century.
Erin Allmann Updyke	Right.
Erin Welsh	But for whooping cough, this increase in virulence was probably due to a combination of an influx of new susceptibles every year or every few years, increasing population density overall, and a bunch of other things like poor nutrition, poor air quality, ineffective treatment that may have contributed. And it probably could be also or was a big part of it that physicians just got better at diagnosing the disease and correctly attributing cases and deaths to it over that time as it kind of grew in infamy.
Erin Allmann Updyke	Yeah. That makes sense.
Erin Welsh	Okay. In any case by the time that microbiology as a field started and grew, pertussis was high up on the list of diseases that desperately needed a cure or treatment of some kind. Just as it did in the 1700s, the mortality due to pertussis and the prevalence of pertussis grew also in the 1800s with about 10% of infections ending in death.
Erin Allmann Updyke	Wow.
Erin Welsh	And that number would be higher for children of working classes or who just had poor nutrition or lower income. But one issue in trying to control the disease was knowing what the disease was, what was it caused by. So if you didn't know what was causing this, how could you even try to stop it? Physicians did recognize though that it was contagious which I think is interesting as we've talked about again.
Erin Allmann Updyke	Yeah.
Erin Welsh	If you read some of these old medical treatises it's like, 'Oh we can't ignore the fact that there is some sort of environmental component to this but it does seem to be contagious.' So anyway.

Erin Allmann Updyke	I do think that's so interesting, just that whole aspect of it. Before we knew that bacteria or viruses were things that were transmissible from person to person, just this idea that you could still somehow have a contagious disease despite that is so fascinating.
Erin Welsh	Yeah. So there were two researchers named Bordet and Gengou and these two guys had struggled to isolate the bacterium because even though the symptoms of the disease could last for a really long time, there was apparently a really narrow window in which you could actually culture the bacterium. But another issue was that it only grew in the lung, it had that super high specificity that you mentioned towards the lung epithelial cells. So you couldn't pick it up from the blood of someone who was infected and even if you were able to get a little mucus sample, the bacteria would quickly die outside the body.
Erin Allmann Updyke	Yeah.
Erin Welsh	But they kept at it and they first saw the bacterium under the microscope in 1900 and 6 years later were finally able to grow the bacterium in a lab using a special broth.
Erin Allmann Updyke	Wow! 1906.
Erin Welsh	1906. That's kind of late.
Erin Allmann Updyke	But that's amazing that they were able to do it considering where it grows and how difficult it is to culture. I mean it's still hard to culture.
Erin Welsh	Yeah, no, it's amazing. Also Bordet had isolated this bacterium, like when they could finally first grow it, from his son's sputum.
Erin Allmann Updyke	Oh, was his son okay?
Erin Welsh	I don't know.
Erin Allmann Updyke	Okay.
Erin Welsh	But there was one really sad treatise that I read from 1822 I think, something like that. And the physician who wrote it lost several of his children to whooping cough and I think was inspired to research more about it after that horrible experience. Anyway. Okay so then this development of being able to actually culture the bacterium in a lab was super important because it really laid the groundwork for trying to make a vaccine and that was the big target from the outset.
Erin Allmann Updyke	Yeah.
Erin Welsh	And the vaccines themselves, ones for pertussis, weren't that far behind. Just a few years after announcing they were able to culture the bacterium in the lab, these two dudes announced that they had developed a vaccine, Bordet and Gengou, and then not far behind was someone named John Zahorsky at Washington University in St. Louis.
Erin Allmann Updyke	Oh.

Erin Welsh	And he said, 'I've got a vaccine too.' And neither of these vaccines would really prove to be that reliable or that stable, that effective. And it would take another couple of decades for an effective and reliable pertussis vaccine to come onto the market. During those decades the prevalence of pertussis remained high with between 5000 and 8000 deaths annually.
Erin Allmann Updyke	And that's just in the US? Okay. Wow.
Erin Welsh	And then three awesome scientists come onto the scene.
Erin Allmann Updyke	Dun-dun-dun!
Erin Welsh	These are whom our quarantini is named after.
Erin Allmann Updyke	I imagine when you said 'three awesome scientists' like the western doors opening and some spurs. Can we throw that sound effect in? Thanks.
Erin Welsh	Yeah, let's do that.
TPWKY	(saloon music plays)
Erin Welsh	Howdy there, partner. (laughs) I don't know.
Erin Allmann Updyke	(laughs) I don't know.
Erin Welsh	Okay.
Erin Allmann Updyke	Anyways.
Erin Welsh	So walking through those saloon doors is Pearl Kendrick, Grace Eldering, and Loney Gordon.
Erin Allmann Updyke	All right.
Erin Welsh	Pearl Kendrick was born - I love the name Pearl, I think it's wonderful.
Erin Allmann Updyke	It's very adorable.
Erin Welsh	She was born in 1893 in Wheaton, Illinois.
Erin Allmann Updyke	I have no idea where it is.
Erin Welsh	Me neither. I probably should. From the start Pearl was fascinated by evolutionary biology and disease. And after she graduated with a degree in zoology she taught school during the week and then in her free time on the weekends took a train down to New York City to volunteer as a research assistant in a lab that worked on typhus.
Erin Allmann Updyke	Oh my god. I already am gonna love these three women. Like it's gonna hurt my heart how much I love them.
Erin Welsh	Oh my gosh. Well I just love that it's like in my free time, a nerd after our own hearts.

Erin Allmann Updyke	Right? Yeah.
Erin Welsh	And she ended up loving her lab time, her research so much that she was like, 'You know what? This is what I wanna do full-time. I don't wanna be a teacher, I want to work in a research lab full-time.' And so that's exactly what she did.
Erin Allmann Updyke	Wow.
Erin Welsh	She started out working at the State Health Departments first in New York and then in Michigan. And then in Michigan she worked at a microbiology lab in Grand Rapids while also earning her PhD at Johns Hopkins on the side.
Erin Allmann Updyke	What?
Erin Welsh	She full-time full-timed it.
Erin Allmann Updyke	What?
Erin Welsh	She double-timed full-time.
Erin Allmann Updyke	Oh my god.
Erin Welsh	And while she was at this microbiology lab in Grand Rapids she hired and mentored a scientist named Grace Eldering. Eldering was inspired to study science due to an extremely bad case of whooping cough that she had as a kid.
Erin Allmann Updyke	Oh.
Erin Welsh	So she, like Kendrick, worked first as a teacher after graduating but then applied for this job in the Michigan lab where she would work with Kendrick. And together these two made headlines for their many developments in the world of pertussis.
Erin Allmann Updyke	Wow.
Erin Welsh	For instance in the early 1930s they developed a diagnostic test for the bacterium which was great because that could be used to determine how long an infected child was contagious.
Erin Allmann Updyke	Oh.
Erin Welsh	And that was then super important for quarantine and controlling the spread of the disease.
Erin Allmann Updyke	Yeah.
Erin Welsh	Then came their work on the whole cell pertussis vaccine. So up to this point there had been, as I mentioned, several vaccines for pertussis produced but because it was so difficult to culture in the lab, only a very limited number of vaccines could be made. So it was often like a one sample, one vaccine.
Erin Allmann Updyke	Right.

Erin Welsh	It wasn't an effective or efficient way to make vaccines.
Erin Allmann Updyke	Yeah.
Erin Welsh	Kendrick and Eldering found a way around this but didn't have the resources to widely administer the vaccine. But a visit from Eleanor Roosevelt in 1936, so she was First Lady at the time, changed all of that.
Erin Allmann Updyke	Wow. My heart is fluttering.
Erin Welsh	There should be a movie.
Erin Allmann Updyke	I'm fangirling so hard. Can we make a movie?
Erin Welsh	Yeah, okay.
Erin Allmann Updyke	Let's do it. I would watch it.
Erin Welsh	So would I. So Eleanor Roosevelt, she had read about their work and she was like, 'I wanna go to this lab and visit you and learn more about it.' And she was really impressed by all of the progress that they had made. And it's funny, I think in a letter or something from that time either Kendrick or Eldering said that Eleanor Roosevelt was one of the only people who visited the lab who actually understood what was going on.
Erin Allmann Updyke	(laughs) I that's really funny.
Erin Welsh	I love that. So yeah, Eleanor Roosevelt was so impressed that she was like, 'All right, I'm gonna give you guys all the funding that you need.' And they were like, 'Oh great, sweet.' So then within a few years mass production of the pertussis vaccine began.
Erin Allmann Updyke	What?
Erin Welsh	Boom. That's it. Just kidding.
Erin Allmann Updyke	Yeah. There's a third woman.
Erin Welsh	There's a third woman, she's coming onto the scene. So yeah, they had the ability to mass produce these vaccines but the demand still way outpaced the supply. So they needed to find a way to increase the amount of bacteria that could be cultured in the lab.
Erin Allmann Updyke	Okay.
Erin Welsh	They put out an ad for a position and hired a dietician named Loney Gordon on the spot. Loney also came into science sort of through these back channels as well like getting her degree in this and then working as a dietician and then this and that. And they were then lucky enough that she applied for this position because her job was basically to try some different broth recipes until they could find one that worked well for Bordetella pertussis.
Erin Allmann Updyke	Oh okay.

Erin Welsh	And she got there, it wasn't that long actually until she found that adding sheep's blood to a broth did the trick. And so suddenly with this new recipe Kendrick, Eldering, and Gordon were able to start manufacturing this whole cell pertussis vaccine in large enough quantities not only for the state of Michigan but also for other states as well.
Erin Allmann Updyke	Wow.
Erin Welsh	Isn't that great?
Erin Allmann Updyke	And this is in the 1930s.
Erin Welsh	This is in the 1930s, early 1940s, yeah.
Erin Allmann Updyke	Three women kicking booty, developing a vaccine.
Erin Welsh	Yeah.
Erin Allmann Updyke	Ugh I can't, that is so, so cool.
Erin Welsh	It's so inspiring. I love it.
Erin Allmann Updyke	We do need to make a movie about this.
Erin Welsh	Seriously. And also they didn't stop there. They weren't just like, 'Oh this is good enough, let's pat ourselves on the back.'
Erin Allmann Updyke	We're done.
Erin Welsh	They were always seeking new ways to improve the production or efficacy of the vaccine and so they started to play around with adjuvants which if you remember from the vaccines episode, adjuvants are basically chemicals that are added to a vaccine that can increase the effectiveness by stimulating the immune system in certain ways.
Erin Allmann Updyke	Right.
Erin Welsh	So the team from Michigan used aluminum hydroxide in the pertussis vaccine which - and correct me if I'm wrong - stimulates macrophages to basically do better at their jobs?
Erin Allmann Updyke	Yeah, that sounds about right.
Erin Welsh	They pick up the antigens and interact with the lymphocytes and concentrate in lymph nodes and so on?
Erin Allmann Updyke	Yeah, exactly. So they're able to increase the amount of immune response by driving your cells to that area kind of a thing.
Erin Welsh	Yeah.
Erin Allmann Updyke	Yeah.

Erin Welsh	Which makes it a longer lasting and more effective and better vaccine. And so this new and improved whole cell pertussis vaccine with this adjuvant was put to the test in 1943 and it was shown to be super successful, provided lasting and effective protection against the disease. And then a couple years later, in order to reduce the number of shots that children would have to get for vaccines, the pertussis vaccine was combined with ones for diphtheria and tetanus in the mid 1940s. And that's why we called it the DTP vaccine.
Erin Allmann Updyke	Yep.
Erin Welsh	And this vaccine was widely administered throughout the whole world and as a result the incidence of pertussis fell and fell. Here's some numbers.
Erin Allmann Updyke	Yes.
Erin Welsh	Before the pertussis vaccine there were an estimated 270,000 cases of pertussis annually in the US.
Erin Allmann Updyke	207,000?
Erin Welsh	270,000!
Erin Allmann Updyke	Oh I'm sorry, 270,000.
Erin Welsh	270,000!
Erin Allmann Updyke	Wow.
Erin Welsh	That's the number of cases. In the 1980s, so this is after the vaccine had been in use for approximately 40 years and before the vaccine hesitancy movement really began, there were between 1200 and 4000 cases per year.
Erin Allmann Updyke	Wow.
Erin Welsh	That's a drop of almost 99%.
Erin Allmann Updyke	Wow.
Erin Welsh	Wow.
Erin Allmann Updyke	Wow.
Erin Welsh	And so as I mentioned earlier, in the part II of our vaccines episode I went into a lot of detail about how this pushback against the DTP vaccine began and so I'm not gonna do that here. But briefly, there was a global decline in vaccination rates with the DTP vaccine and the fears were mostly based on the pertussis component of the vaccine. And so as you might expect the decline in vaccine coverage lead to outbreaks. And so in Sweden for instance the annual instance of pertussis cases went from 700 total in 1981 to 3200 in 1985, just 4 years later.
Erin Allmann Updyke	Wow.

Erin Welsh	In Japan there were 206 cases in 1971. In 1979 there were 13,105 cases.
Erin Allmann Updyke	Holy mackerel.
Erin Welsh	Obviously something had to be done to get people to vaccinate again or to somehow reduce these fears, whatever it was.
Erin Allmann Updyke	Yeah.
Erin Welsh	So because so many people were not vaccinating out of fear that the whole cell pertussis vaccine would lead to deadly side effects in their kids, one solution was just to make a new vaccine which is how we got the acellular pertussis vaccine. So instead of these whole killed bacteria which is what the - the name gives it away - the previous vaccine was, it included just these toxins, these antigens from Bordetella pertussis.
Erin Allmann Updyke	Yeah.
Erin Welsh	And the efficacy, and I'm sure you're gonna talk more about this, but the efficacy of this vaccine wasn't as high as the whole cell version but it was associated with fewer adverse reactions and so that replaced the 'P' component of the DTP vaccine and it became DTaP to stand for acellular pertussis in the 1990s.
Erin Allmann Updyke	Yeah. Which Erin means that we got at least one whole cell vaccine.
Erin Welsh	Cool.
Erin Allmann Updyke	Yep. Probably a bunch actually cause we were pretty much done getting our vaccinations by the time they introduced DTaP in 1992.
Erin Welsh	Yeah. Excellent.
Erin Allmann Updyke	Yeah.
Erin Welsh	One of the things that I find interesting when doing the research for some of these episodes is that I get to read these articles that were written over a really long time span.
Erin Allmann Updyke	Yeah.
Erin Welsh	So like some were written in the 1800s, 1700s, whatever, translated from this and that. And you can see how the language used and the sentiment about a topic really changes over time.
Erin Allmann Updyke	Interesting.
Erin Welsh	And that was especially apparent for pertussis. In more recent articles pertussis is always described in the introduction as this reemerging problem that highlights the difficulties in educating the public and how quickly progress can be undone. But in these older articles or chapters from before the 1970s but after the vaccine was developed, it was written about as a great triumph of modern medicine in many of them.

Erin Allmann Updyke	Wow.
Erin Welsh	And there was one line that really stuck with me when reading one of these old articles and it was the one that you mentioned earlier, the one from 1975. The author says, quote: "As recently as 1948, pertussis remained a leading cause of death in children under 14 years of age in the United States. Now the disease has become almost a medical curiosity. The Center for Disease Control for example no longer routinely reports pertussis."
Erin Allmann Updyke	Wow.
Erin Welsh	So Erin, that was 1975, this is 2020. Tell me just how much that statement is no longer true.
Erin Allmann Updyke	Yeah you're not gonna like it. Let's take one more quick break.
Erin Welsh	Okay.
TPWKY	(transition theme)
Erin Allmann Updyke	Let's just go straight to the facts.
Erin Welsh	Let's do it.
Erin Allmann Updyke	2018, United States of America. You wanna guess how many cases of pertussis there were?
Erin Welsh	Is it more than 5000?
Erin Allmann Updyke	Oh yes.
Erin Welsh	Oh my gosh.
Erin Allmann Updyke	15,000!
Erin Welsh	Okay.
Erin Allmann Updyke	15,000 cases of pertussis in the US in 2018 including 5 deaths.
Erin Welsh	15,000 cases of a vaccine-preventable illness.
Erin Allmann Updyke	Yep. So let's talk about that. Well first really briefly we'll talk about it across the globe and then we really need to spend some time talking about this vaccine-preventable disease aspect. The World Health Organization didn't have super great numbers more recently, like in the last couple of years but for example in 2014 it was estimated that there were over 24 million cases of pertussis worldwide and over 160,000 deaths in children under age 5 years.
Erin Welsh	What?
Erin Allmann Updyke	160,000 deaths from pertussis in children under age 5 in 2014.
Erin Welsh	Oh my gosh!

Erin Allmann Updyke	Yeah. So this is not a disease that has gone away and in fact it's been on the rise for a number of years now, probably since the 90s, it's been kind of increasing every year. And there's a number of reasons for that. So let's start talking about this vaccine. You mentioned that in the late 80s, early 90s is when we pretty much switched from a whole cell vaccine to an acellular vaccine. That's really important. The acellular vaccine does not provide as long lasting immunity as the whole cell vaccine. So that means that immunity while it still exists is not for your whole life when you get the acellular vaccine.
Erin Welsh	Right.
Erin Allmann Updyke	However, and this is really important especially I think in talking to people who are vaccine hesitant who maybe sometimes use that as an excuse, 'Well it doesn't provide long lasting immunity, wouldn't it be better just to get infected with the disease that kills people to begin with?' Even getting infected with pertussis does not provide lifetime immunity.
Erin Welsh	Interesting.
Erin Allmann Updyke	Yeah. This is a very interesting aspect of pertussis that I didn't realize until starting to research this.
Erin Welsh	Yeah.
Erin Allmann Updyke	So even getting infected doesn't provide lifelong immunity. Does it provide longer immunity than getting a vaccine? Yes, most likely. But still you can get reinfected with Bordetella pertussis even if you get infected as a child and survive that infection.
Erin Welsh	Is the infection less severe in subsequent infections?
Erin Allmann Updyke	So overall, great question. Overall whether you get infected and survive which again, not everyone does, if you get infected or you get vaccinated then the disease that you get subsequently is most likely to be less severe. So even though vaccination doesn't provide lifelong immunity, it's massively protective against serious illness and death from pertussis. Even with the whole cell vaccine, immunity does wane but it's usually over maybe 10, 15, 20 years whereas with the acellular it might be 7-10 years that your immunity starts to wane. So that means that if you got your last vaccine say when you went to kindergarten, then by the time you get to high school you might not be immune anymore or at least not completely immune, your immunity has waned. So what we see is while we have these really high numbers of pertussis today in the United States and across the globe, it's not just because of vaccine hesitancy, it's not only in unvaccinated people. We also see increasing, we see actually a shift in the age groups of people who get infected.
Erin Welsh	Oh, yeah.
Erin Allmann Updyke	So while you talked about kind of throughout the last 500 years of this disease, it's been mostly a disease of children, right? Not babies necessarily but children, this is a disease of childhood, maybe like 1-2 year olds up to 10 year olds, where the majority of people who got sick before the introduction of any vaccine. Now today the largest numbers of people who get sick are actually adolescents and young adults. So in 2018 in the US 30% of those 15,000 cases were in people age 11-19.
Erin Welsh	Wow. Okay.

Erin Allmann Updyke	Yeah.
Erin Welsh	I have a question about sort of the vaccine. Now when you go to the doctor, cause I know the tetanus vaccine you need to get reupped every 10 years.
Erin Allmann Updyke	Yep, 10 years. Yep.
Erin Welsh	When they give you that booster, is it DTaP or is it just tetanus?
Erin Allmann Updyke	Good question. It used to be just TD which is tetanus and diphtheria. Now it's recommended that adolescents get at least one booster of TDaP which is the adult version of tetanus, diphtheria, and acellular pertussis.
Erin Welsh	Okay.
Erin Allmann Updyke	But it didn't used to be the case because we thought oh this provides a long enough immunity because the whole cell vaccine did.
Erin Welsh	Yeah.
Erin Allmann Updyke	But now it's recognized that immunity wanes faster than we maybe expected and that's part of the reason that we see an increase in the number of cases in older age groups. But this is really important because the other group that's massively affected besides adolescents are the very, very old who are immunocompromised and tiny babies who are too young to be fully vaccinated.
Erin Welsh	Right.
Erin Allmann Updyke	And in those groups up to 50% will be hospitalized and in that age group is where we also see the highest mortality rates. So while infants under the age of 6 months were only 9% of the total cases of pertussis in the US in 2018, 42% of those babies were hospitalized.
Erin Welsh	Two questions. How old do you have to be to get the first pertussis vaccine? Second question, when you go in for your tetanus booster, do you have to specifically ask for Tdap?
Erin Allmann Updyke	First question is easy, you get your first DTaP at around 2 months of age, as early as 6 weeks but usually around the 8 week, 2 month mark. And it's a series of four vaccines usually, so you get it at 2 months, at 4 months, at 6 months. So that's why up to 6 months you haven't gotten your full dose of it so you're still at risk.
Erin Welsh	Okay.
Erin Allmann Updyke	And in those kids and in older adolescents it's more likely to present with an atypical course which we kind of touched on a little bit, we hinted at in the biology section. But once you have some antibodies that you've built up against this infection, you're less likely to have that characteristic whoop of the whooping cough.
Erin Welsh	Oh, okay.
Erin Allmann Updyke	Because you have a less kind of intense infection.

Erin Welsh	Yeah.
Erin Allmann Updyke	But what's also scary is that in tiny infants this can also present with just apnea which means cessation of breathing entirely.
Erin Welsh	Right.
Erin Allmann Updyke	So you don't have the coughing, you don't have the whoop, you just have babies who stop breathing which is terrifying.
Erin Welsh	Yeah, that's horrifying.
Erin Allmann Updyke	Yep. Your second question was do you have to specifically ask for a Tdap? At this point the recommendation is if you haven't, if you are an adult who hasn't had a Tdap booster at any point in your life then you should get one and then after that you would just get your regular tetanus and diphtheria every 10 years. But let's talk about a couple of specific groups that should get boosters and can talk to their physicians about this.
Erin Welsh	Yeah, would you just go to your physician and say, 'Hey, can you check my titers?' Or 'Hey, check my records.'
Erin Allmann Updyke	Absolutely, you could do that. Yeah, check my records, have I had one recently? If not, most physicians will be like, 'Yeah, let's give you a Tdap because it's certainly not gonna hurt you.'
Erin Welsh	I was gonna say is there any harm in getting an early booster?
Erin Allmann Updyke	No, there isn't. And there are a few groups who should really consider getting boosters. Number one, anyone who's going to be in contact with a tiny baby. Pregnancy, it's now recommended and in a lot of countries it's standard practice that during pregnancy in the third trimester, so between like 27 and 36 weeks, we give Tdap boosters. And this has been hugely important in preventing illness in that tiny baby age group. So pre 2 months where that baby is entirely unvaccinated. If you vaccinate during pregnancy then you can pass antibodies, maternal antibodies, onto the baby.
Erin Welsh	Right.
Erin Allmann Updyke	Which is massively protective.
Erin Welsh	That's great. That's amazing.
Erin Allmann Updyke	And didn't used to be standard practice, unfortunately. That's pretty much all I have, Erin, about the state of pertussis today. I tried to find some current research on what's going on and the NIAID, the NIH page was last updated in 2016.
Erin Welsh	Whoa.
Erin Allmann Updyke	Right?
Erin Welsh	Come on.

Erin Allmann Updyke	Come on.
Erin Welsh	Well it's hard because it's like with many of the other diseases that we do an episode on it's like, 'Oh there's a new drug therapy, there's a new vaccine in development, there's a new something.' But this is like we have antibiotics that can work if you give them early enough and we have a vaccine that works. So maybe the progress needs to be made in public education?
Erin Allmann Updyke	I think so.
Erin Welsh	In access? Like reducing the barriers to vaccine access?
Erin Allmann Updyke	I would say there could still be work to be done on creating a more effective vaccine that produces longer lasting immunity as well especially since we're seeing waning immunity and kind of developing a better immunization schedule perhaps for older children and adults. But what's hard is that it's easy to give vaccines to small kids because they come to the doctor on a regular schedule. Once kids get older and become adults, we don't necessarily go to the doctor on a regular schedule so it's really hard even if you have an effective vaccine to give a booster, it's hard to get that booster to everyone to actually create the herd immunity that we need to protect the vulnerable people in our population.
Erin Welsh	It still seems like an upward battle.
Erin Allmann Updyke	It's an upward battle for sure, it always is with diseases though, isn't it?
Erin Welsh	Yeah, yeah. But there's a lot of amazing work done in this upward battle and for pushing for vaccine education information and for just promoting the use of vaccines. And so one of these amazing people who's working on this you heard from earlier, Catherine Hughes, and we wanted to have her talk a little bit about Light for Riley.
TPWKY	(transition theme)
Erin Allmann Updyke	As traumatic as it was I'm sure to go through and to relive it, you have really turned this into a lot of advocacy and done amazing things as a result of this tragic situation. So can you tell us a little bit about sort of what that's been like for you to kind of take the worst possible situation and try and make something good out of it?
Catherine Hughes	I really believe that life can be measured in years but it can also be measured in impact. And so when Riley died we felt devastated that his life was so short in years but we thought that perhaps we could somehow extend his life by making sure that it had an impact on the world. So we sort of were loaded with that really strong urge to do something to create a legacy for Riley. But we were also filled with the sense that what happened was so unfair and that it was preventable and that it shouldn't happen to other babies and other families. So we were really driven to spread awareness and we started our campaign which is called the Light for Riley campaign. We were really determined to shine a light on the importance of vaccination and the dangers of whooping cough.

	It was when Riley was really sick in hospital that I sort of jumped on my phone and began googling all the information I could find out about whooping cough. And that's when I learnt that other countries were offering pregnant mums a whooping cough vaccine during pregnancy. And I felt so upset that this hadn't been offered to me in my pregnancy. I'd had the flu vaccine in pregnancy, I knew I was the type of mum to say yes, if you recommend it, I'll do it. And we know now that babies that are born to mums who have these whooping cough vaccine in pregnancy, the chance of them catching whooping cough is drastically reduced. So I truly believe Riley would probably still be here with us today if this pregnancy whooping cough vaccine had been offered to me.
	So with that knowledge it was very instinctive for us to embark on our Light for Riley campaign. We've done media interviews and social media campaigns and we travel around to pregnancy expos where we talk to pregnant mums about the importance of getting vaccinated. And we've seen really good uptake of this vaccine in Australia, so around 80% of mums are saying yes to this pregnancy vaccine. But then again that's still 20% of babies who are being born at risk of contracting this disease which is always circulating around our community. So there's so much more that we want to do.
Erin Welsh	It's incredible work that you're doing and it's also really inspiring because this must not be an easy thing to do. In your experience with the Light for Riley campaign, what do you feel like have been the biggest challenges you've had to overcome?
Catherine Hughes	I think we've had two challenges with our Light for Riley campaign. The first is just coping with grief while trying to put ourselves out there. Grief is a funny thing and I think it's different for every person but that's certainly been a challenge trying to manage grief and advocacy. And the second challenge we faced was for want of a better word being attacked by the anti-vaccine movement. This happened within a day of Riley's death, we were getting messages on Facebook from anti-vaccine activists and we've had an incredible amount of blog posts and Facebook messages and comments and all sorts of things from the anti-vaccine movement. I truly believe that Riley's death is a bit of an uncomfortable truth for them. Riley was unvaccinated. He was too young to be vaccinated. And it's probably scary for them to realize that unvaccinated children die from vaccine-preventable diseases.
	We've also seen a lot of conspiracy theories about us, we've been told that we are actors, that we're being paid by Big Pharma, we've been told that Riley never existed, we've been told that we murdered him, all sorts of stuff. And again I think it's just because anti-vaxxers can feel very uncomfortable when it comes to facing the truth. The best way for us to deal with the anti-vaxx movement is really to give them as little attention as possible, we don't respond to them for the most part, we ignore them. The people that we wanna focus on are those who are on the fence or just don't know much about vaccination, they're really the people that we want Riley's message to get across to.
Erin Welsh	What sort of future plans do you have for the Light for Riley campaign? Do you have anything that's currently in the works or anything upcoming?

Catherine Hughes	In 2016 we launched our charity The Immunization Foundation of Australia and so that's kept us really busy, I absolutely love being a director of this foundation because we're not just focused on whooping cough but on immunization in general. We want all babies and all families to be protected from these potentially deadly vaccine-preventable diseases. So we'll continue traveling, I do lots of speaking and workshops, we present to schools, we've got puppet shows for kids to make them feel more comfortable with the process of vaccinating. We're looking to collect more stories about families who have suffered through vaccine-preventable diseases cause we believe it is so important that people know their stories because vaccination is almost a victim of its own success, we don't see these stories around so much because vaccines work so well. But as parents we need to know why we vaccinate. And we're also looking at hopefully being able to donate some vaccines overseas later this year as well to children in developing countries.
Erin Welsh	That's wonderful. What an inspiring campaign. Where can our listeners learn more or read more about Light for Riley and some of the work that you're doing through the campaign?
Catherine Hughes	If you go to our Facebook page which is just Light for Riley on Facebook, you can read all about Riley's story there. And then also on our website which is www.IFA.org.au.
Erin Allmann Updyke	Thank you so much for sharing your story not only with us and our listeners but with everyone around the world with your campaign and all of the work that you're doing. It's really incredible.
Erin Welsh	Yeah. This was really wonderful, thank you again so, so much. We really appreciate it.
Catherine Hughes	Thank you, thanks. It's such a pleasure to speak to you guys. And apologies for my terrible Australian twang, hopefully it doesn't ruin your whole podcast.
Erin Allmann Updyke	I love it.
Erin Welsh	It's perfect! We love it. (laughs)
Erin Allmann Updyke	I think we need a little bit more twang on our podcast.
Erin Welsh	For sure, for sure. That was fantastic, it's so inspiring to hear yet another awesome woman doing incredible work on pertussis.
Erin Allmann Updyke	Yeah.
Erin Welsh	Should we get into sources?
Erin Allmann Updyke	Let's.
Erin Welsh	Okay. I have somehow accumulated an unbelievable number of sources for this one.
Erin Allmann Updyke	Wow, look at you, overachiever.

Erin Welsh	There was no consolidated... Usually I'm like oh great, there's a book, I'll read that book. But there was no single book this time so it was much more of a digging down the rabbit hole. But I'll mention a few of these. So one was from Aslanabadi et al from 2015 and that was about these possible epidemics in Persia. A couple great articles about just the history of pertussis, one by James Cherry from 2015, another by Chow et al from 2016. And the evolutionary paper came from Diavatopoulos et al 2005. And the title of our quarantini Three Women & a Baby came from a title of a chapter of a book, 'Between Hope and Fear: A History of Vaccines and Human Immunity' by Michael Kinch and that one I mentioned also on our vaccines episode. And honestly there are a bunch more and I'll just put them all on our website. Sorry that was a really long list.
Erin Allmann Updyke	Yeah, I have a number. We'll post all of them on our website thispodcastwillkillyou.com under the EPISODES tab. All right so thank you to Bloodmobile for providing the music for this episode and all of our episodes.
Erin Welsh	Thank you again to Catherine Hughes for being so amazing and coming onto our podcast and being willing to share her story. And we hope that you all enjoyed it as well. And we will post links to Light for Riley in our show notes and on our website, so keep an eye out for that.
Erin Allmann Updyke	And thank you to you all for listening as always, we really love making this podcast, so thanks for letting us do that.
Erin Welsh	Yes, we do. Well with that, wash your hands.
Erin Allmann Updyke	You filthy animals.