

COVID-19 Chapter 5: Vaccines

Erin Welsh “My husband was exposed to a person who was later positively diagnosed with COVID-19, although that person has remained asymptomatic. My husband and I have been self-quarantined in our home since we found out that person had tested positive. We are in our early 30s and not worried for ourselves, but do not want to risk spreading this to anyone else. My husband began developing mild symptoms two days ago and I began developing mild symptoms last night. We are both experiencing shortness of breath, chest congestion, cough, mild fever, and general body ache.

Our case manager with the public health department spent most of the afternoon fighting to get tests ordered for us. When we called urgent care to say we were coming, they told us to stay home. They agreed to see us when we explained that the health department told us to get tested at our nearest urgent care. The Washington Post is reporting that sick people across the country are being denied coronavirus testing. If my husband had not been exposed to a confirmed case, I believe we also would have been denied. How will we know who has this sickness if testing is not widely available? Our urgent care appointment was incredibly frustrating. The nurse met us at a side door with masks. We were there for nearly two hours; no one seemed to know how to treat us, what protective gear they were supposed to wear, what questions to ask us. The nurse took off her face shield while in the room with us to make it easier to see the computer. We overheard her say she has pneumonia. Why was a nurse with pneumonia assigned to us?

We were there for nearly two hours and the whole time could hear people outside of our room asking one another what to do; someone was on the phone with what seemed to be the CDC. Their guidance appeared to change while we were there. The healthcare system is not prepared for a pandemic. We were first tested for flu; my results came back positive, my husband’s negative. We were both written prescriptions for tamiflu. We were also tested for COVID-19, but will not hear back until Monday or Tuesday or maybe even Wednesday because labs are not staying open over the weekend. When you get tested for COVID-19 you have to sign a form saying that, among other things, you will self-quarantine until you get your results back. Our doctor sent our tamiflu prescriptions to a pharmacy inside of a Target. We had to point out to her that this would break our quarantine, and maybe it would be a better idea to send it to the pharmacy that was literally next door and offered drive-thru pickup. It still took over two more hours to fill our prescriptions there as the one sent to Target was not cancelled properly.

So now we wait, under mandatory quarantine. We have enough food and other supplies but worry for others who do not. I hope the government and healthcare system figure out what do, and quickly.”

[musical interlude]

Erin Updyke Erin what date did we get that email?

Erin Welsh So, we got that email on March 13th.

Erin Updyke Oh man.

Erin Welsh So. So this was an email that we received from someone who wanted to share their story. And we asked whether we could share this anonymously, they did not want their name to be shared. And we really appreciate you sending us this email, because I think it's hugely important. Because it illustrates what a lot of people in the US are facing right now, these challenges in getting tested.

Erin Updyke Mhm. Absolutely.

Erin Welsh Hi, I'm Erin Welsh.

Erin Updyke I'm Erin Allmann Updyke.

Erin Welsh And this is This Podcast Will Kill You. Welcome to Chapter 5 of Anatomy of a Pandemic. This is our series on COVID-19.

Erin Updyke So far, what have we talked about? We've talked about the SARS-CoV-2, the virus itself, we've discussed COVID-19 the clinical disease picture, we chatted about control strategies and also what we might expect from this epidemic curve and what we've seen so far. So, in this episode, we asked an expert all of your questions about vaccines and the development of a vaccine against SARS-CoV-2. But we'll get to that in a minute. First...

Erin Welsh First things first, it's Quarantini time! [laughter]

Erin Updyke Of course it is.

Erin Welsh How are we still managing to sound bubbly for that part? I don't know. Are we? Do we sound bubbly?

Erin Updyke I, I don't know.

Erin Welsh Okay.

Erin Updyke Do we?

Erin Welsh I don't know. What are we drinking in any case?

Erin Updyke I'm drinking water. But, if you want a quarantini [laughter] you could make quarantini number 5, which is essentially a tequila sunrise.

Erin Welsh Yeah. So. Tequila, orange juice, cherry, little bit of cherry, splash juice, grenadine.

Erin Updyke We'll post the recipe for this quarantini as well as our non-alcoholic placeborita on all of our social medias and our website... every time. Every time.

Erin Welsh Every time.

Erin Updyke Okay.

Erin Welsh So, a couple of pieces that might be helpful to know before we jump into this interview, just so that we are all on the same page when it comes to vaccines. If you want a primer on how vaccines work and all the various types of vaccines, we have this in enormous detail in our two vaccines episode, the first of which has a lot of detail on the types of vaccines and how your immune system responds to vaccines. So, if you haven't heard it or if you've forgotten, entirely, which, you know, I'm among those [laughter] it exists online for you. But for this interview, let's quickly go over some of the different types of vaccines there are whole vaccines, so this is a vaccine that's made of an entire virus or bacteria, and those can be either killed or what we call attenuated so that means they are less virulent. And they can't really cause disease. There are component vaccines, which means the vaccine is made of pieces of the virus (or bacteria), usually components of their surface so that our body can make antibodies against these surface proteins that can then help fight off the virus if we ever get exposed to it, and finally the newest kinds of vaccines, which, I think are fascinating, are DNA or RNA vaccines. And so that means injecting the DNA or RNA sequence (or part of it) of the virus or bacteria into your muscle, and then your body has to use that sequence to make the proteins. And then your body makes antibodies to those proteins. Thus, immunizing you.

Erin Updyke It's, it's very cool. RNA vaccines are awesome.

Erin Welsh It's beautiful.

Erin Updyke And so, having these different types of vaccines mean we have a number of different ways to target infectious diseases, including novel pathogens like SARS-CoV-2. In the past, vaccine development relied heavily on creating attenuated versions of pathogens, so, live strains of bacteria or viruses that don't cause disease but otherwise act a lot like 'real' pathogens. Or, in other cases, we made vaccines out of whole, killed cells. But, both of these types of vaccines take a long time to produce, largely because they require first isolation and then culture of the pathogen in question. And then, you have to grow the pathogen in large enough quantities to be able to produce a vaccine. And this process takes a long time and a lot of money too.

Erin Welsh So much money.

Erin Updyke Mmhm.

Erin Welsh Today, with the advent of molecular techniques including gene sequencing we can much more rapidly determine a protein or a gene sequence that could be used as a target for vaccine development. And we've seen this time and time again with every new pathogen that has emerged in recent years. From SARS, to MERS, Ebola, Zika, groups rapidly begin to try to identify potential targets that we can use to create a vaccine. But even though we can do this more rapidly than in the past, and even though genetic tools give us a kind of a head start, as you'll hear our guest explain, there are still very many steps to the development of an effective vaccine, and they can't be skipped.

Erin Updyke So, our guest today is Dr. Maria Elena Bottazzi. She's been working for years with her group in Texas on a vaccine against coronaviruses, since the days of SARS and MERS. So we brought her on to talk about her work on the development of a vaccine for SARS-CoV-2, the virus causing COVID-19. She'll answer all of your questions about what the steps are in vaccine development, looking at that timeline to development and whether we can hasten the process along while still maintaining safety standards. So, the vaccine that her group is working on is a component vaccine, so it's made of that spike protein that you've probably heard a lot about in the news, and if you've listened to the other episodes in this series. But, we'll let her introduce herself and tell you all the details of that vaccine that she's working on. Right after this break.

[musical interlude]

Maria Elena Bottazzi So I'm Maria Elena Bottazzi and currently I co-direct, together with Dr. Peter Hotez, a center for vaccine development which is based in Houston and it's embedded with Baylor College of Medicine and Texas Children's Hospital. So it's a very unique vaccine center because we not only apply certainly business practices, you know, regulatory practices like any other big biotech or pharma, but we do it embedded in academic health centers because we have a lot of support through, you know, collaborations with other, I guess, researchers. But at the same time in the nonprofit sector, try to build these vaccine technologies with the ultimate mission that they can be affordable, reachable, and certainly be deployed to populations who really need them. You know, for the public good.

Erin Welsh Excellent. Talking now about SARS-CoV-2, which is the virus that causes COVID-19. What about this virus makes it a good candidate for a vaccine?

Maria Elena Bottazzi So COVID-19 as a coronavirus and, you know, by that also any virus, you know, usually developing interventions to prevent them in are not easy to do. So there's nothing particular about this virus that would make it easier or less easier to develop a vaccine against it. And you know, still with all the science advancements and technology advancements we can't really predict when we would be successful at developing vaccines. And certainly now you even hear that most of the vaccines that are being developed in this new, I guess, era compared to maybe the, you know, old generation vaccines like the measles, mumps, rubella, is that new vaccines tend to be coming more and more that are not considered fully protective type of vaccines, but they're vaccines that are geared

to reduce the severity of illness. Maybe reduce the, certainly, intensity of infections by different pathogens. And it's getting harder and harder to develop vaccines that are going to 100% protect an individual. But that's still okay. Right? I mean that, you know, that's better than nothing, you know, again, I think the value of vaccines, whether they're fully protective or they are partially protective ultimately is to try to, again, reduce deaths, reduce severity, hence reducing people to having to engage the healthcare systems by being hospitalized or of course even going all the way to being an put into intensive care units, and change the way that we therefore can manage these diseases by, you know, being able to treat them like if you were getting a common call with you can basically maintain them through some simple at home type of a containment or even just a clinical management.

Erin Welsh So is the reason that it's becoming more difficult to create these completely protective vaccines, is that, does that have something to do with the timeline of vaccine development? Or is it just sort of in the pathogens that we're talking about today where we've kind of tackled all of the low hanging fruit of the infectious disease world?

Maria Elena Bottazzi Well, maybe it's actually a little combination of both. Right. So, again, if you think of how the old vaccines were originally generated, you know, we used to do them quite rudimentary right? You know, using the entire pathogen and then you either kill the pathogen or inactivate the pathogen. And even though those vaccines are certainly still an approach that people occasionally evaluate, more and more now they're becoming much more sophisticated in the sense that we do them synthetically. Therefore we avoid also putting in any components of the pathogen that is really not necessary for us to, you know, confer protection in the human host. You know, so, yes, I mean, the procedures, the ways that we produce vaccines and test vaccines, you know, have some level of impact of how quickly we can move them. But I think the, the second, which is the fact that pathogens, the ones that we consider the easy pathogens that we knew we could develop vaccines very rapidly, most likely we already did them. But now we're dealing with very complex pathogens that even have very multiple transmission modes or that their cycle of survival includes an intermediary vector or reservoir right? So like, I just can give you as an example. You know, the malaria vaccine, right? Why has it been so hard? Because what do you develop a vaccine against? Which stage of the parasite, you know, do you do it from the parasite that is in the blood stage or not? Do you look at, you know, the parasite when it's inside the mosquito? These viruses more and more are also quite intelligent in themselves. So they're very complex in the nature of how they not only find ways to infect, but also where they come from. And therefore it makes it a little bit more challenging for us to find how we can tackle them and prevent them to not only infect us, but certainly cause disease.

Erin Updyke Excellent. So in the case of SARS-CoV-2 this new coronavirus, how is the vaccine that your group is working on being made? What is it targeting, and how is it going to work against this new virus?

Maria Elena Bottazzi So if we look at the vaccine that we currently are developing, as I mentioned, since our mission is really to always find ways that would lead to a technology that is already using a proven platform. So that's always been our case. So by proven platform, I mean, in our cases a is a recombinant protein based vaccine. And the reason we select that is because we know there are already many vaccines that are licensed and being used that use that same technology. So the backbone, therefore of the way that we want to make the vaccine, it's proven and already has a lot of safety and as well as data on how you can rapidly produce it and how good are they by scaling them? And certainly the amount of costs, you know, that these types of platforms costs. So recombinant protein based vaccines are, in general, quite affordable. And more importantly, they don't need to have very sophisticated manufacturing plants. And even in low middle-income countries that do have capacity to develop their own vaccines could rapidly adopt them. And that is certainly one consideration that we want is that, you know, we don't develop something that is too much of a high cost or it has too much complexity in the technology that then we can only make it in the U S and then nobody else is able to adopt it because it's just too expensive or too labor intensive. So that's one aspect. The second aspect specifically for COVID-19 is that we, everybody's trying to attempt to develop a vaccine targeting the, what they call the spike protein, which is a protein the virus uses to infect the human cells. But even within the spike protein, there are a lot of components that maybe they're not necessarily, you know, useful in the induction of this protective response. So we, with a group of partners from the New York blood Center as well as the University of Texas Medical Branch here in Galveston, we were kind of like picked apart the spike protein, and we narrowed down what we think is the most essential piece that we need for us to be able to induce a response in humans that is protective, but at the same time evaluates the safety of using it. So it's actually a small piece that is called a receptor binding domain. So amongst the spike protein, the spike uses this domain to specifically target this component in our human cells that needs to be bound on and therefore used to infect the cells. So we therefore engineered in our lab a recombinant protein that specifically just expresses this receptor domain. And we, when you put it in the right formulation, we know that in animal models it does induce a strong and certainly efficacious response, and protects against, you know, our challenge of the SARS virus. Now, there's a disclaimer here that, you know, our vaccine was developed back in 2011. So the engineering of this vaccine was really based on the SARS virus that was circulating at that time and not COVID-19 virus. But there are several evidence and strong scientific evidence that the two viruses are very similar to each other. So we believe that we should evaluate it to see whether there may be a potential of cross protection.

Erin Welsh That's wonderful. Kind of giving you a jumpstart on the SARS-CoV-2 vaccine potentially.

Maria Elena Bottazzi Right. And you know, we will not know if it's a perfect fit. It may not be a perfect fit, but you know, I think if anything at this point, I know there are many efforts trying to develop very specific COVID-19 vaccines, and they certainly all use different strategies and even different platforms. Some may be more favorable

than others. Again, we probably are the only ones focusing on this small domain. We also are in parallel trying to engineer a brand new vaccine that is against specifically the RBD of this new virus. But in the meantime, you know, since we were already so advanced with the prior vaccine because we already even have it in our freezers manufactured with a grade that can be used in the clinic, we think that we should not just wait for us to develop a new one. We should, you know, in parallel start evaluating the one that we already have designed.

Erin Welsh Do you mind walking us through that timeline for vaccine development and then testing and then deployment and then maybe how soon you think we could expect to see an effective vaccine for SARS-CoV-2.

Maria Elena Bottazzi Certainly. So developing vaccines and to be quite honest, any biologic, it's a long process. So if you start from scratch, like for example, we're starting from, you know, looking at the genetic code of a, of the virus, identifying what we want to target. I mean, at least for this, we already have a heads up because we already had an idea of what to target. So let's, let's take the example. Okay. We know we want to target the receptor binding domain of the spike. So, rapidly we clone that, we have to look for the process for making it, you know, at laboratory scales. But then that laboratory scale has to be scaled up to the point where it becomes not only a pilot scale in manufacturing agencies, but eventually even what we call industrial scales. That, just that process of from the cloning, engineering, to scaling, and producing usually can take from six months all the way to maybe 18 months, to even 24 months. Of course it depends on is it easy to make it, is it not easy to make it? Are the processes very complicated? Since we already know for SARS that we already had developed was a very simple approach and it ended up being quite an easy process. We, for instance, think that, you know, we could have a new process for the SARS-2 RBD or the COVID-19 RBD in probably the next six months. So that's one piece. However, after that, of course, you know, producing something doesn't tell you whether it's usable or if it's going to be safe or if it's going to be protective. So, we, before going to humans, you have to start a whole preclinical plan where you have to have an animal model, of course, that has to be suitable for the pathogen that you want to test your vaccine against. We know that there are currently several groups that have been developing these COVID-19 animal models. They probably are not ready 100%, but you know, there are already a few that people are using to be able to evaluate any kind of a vaccine, or even drugs for example. So that process of evaluating your produced vaccine candidate usually can take, again, another six, maybe, to another nine months. So there goes a year, right? And that's just only preclinical. After that, when you decide that, yes you can make it, yes you have indication in some model, then the critical activities start. And by critical activities mean what we call the regulated, the activities that then you can provide as evidence to our regulatory body, in our case, the United States Food and Drug Administration, so that they can evaluate that information. And those include three main components. So, a formal manufacturing campaign, a formal toxicology study in an animal model, and then of course, a plan of how you're going to do the first in-human safety evaluation. And those three activities generally take another year or a year and a half. So you already have one year for

the, what we call research and development. One year, maybe two years for the initial critical path activities. And after you finish that first, then you design a long-term plan where eventually you evaluate in larger populations, you look at efficacy you look at safety. And so as you can see, can be a two-to-three year program, or can become a 10 year, 20 year, 30 year, as you have seen for many other vaccine programs. There is never an assurance that we will find one. But, of course you have to do the studies to be able to evaluate if there's even the feasibility of doing so.

Erin Welsh In a situation like this where there's increasing need for the development and deployment of a vaccine, you know, I have seen a lot of news articles talking about shortening those steps. And so, which of those steps would be shortened to then maybe, you know, get an early release of, of a vaccine?

Maria Elena Bottazzi So I think that it's not really a shortening of the steps, as much as trying to instead of doing them linearly and one after the other, that there's been some, I guess, in consultation with the regulatory bodies, that you can stagger and maybe do things in parallel. So for example, as you're already developing this process, you rapidly already engage the manufacturer, and you could already have them do some what we call engineering runs and therefore you don't have to wait until you have a process fully developed before you already engage a manufacturer. Right? So you condense it that way. In the area of preclinical testing, you may be able to, while you're doing some of these preclinical tests, you already ramp up to have a design for your toxicology study. And then on top as you're doing your toxicology, you don't have to wait for the end of it while, as if you release the safety data as it comes out, it, I guess, educates how you can then start your clinical study. So, normally they like you to do one thing and then get all the data, and review it, and then plan for the next step. In these kinds of emergencies, they're allowing that you can unblind some of the information so that you can start things in parallel, and not necessarily wait until you have a study totally completed. And that's how they're trying to condense the timelines. Definitely one thing that you cannot do is you cannot skip steps, right? I mean, I think, even though maybe in the news, there's this perception that, you know, how could they, have they done this? You know, we haven't seen any data, because ultimately, you know, we, in the scientific community, we get access to the information because people publish it or make it available, right? I mean, right now, I think either there's been no time to sometimes see all the data that is kind of around, or sometimes we do see data, but it hasn't really been evaluated by peers. So it's at the same time it's quite struggling, right? Because these agencies I assume have purview of information that maybe not all of us have, and it's the key to have experts in whatever communities they're set up to make sure that they try to make the most safe and appropriate decision. And that said, you know, it's a strong, a big pressure on, on people, right, to make these decisions when you are on top have this urgency behind you, right?

Erin Updyke So, I know a lot of the focus has been on the development of vaccines and in general we are better at developing vaccines than we are antivirals it seems. Do

you know if there are antivirals that people are working on or, or maybe why it might be easier to develop vaccines than it is antivirals?

Maria Elena Bottazzi So in fact, I think you got it the other way around. So usually what we call either small molecule drugs or even some things, these types of immunotherapies tend to have a little bit more on accelerated process for moving forward towards, you know, eventually use the usability. And the reason is the following vaccines, at least the ones that generally are being developed, they're what they call preventive vaccines. So the intention is that you use them in normal healthy populations. So, the risk/benefit of giving something to a healthy person that eventually can then lead to something that is of high risk, the bar is a lot higher, right? You know, you are a little bit more cautious of what you use to give to a healthy person. Therapies, as you know, they're intended to be therapeutics, and therefore you are already tackling and supposed to use them in already sick people. So, the bar may be a little bit lower, right? Because being sick, and being certainly severely sick, and with the option of death, you know, there's a lot of protocols that you can use with the argument of compassionate use where you are trying to really evaluate that this is going to not only extend the life, or certainly improve the quality of life, in the event that you can't totally prevent the ultimate death, right? For now, the level of urgency as you've heard in the news, you know, the ideal is first have the ideal diagnostics, right? Because you need to know who is infected and who's not. Second is if you already have those infected, how can you really prevent these people to have severe disease and therefore avoid deaths. And so here is where a lot of the therapies are being rapidly evaluated and even repurposed. Some therapies that may be used for something else, they are evaluating them. But ultimately in the long-term, you want to, if you can't avoid infection through, you know, either containment or other practices, you eventually will need to have a preventive vaccine, right? Because even if this outbreak or pandemic disappears, if there were to be something in the future, you don't want to scramble again just to try and to find therapies. You want to have a full toolbox, right? Good diagnostics, good preventive measures for those who haven't gotten the disease yet, and also already have therapies for those who unfortunately do get it.

Erin Welsh Gotcha. That makes sense. Just as in our first episode on coronaviruses, we asked the people that we interviewed what about this disease concerns you and or is cause for concern? And what about it is maybe not as much of a cause for concern as the media has made it out to be, or something maybe about the vaccine development stages that reassures you?

Maria Elena Bottazzi Well, I think to be quite honest I think it is a concern, right? And I think that concern stems from the rapid transmission that we are seeing from people to people, right? And as you have noticed, you know, there's been some really enormously drastic attempts to try to even reduce our social connections to try to minimize the transmission of this virus. And it's been quite interesting, even compared to the other coronaviruses that we have seen before. So that's definitely a distinction. I think the unpredictability, right? You know, that you cannot really predict, you know, even how these curves will be looking, how, you

know, certainly what happened in China and what's happening in Europe. We're trying to make a lot of inferences of what's going to happen maybe in the Americas. So there's a lot of unknowns, and, I think it's, it's a stress that everybody has, not only personally as an individual but as a community, but you know, including all the first responders and certainly the medical and researchers that are, you know, more in the trenches about this. It's very hard to predict, right? So we should take this seriously and try to, as much as we, you know, are not very happy, you know, to try to really contain our social connectivity at this point. And it's tough. Now I think, you know, the other challenge that I see is, and I appreciate that a lot of media is trying to push information, is still, you know, again, to be very conscious of the quality of the information that has been pushed out, and who is using reputable sources, where are the reputable sources to look at, and not get totally blindsided by noise that is really trying to disrupt, you know, where the real information is, and people are just getting distracted. So I hope that we can figure out a way, and this is a lesson learned of the power of course of media and social media, but that at the same time it's making our lives a little difficult because people are just getting distracted by information that is just absolutely not useful. And then I think in the area of, again developing vaccines, if anything, I hope that this just, that the population understands that, ultimately, those of us who are working on these types of interventions, we don't take this lightly. That the way we do this is, you know, to ensuring first and foremost the safety of anybody that will eventually use them. And so that they can reinvigorate again their acceptance that vaccines work. That even in the context of COVID-19 there are so many other diseases that are certainly potentially important. There are a lot of them that already have vaccines that clearly they're a hundred percent protect or even partially protective. And we should therefore continuously ensure that we are up to date with our vaccinations. Because I think you know, we are also seeing that there was a little bit of a disconnect about, you know, the, the value of vaccines and how it brings value as a public health tool and that this is really a public health. You know, that all communities have to engage in and need to support these types of initiatives.

[musical interlude]

Erin Welsh Thank you again so very much to Dr. Bottazzi, we really, really appreciate it.

Erin Updyke Yeah, thank you so much for spending the time to talk to us and explain all of those things.

Erin Welsh Also, we're very excited that she's working with Dr. Hotez.

Erin Updyke Our friend Hotey! [laughter]

Erin Welsh Our friend Hotey [laughter]

Erin Updyke I think that, he probably hates that I say that. [laughter] I don't know, let us know.

[laughter]

Erin Welsh I love it, and that's more important.

Erin Updyke So, what have we learned from this episode? First of all, there are a lot of different strategies to vaccine development. So we learned a lot from Dr. Bottazzi about the strategies that her group is using. So, developing a component vaccine based on the platform that they had been using for MERS. But one thing that I want to point out, is that there are a number of different strategies that groups can use. And they're all doing this simultaneously. So there is a group that has started safety trials, so phase 1 trials of an RNA-based vaccine. And I think this is pretty exciting cause this is the first of its kind in humans, that's actually being tested in humans. There are DNA-based vaccines that are being used in animals right now, but this one, it's the first RNA-based vaccine that I know of, and it's first one being tested in humans. So it's gonna be very interesting to see how that trial goes. And if you want to know even more details about the work that Dr. Bottazzi's doing as well as what other types of vaccine trials are going on remember that you can check out clinicaltrials.gov to see all the registered human clinical trials for vaccines and drug treatments. So. Yeah.

Erin Welsh Point two. We also learned that while you could in theory, at least, create a vaccine for nearly any pathogen, it seems that a lot of the pathogens that we are seeing emerge have complexities that makes them super difficult to target. And whether that's a complex life cycle, or complex components so it's difficult to know which component of the pathogen to target, or maybe whether it's just completely novel pathogens that we know nothing about. So we're starting from scratch in a lot of these cases, and that can make creation of a successful vaccine much more challenging.

Erin Updyke Number three. And this I think is a really important point to take away from this interview. Although we can try and do some of the steps of vaccine development in parallel, we can't skip on safety, and nobody is trying to. So there isn't a way to *drastically* shorten the time course of vaccine development. So, the fact that there were groups like Dr. Bottazzi's group already working on vaccines for similar viruses means that they already had platforms in place which could be built upon. And that is unbelievably helpful in helping to hasten the development of vaccines for novel pathogens.

Erin Welsh The other big take away I think that was super interesting from our conversation with Dr. Bottazzi, is that one of the big challenges in vaccine development is in ensuring safety, since vaccines are something that we inject into otherwise healthy people to prevent them from getting a disease, rather than treatments, which are something that we use once someone is already sick. And so this is a difference in weighing the risks of a particular vaccine versus a particular treatment. And this is interesting because honestly, we don't really have a lot of specific treatments for most viruses, but, we'll hopefully talk in a future episode about how many different treatments are out there that are already trying to help people currently infected with SARS-CoV-2.

Erin Updyke Yeah, which is awesome. Number 5, and what I think my favorite takeaway from this episode, is to underscore just how important it is, even in times when it seems like everything is fine, and there's no scary disease coming after us, we need to be funding research into vaccine development. Because we never know exactly what disease might emerge next, but having systems and platforms in place that we can build upon is really useful in ensuring rapid access to potentially life-saving treatments and vaccines. And so, I think we've kind of touched on this in almost every episode, but, funding science research is really important.

Erin Welsh Yeah, absolutely, and I think, you know, one of the things that kind of occurred to me as we keep saying these things, as we keep saying "ooh, social responsibility for social distancing" and "you need to keep funding this" we're kind of preaching to the choir.

Erin Updyke I know. [chuckles]

Erin Welsh I don't know if there are many people, I don't know if there are many of our listeners that need to be convinced of these things, especially now. But, these things are still an issue. And so if you want to make an impact if you want to spread the word, you can just spread it by talking about it, or you can contact your congressperson if you're in the US.

Erin Updyke Absolutely.

Erin Welsh Make your vote matter with these sorts of issues and topics. And so, this is something that you can make an impact on. And you know, I kind of feel like we are just shouting into an echo chamber a little bit, but, you know.

Erin Updyke It's true.

Erin Welsh Let's get the message out there.

Erin Updyke Yeah. [chuckles] that's all we can try and do, man, really.

Erin Welsh Yeah. And voting.

Erin Updyke Good point, Erin!

[light chuckles]

Erin Welsh Okay, sources?

Erin Updyke Sources. So if you'd like to know more about the study that's going on right now with that RNA vaccine, we'll post the details to that clinical trial. And then if you'd like to know more in general about the different strategies that groups use to try and develop vaccines for emerging viruses, there's a great paper by Afrough et al. that was published in *Clinical and Experimental Immunology* last year. So we'll post that on our website as well.

Erin Welsh Awesome. Thank you so much, again, to Dr. Bottazzi for taking the time to chat with us about the work that she is doing on a vaccine. We really, really appreciate it.

Erin Updyke Mmhm. And thank you to Bloodmobile for providing the music for this and all of our episodes.

Erin Welsh And thank you to you, listeners. We really appreciate you listening [chuckles]

Erin Updyke Chapter 5!

Erin Welsh Chapter 5! [laughter]

Erin Updyke Wow did you make it this far? That's amazing. I feel like people should get a prize if they actually listened to all of this.

Erin Welsh Definitely.

Erin Updyke What's a prize?

Erin Welsh Hmmm...

Erin Updyke I think the prize is the next episode, Chapter 6.

Erin Welsh Yeah! Chapter 6 will be your prize, that's exactly right. That's, this... This is Exactly Right.

Erin Updyke This is... Exactly Right.

Erin Welsh We're losing it. Okay [laughter] So.

[laughter]

Erin Welsh Before we lose it completely, wash your hands...

Erin Updyke You filthy animals!

[musical outro]