# The Suno India Show

## What goes into the fast tracking development of a vaccine- A virologist explains

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***Padma Priya:*** *With confirmed COVID-19 cases worldwide surpassing 13 million, as of the day of this recording, with no sign of it slowing down, scientists are pushing forward, with efforts to find and develop vaccines and treatments to slow down the pandemic, and lessen the virus' effects. It is estimated that some of the earliest treatments will likely be drugs that are already approved for other conditions and have been tested on other viruses. Many groups across the world are also working on potential COVID-19 vaccines, with several, also backed by the nonprofit Coalition for Epidemic Preparedness Innovations (CEPI). Currently, there are more than 150 projects around the world centred on the development of COVID-19 vaccine. According to a WHO summary of the state of vaccine development for COVID-19, there are already 23 potential vaccines in human trials, with 3 of them in or starting large-scale late stage, or Phase III trials to test efficacy.*

*More recently, vaccine development and discussion came into limelight after a letter by Indian Council of Medical Research (ICMR) was circulated widely, which set August 15 as a deadline for a vaccine to be rolled out in India. While ICMR later clarified that the letter was internal and was aimed at bypassing the "red tape" surrounding vaccine research, a lot of experts and ethicists have raised concerns on this.*

*Hi. I am Padma Priya, editor for Suno India and you are listening to The Suno India Show. This episode is part of our mini-series where we bring to you conversations with leading virologists, doctors, scientists and other experts on all things vaccines, drugs, ethics surrounding the research and development and access to these drugs and vaccines.*

*In the first episode, you heard Dr S P Kalantri, talk about Randomised Control Trials, and their importance in testing the efficacy of the drugs.*

*In this episode, I spoke to Dr Shahid Jameel, the Chief Executive Officer of the DBT Wellcome Trust India Alliance, which is a biomedical research charity, which funds research for non-profit institutions in India. They work as a partnership between the government of India's department of biotechnology and the Wellcome Trust, which is a large UK based charity. Before joining India alliance in 2013, Dr Jameel was the leader of the virology group at the International Center for genetic engineering and biotechnology, where he worked for 25 years researching viruses.*

**Padma Priya:** *When this pandemic hit and when you heard about the novel Coronavirus, what was the first thought that came to your mind as a virologist?*

**Dr Jameel:** The first thought that came to my mind is, "So, here we go again!" There was one in 2003, another in 2012, and here comes another coronavirus. Frankly, I didn't think at that time that it would cause so much devastation, spread so fast and amongst such a large population in the world, and essentially, change our lives.

**Padma Priya:** *What about this virus has been so difficult for scientists? Even 6 months down the line, is there anything new that we know about this virus? We are still debating here if it is airborne or if it's aerosol transmitted. So, what about this has been, I would say, particularly frustrating for you, as a virologist and a scientist?*

**Dr Jameel:** Well, I'm really not frustrated. As a virologist, I'm fascinated. We talk about having learned so little in 6 months. But, I honestly think that we have learned a whole lot in these 6 months. Never in the history of any disease, have we had more than 140 vaccine candidates in the pipeline, 60-70 odd very serious candidates, 17-20 candidates already in human trials. That really speaks of the power of technology of the accumulated knowledge. When SARS came in 2003, I recall, we jumped on very quickly and started working on the SARS virus. Of course, we didn't have the containment to grow the virus but we did other things with it. When I compare that time to this time, life is moving really in the fast lane right now.

**Padma Priya:** *As part of preparation for the interview, I put a status on my Facebook, asking friends and family members to leave comments. I said that I'll be interviewing an expert and asked what are some of the questions and doubts that they have about vaccines. I think For me, what was really interesting was the number of people who wanted to know more about how a vaccine is developed in the first place, and what fast tracking of vaccines actually means. So, firstly, how exactly is a vaccine developed? And, what do scientists, researchers and other experts mean when they talk about fast tracking vaccine development?*

**Dr Jameel:** One is how vaccines are developed and the second is how vaccines are tested and approved, because the fast tracking really comes in the testing and approval point. There is nothing simple about making vaccines, because there are many ways you can make a vaccine. Possibly, the simplest way to make a vaccine is to grow the disease causing organism. I will focus on viruses since we are discussing viruses. But, the principles apply to bacterial vaccines as well. If you are able to grow the virus quickly to large amounts, that's possibly the easiest way to make a vaccine. You grow the virus to large amounts, you purify it, and the purification is fairly simple because you essentially purify it away from the cells on which you grow the virus. You then treat it with a chemical to inactivate it and shoot it into animals and people to test it. Now, that's the simplest way to make a vaccine. That's called an inactivated vaccine. This started big time in the 1950s with the polio vaccine, the

Salk vaccine, which was developed by Jonas Salk in the US. It started trials in humans in the US. It became so valuable that when the next vaccine, the live attenuated vaccine or oral polio vaccine came, the US didn't have the capacity to test it. So, it was given to the Russians to test it. The first test happened when a virologist couple gave it to their children. It was very successful. Now we know that the oral polio vaccine is talked about much more. Even in our pulse polio program, that vaccine has proven very successful. Those are the ways to make vaccines based on viruses. You can have an inactivated virus or grow the virus on different kinds of cells to a point where the virus becomes very weak and unable to cause disease but still able to multiply in vaccinated people. That's called a live attenuated vaccine. Those vaccines are based on whole viruses. You also have sub-unit vaccines where you can take a part of the virus, typically a protein on the surface of the virus, and you can produce that protein in large amounts. Now, in the days of recombinant DNA technologies, you make it through recombinant means. And a good example of that vaccine is the Hepatitis B vaccine, which was made in the 1980s. And was the first recombinant human vaccine to have been produced, which essentially is expressing the surface protein of the virus into a in an yeast cell and purifying the product out of that, formulating it and using it as a vaccine. The third kind of vaccines are what is known as viral vector vaccines, where you take a common virus that has limited disease causing potential as a vehicle to carry a particular gene into the host, and there the virus replicates and expresses the gene that you have put in. And that leads to immune responses. Now, examples of that vaccine that we see right now are the Oxford vaccine, for example, which uses an adenovirus found in chimpanzees. And it is expresses the spike protein of the of this Coronavirus SARSCoV-2 to to produce an immune response and there are many others based on other kinds of adenoviruses based on measles virus, a virus called the adeno associated virus based on another virus called the vesicular stomatitis virus. So these are different viral vectors that people have used. Genetic vaccines are based on either DNA or RNA, RNA we have seen only this time around. And the example would be the Moderna vaccine, which was the first to go into human trials. A DNA vaccine essentially takes out a piece of DNA on a plasmid and shoots that in, instead of sending the plasmid through a viral vector, you send it directly. And those are called DNA vaccines. An example of a DNA vaccine in India, for example, is the Zydus Cadila vaccine that has been approved for trials. So these are the different kinds of vaccine platforms that are available. The question is how come so many vaccines got developed so quickly? Yeah, and the reason for that is that people have been researching vaccines and people have been developing those platforms. So the DNA platform available viral vector platforms have been available. And, you know, people who have been working on these platforms very quickly stitched together the genetic components of the new virus into those vectors and produced vaccines. So it's really sustained efforts of scientists around the world who have created these platforms that have led to this really explosion in vaccinology that you see today. Now the way vaccines are tested is not very different from the way drugs are tested. Once a vaccine is developed in the lab, Then you know it has to be first tested in animals. In labs, you typically do trials in small animals typically mice, sometimes you do it in guinea pigs or ferrets, but generally small animals. Do two things: one to see whether the vaccine is safe in

animals and second, whether it raises the right kind of immune responses. Once you are certain that it gives the right kind of immune responses in a small animal model, you contact a company and the company essentially produces large batches of the vaccine candidate and they follow what is known as a good manufacturing practice protocol which essentially means that every single component is controlled for quality. Every single step is documented, which often doesn't happen in a research lab. To that the company can produce multiple lots of the vaccine. The first thing that happens is toxicity testing in animals and the protocol is that you must test in at least two different animal species. Now, once the toxicity is tested, and the vaccine is found to be safe in animals, the company produces that documentation to the regulator, which in India is the Drug Controller General of India (DGCI). And the regulator looks at the document and gives permission to carry out trials in humans. The human trials are divided into three phases. Phase 1, you essentially test the safety of the vaccine in a small group of healthy volunteers. This is typically anywhere from about 10 to 100 people that you would test it in. And these have to be healthy humans, handy volunteers. Once you find the vaccine to be safe in these people, then the regulator allows you to go through phase two. Phase Two is essentially a trial to do again, safety studies in a larger group of more diverse populations. So in Phase 2, you will have to, for example, test it in people of different age groups, you'll have to test it in both men and women, you'll have to test it in people with comorbidities. So for example, testing in children or in people with comorbidities would not be allowed in Phase 1. But after getting Phase 1 safety data, you can test it in these populations. So the idea simply is that the vaccine when it goes into the population will go into all sorts of people, and therefore it must be tested in varied populations. In phase two, you also do immunogenicity studies. So you see if, in different groups of people, you're getting the right sorts of immune responses or not. And the third thing you do in a Phase 2 is to set the dose and schedule for vaccination. Should you give one shot or two shots of three shots, how far apart they should be? How much amount of the vaccine you should be giving in each shot, all those things are set in Phase 2. And phase two typically contains a few hundred people who test vaccines. Once all this data is produced to the regulator, the regulator will allow you to do a Phase 3 trial, which is essentially an efficacy trial. It determines how effective the vaccine is in the field to prevent infection and or disease. And in this case, you have volunteers who are randomly divided into two groups. You have a placebo group and you have a vaccine group. You have thousands of people in an efficacy trial. And then after you have given the right numbers of doses that you determined in Phase 2 after you have gone through an observation period, which will vary depending upon how prevalent the diseases in a given area, you break open the code and find out how many people in the placebo group got infected compared to vaccine group. And that really determines the efficacy of the vaccine. So it's a fairly long process that can take anywhere from months to years. And there is really no getting away from this because at the end of the day before a vaccine goes into a population, you have to ensure that the vaccine is safe and the vaccine is efficacious. It does what it is supposed to be.

**Padma Priya:** *In such a scenario, what does fast tracking mean? What does it mean when someone says we're going to fast track it, it's going to come out and say 12 to 18 months?*

**Dr Jameel:** So what I explained to you is a serial process, yeah, tested in animals. Then we go to Phase 1, Phase 2, Phase 3 in the accelerated protocol which not just India but world over it's being followed now in the accelerated protocols since we are in a pandemic, the regulators are given permission to try the safety in humans even before the animal data is fully available. You may provide safety from animals for the regulator to allow you to do safety in humans without getting immunogenicity data from animals. In some sense, the processes run in parallel while the animal data is getting completed, the human trials can start and this is how it has happened this time around. You could also combine Phases 1 and 2. So for example, the regulator in India has given clearance for both the ICMR Bharat Biotech vaccine and the Zydus Cadila vaccine for both Phase 1 and Phase 2 trials, but at the end of the Phase 1 Phase 2 the regulator will look at data and only then give permission for Phase 3 trials. So, there are some things you can fast track but then there are other things you cannot fast track. So, that has to be clearly understood. So, in the context of an August 15 deadline, I think that was a very ambitious, impossible deadline. And I think ICMR has also clarified that chapter so, we will not focus too much on it, but there are, let me just say that there are things that you can fast track, but then there are things that you cannot fast track. The second issue is emergency use approval, which you said about Ebola for example. Yeah. So the Ebola vaccine was given emergency approval to be given to humans. Before even the Phase 3 efficacy testing was done. So Phase 1 was done, Phase 2 was done, so they knew it was safe, but they were not fully sure of the efficacy. They knew that it was producing the right kind of antibodies. So they knew that it might work, but they had no efficacy data. And it was given because there was an ongoing outbreak of Ebola. So essentially, phase three was tested in an outbreak situation. So that was the emergency use approval. Now for the COVID vaccine so far there has been only one emergency use approval and that has been getting a vaccine from China, it is produced by a Canadian and Chinese joint venture called CanSino Bio. That has been given limited emergency approval after phase two, to be given only to members of the army in China, it has not been approved to be given to anyone else. So, maybe the Indian drug regulator can follow that and give emergency to, you know, approval after seeing the fees to data for the vaccine here to be given to high risk populations, such as healthcare workers, security agencies, it's really entirely up to the regulator.

**Padma Priya:** *Talking about the efficacy um, how is the efficacy for vaccines determined? In a population as huge as ours, what does the efficacy of a vaccine actually mean?*

**Dr Jameel:** So when you test for efficacy, you do the trial at multiple locations so that you make sure that you're testing it in as broad a population as possible. So for example, you would not be testing it just in North India or South India, but you will be testing it across the country at multiple sites. You will be testing it on people of various age groups and there are

always exclusion and inclusion criteria for any vaccine or drug that have to be approved by the regulator and which also has to be approved by the ethics committees of the institutions where the testing is going to happen. Firstly, it has to be tested across the country and in a large enough population, so it would have to be tested on thousands of now, let's say that the protocol is that you will give three shots of the vaccine. Maybe the first two shots, three weeks apart, or four weeks apart, and the third shot you will give after that say two months or three months. So, after all this is over, there will be an observation period and the observation period will depend upon how much the disease is prevalent in that area. To give you an example, if an efficacy trial were to be done in Delhi or Mumbai, or Chennai, Bangalore, where the virus is transmitting quite fast right now, the observation period could be shorter. But if you were to do the same thing in Kerala or in Arunachal Pradesh, where there is very little virus circulating, you would have to follow a longer observation period. The idea is for people to get naturally infected. And at the end of the observation period, you will do assays on the blood drawn from people in the trial to figure out how many people got infected in the vaccine group versus how many people got infected in the placebo group. So, let's say you are trying a thousand people 500 placebo 500 vaccines. And in the placebo group, you find that, you know let's say 100 people got infected, and in the vaccine group, you'll find that nobody got infected. Now that's a vaccine that has hundred percent efficacy. But you know, there will be some people also in the vaccine group who will get infected, and that will determine what percent efficacy you see in a large population.

**Padma Priya:** *And does efficacy ever hit like hundred percent? Do we say polio vaccines are hundred percent efficient?*

**Dr Jameel:** Efficacy also depends on many other many factors. What sort of morbidities people have the genetic background of the person in whom you gave the vaccine. That's why efficacy is almost never 100% population efficacy. So for example, the oral polio vaccine since you talked about it. In many countries, the pulse polio type program was carried out just a few times and they found that children had the right kind of immunity raised to polio virus. In India on the other hand, we have gone through 10-20 doses in children, and yet we don't find that they have very good immunity. And the reason for that is that children in India and other parts of the world also Sub Saharan Africa, are exposed to many other gut pathogens, which do not allow the vaccine virus to colonize the gut and, you know, replicate and produce immunity. So that's just one example of what can happen. So, yeah, never hundred percent, and that's why you have to test populations. The second factor is you have to distinguish between a vaccine that prevents infection versus a vaccine that prevents disease. And this is an important concept to understand most vaccines prevent disease, they do not prevent infection. So if you look at influenza vaccines, for example, it does not prevent infection by the influenza virus, but it may prevent disease. It prevents people from getting bad disease. And that's really what you won't want to not have disease. You don't care whether you get infected or not. But you shouldn't get sick. So, that's that's an important distinction to make.

**Padma Priya:** *What does naturally developed herd immunity mean, as opposed to vaccine developed herd immunity? And earlier, even though the last few months there has been a lot of discussion that in India, we might have to try and achieve this herd immunity. So just as a layperson, what does that actually mean as a public health strategy when we're talking about herd immunity, and what is vaccine developed for herd immunity?*

**Dr Jameel:** Okay. So herd immunity essentially means that in a cluster, in a group, it could be a city, it could be a district, it could be a state. If a certain percent of people get infected and naturally develop immunity, then they will also protect people who have never been infected and don't have immunity simply because the virus cannot very efficiently transmit from one human to another. You essentially limit the susceptible hosts because once you achieve, for example, 60 to 70% of a group of a population group having natural immunity, then, you know, the virus just burns itself out, it doesn't really transmit efficiently within that population. And you can then extrapolate it to a country. That's really what is meant by herd immunity. People who are not have not been exposed are also protected because there are others around them who have been exposed and who have immunity. Okay, so that's natural herd immunity. You can achieve the same thing by vaccinating. So if you have vaccinated let's say 60-70% in a given population, the virus will not be able to transmit through them and therefore, the chance of the virus to find a susceptible person will be reduced. Therefore, the susceptible person will also be safe.

**Padma Priya:** *After how long after taking this vaccine, supposing it comes anytime in the next early next year or whenever? Will it help us remain immune to the vaccine or to the virus? Because there is also very little information now regarding reinfection and correct me if I'm, if I'm wrong about that. But how, how is it that scientists are sure that it will protect people like this vaccine to protect people from infection from getting on, say another round of infection?*

**Dr Jameel:** Firstly, scientists are not sure at all, and scientists are never sure. Unlike many other professions, scientists always doubt their own data scientists question their own data and scientists doubt everything. So science is based on doubt. It is based on a culture of doubt of questioning. Unlike, for example, religion, which is based on a question of belief, cultural belief, we don't know how long the immunity will last simply because those tests haven't been done. Yeah, there is no vaccine that has been tested. We can get hints from people who have had the disease naturally and who have recovered from disease. And we can sample them and see how long antibodies are lost in these people and how better they have memory. To this infection, all that we can measure. And, frankly, in this case, what we see is that people who are asymptomatic or get mild disease don't show very strong antibody response and their antibody daily disappears fairly quickly compared to people who get severe disease. So that's one point to understand. The second is that these studies are typically done in a longitudinal manner. So you can sample somebody who has

recovered from disease after one month after six months after a year after five years. In this case, we just don't have enough time yet, the disease is barely six months old. Yeah. So about all we know is data points that cover in about three to four months. For people who have recovered from disease, but that's just not enough information to answer this question, whatever information is available, indicates that the vaccine delivered responses may also not be very long lasting. Now, whether the vaccine response wanes in one month or six months or a year, I don't know, nobody knows. But consider that there are other viruses that behave similarly. For example, every year you have to take a flu shot. Because the virus changes every year we are not talking about changing viruses, but maybe we are talking about immunity that's not long lasting. Also consider that there are four other corona viruses that are circulating in humans. For a long time they are endemic to the human population. Two of these are responsible for about 20% of the common cold that we get annually. Now, we get exposed to these viruses, they cause about 20% of common cold every year. So it means that the immunity is not long lasting. So all these, to my mind indicate that even vaccines will give temporary respite but they will not be the magic bullet that everyone thinks that they will be. But you know, we will get whatever we can in a pandemic situation to protect people who are vulnerable. Even if there is a vaccine available, let's say in six months time that has only 30% efficacy or only 50% efficacy even that will be useful to protect vulnerable groups. There is a value in having the vaccine.

**Padma Priya:** *Talking a bit about India and you know how it is currently in the race for developing a vaccine. Do you think that you know, apart from say R&D we also have the manufacturing ability or the capacity to scale up in case a vaccine is found?*

**Dr Jameel:** Actually, our strength in India is manufacturing and scale up. In the vaccine field, we have done R&D but where we lack in R&D is to have platforms available where you can very quickly move no matter what disease comes through. And I feel that in the very near future now, actually we should start putting together those platforms, because this is not the last outbreak that we will see in our living memory. But India's true strength is in manufacturing. India provides roughly 60% of vaccines to UNICEF for childhood immunization. So, we have very large capacity. It is estimated that the global capacity for vaccines is about 8 billion doses every year, out of which about 3 to 4 billion a year resides in India. Whether it's a vaccine developed elsewhere or developed in India Indian companies will be involved in manufacturing and scaling up vaccines. There will not be an affordable COVID vaccine for the world without Indian involvement. I'm very sure of that. And if you look at companies like Bharat biotech, Zydus Cadila, e biosciences, they are all in partnership with various different developers and they have multiple vaccine platforms that they are developing. There will not be a global COVID vaccine without India.

**Padma Priya:** *Will there be any side effects because it's being fast tracked because you might not spend the same amount of time that you would spend in another vaccine?*

**Dr Jameel:** So, the side effects of something that are studied in Phase 1 and 2, when you look at safety and I believe that that should not be faster. Phase 1 and Phase 2 should be done properly. So that we know that the vaccine is safe. There will always be some side effects of vaccines or anything that you take, nothing is hundred percent safe. It's always a risk to benefit that you estimate even the paracetamol is not safe to some people. So that has to be kept in mind the risk benefit is that it is important, but yes the vaccine needs to be tested for its safety. And I really feel that it would build a lot of confidence in the fast tracking process. And in vaccines, if people who are involved in the development, manufacture, testing and approval of the vaccines come forward and take it themselves that will build a lot of confidence. Maybe our members of Parliament's should be the first ones to take the vaccine. Yeah, imagine how much confidence it will build in the rest of the country.

**Padma Priya:** *When it comes to vaccination, if there is any, and we've seen these instances, I think even with polio vaccination, if say something happens with, say, one child, then often that community gets really scared, and there is a lot of fear that gets generated. What would be some of the steps that you would also be taking to make sure that that kind of fear doesn't set in?*

**Dr Jameel:** These are natural. And therefore I think a couple of things must happen. One is that the communication must be absolutely clear. Don't hide facts and let people make a choice. Because as I said, it is a risk benefit. Even the pulse polio vaccine, which has been so hugely successful in eradicating polio from the world has, you know, leads to poliomyelitis in one out of a million children who are vaccinated. Now, people get hung up on that one child who gets the disease, and I know it's cruel. It's a statistics but that one child is hundred percent for that child, but essentially, if you look at a population level, if it's one in a million, look at the number of lives you are saving. So, I think firstly, it's very important to be very clear in your communication, be honest and say, what might be the side effects and let people decide whether they want to take that vaccine Or not. And the second as I said, it will build a lot of confidence if people who are at the forefront of this come forward and take the vaccine themselves so build trust in the system, that's what I'm saying.

**Padma Priya:** *In a situation like this in a pandemic, where you know, you have vaccines being developed, you have drug research going on, who actually takes accountability. Now, if say, something happens in case of side effects, like I mean, now say for example, the Bharat Biotech one has been done in collaboration with the ICMR, but who takes the ultimate accountability in that sense? Will it rest with the government or will it rest with the pharma company or will it rest with both?*

**Dr Jameel:** Every trial site must have facilities to treat people who may, you know have any adverse effect. So that is one thing that you must ensure that they have capacity to treat any emergency. Secondly, all vaccine volunteers in a vaccine trial volunteers are protected

by insurance, both health insurance as well as disability insurance. So that's that's one safeguard. I don't know in this case, what's the arrangement? But I would assume that if ICMR and Bharat biotech are jointly developing this vaccine, then the accountability rests with them jointly. You can't. You can't have, you know, all the fruits without the accountability.

**Padma Priya:** *If say six months down the line, a vaccine comes up, maybe it should be given to high risk populations. Now, who decides which part of the world or which, you know, community, which groups should get this vaccine first?*

**Dr Jameel:** So, these are commitments that have to happen at the country level and WHO and you know, every country is a member of the World Health Assembly, which is a unit of WHO and you know, these agreements are really made there. What I am aware of is that, out of the 3 billion doses, manufacturing capacity in India, India has ensured that about 1 billion doses are available for India, and the other 2 billion can be exported to the world.

**Padma Priya:** *What is your assessment of how long this is going to go?*

**Dr Jameel:** Let me just say that when you talk about models all models are wrong. But some models are useful. And all models really depend upon the data that is available for making that model. So far we have seen all kinds of models being proven wrong. So, I can't really tell you how long this will last in India, but I can tell you what I'm most worried about at this point. I'm most worried about the monsoon setting in and cases of dengue and malaria going up. I'm worried that in October, November, we will start our flu season. So the clinical presentation for all these diseases is the same. You get high fever, you get chills. And my worry is that a lot of people will not get the treatment that they should be getting, because the system is so overwhelmed with COVID. So that's at this point that is my biggest worry that you know, we have not built the standard operating protocols, we have not built the capacity to really look at these things. When an individual presents to a hospital with high fever today, the hospital will think it's COVID and many hospitals will not even let that person be admitted or treated. That person may not have COVID they may have dengue which can itself be life threatening, if not treated. That person may have malaria which can become cerebral malaria and they can go into a coma, that person could be infected with the flu virus. So you know, we need to really start thinking about putting together those standard operating protocols to take care of these diseases otherwise we may see mortality which is which would be unfortunate. It would be for things that we know how to treat. That's my worry at this point.

**Padma Priya:** *What have been some of the key learnings for you? And what do you think some of the key learnings for India should be with regards to pandemic management, but for*

*you personally and then overall, your expert view on what you think India should improve upon?*

**Dr Jameel:** For me personally, don't ever underestimate a virus. They can really do things and see where we are today. You know, bars are closed, temples and mosques are closed. So I wrote somewhere that, you know, when heaven and hell agree, you know, you really need to worry about this. And that's, that's what is happening here. So it has completely changed our lives. And it's, it's fascinating at one end, but it's also scary. And I really think we should learn from this and we should change our ways. Otherwise, we're speeding up the emergence of new viruses. So that's really my part in my learning. I think if as a country, we should, what we should have done, and I hope we have learned this is that pandemics can only be controlled through the right information and building trust and we have seen you know, sub-optimal, you know, action on both of those counts. We need to, you know, gather data properly, we need to report data properly. Unless we do that, nobody is able to put together the right modules and we are not able to prepare. And, you know, we took this lightly in the beginning, although we did clamp down very early, but it's, you know, it had many other social implications. So, I would say one of the things that we should have learned from this is that controlling pandemics, or any disease outbreaks, large disease outbreaks is not just a medical buy or biological problem, it's also a socio economic problem. And we need to very carefully understand this for somebody who doesn't know where his next meal is coming from, you know, things like wearing a mask or social distancing, or hand washing is very theoretical. So let us take care of vulnerable people. I think that's very, very important. That's the way we will build trust. And that's the way we will control outbreaks because then people will listen and follow rules. We turn a public health problem into a law and order problem. And I think that is a mistake we have made.

*Thank you for listening to this episode of COVID Science series on The Suno India Show. I hope you learnt as much as I did from this conversation. As always, please spread the word about the work we are doing at Suno India and help us remain independent. Log on to Sunoindia.in and help support our work. Lastly, help us by spreading the word about our work with your friends and family and rate us on Apple itunes, Castbox or wherever you listen to your podcasts.*