

One Health Policy & Practice: What can Canada and India learn from each other?

Dominique Charron: So delighted to have you join us. Thank you for adding our discussion today to your busy calendars. Before I introduce the speakers, well, and talk a little bit more about the session, and how things will go today, I do want to acknowledge that all of Canada resides on traditional territories of Indigenous peoples, and it is our practice to make an acknowledgement of the traditional inhabitants of these lands. And here in Guelph, we are on the traditional lands of the Credit, the Mississauga of the Credit, and we acknowledge their traditional stewardship of the land and their rights to this land.

We also acknowledge a traditional Dish with One Spoon agreement between the Haudenosaunee, Anishinabek, and other allied nations of the region from a long time ago, which is really fundamental to supporting the agreement of working together, of peaceful cohabitation, and of sharing the resources of the land together. And so, at the University of Guelph, we also support that treaty, that agreement between those peoples.

Now, I am speaking to you from the traditional unceded territory of the Algonquin people in Ottawa, which is quite a distance from Guelph, but I'm very honoured as well to acknowledge the role and voices of the Indigenous people in this space, and to acknowledge that in our work, whether it's here in Ottawa or at the University of Guelph, the knowledge and practices and traditions of indigenous people have a very important role in informing our way of being. And when we think about One Health in particular, the idea of our well-being as people, being so closely connected to the land, to animals, and all the Indigenous knowledge and practices around that integration and balance is helpful for us as we... as we move forward in trying to take an integrated approach to health.

And we also support this idea of two-eyed seeing, which is a way of bringing this traditional knowledge together with scientific Western knowledge. And that's part of our practice as well at the University of Guelph. So, thank you for joining us.

My name is Dominique Charron. I am a visiting scholar at the One Health Institute of the University of Guelph. I have a background in veterinary medicine, epidemiology, and I've been a scholar of integrated approaches, such as One Health and ecosystem approaches to health, for most of my career; spent quite a bit of time in public service, in public health and then in international development. And it's really an honour to moderate this panel today.

This is a first event in a joint initiative between the University of Guelph and the M.S. Swaminathan Research Foundation of India. We are looking to strengthen the links between Guelph and MSSRF and strengthen the collaboration and see how we can learn from each other. We're looking forward to organizing regular exchanges subsequent to today on topics of mutual research interest at the intersection, really, of food, health, agriculture and sustainability.

And you can find out more about this partnership on the website of the Canada India Research Centre for Learning and Engagement at the University of Guelph, just beautifully named CIRCLE. And this centre was established in February 2020, just before the pandemic and aims to be really an interdisciplinary nucleus for Canada at the cutting edge of research with India and about the Canada-India relationships, South Asia, and the diaspora to showcase, advocate, catalyze and foster, equitable, respectful, and sustained exchange of knowledge between Canadian and Indian scholars on complex emerging, unexplored and explored topics related to sustainability, social and economic well-being. And I encourage you, as I mentioned, to visit the website, and for more about what CIRCLE does.

So today, we have an event that will run until noon Guelph time, which is well, just an hour and 20 minutes left in our session today. And we have three speakers today. Unfortunately, one of our speakers was not able to join us today, so we will have a little bit more time for the three speakers whom I'll introduce in a moment, and I invite you all following their presentations of about 15 minutes, maybe a little bit longer, and we'll have a panel discussion where I will ask them some questions, and we'll discuss a little bit about these linkages between what's being done in One Health in India and Guelph and Canada, and compare.

And then we'll hand the floor to you, the audience, where you will have chance to ask questions directly, if you wish, or put them in the chat, and I can ask them for you. And we'll wrap it up just before noon, Ottawa time. I invite all of the audience to please be on mute, to make sure you're on mute so that we don't disrupt the panel and keep your video off unless you're asking a question, and you can raise your hand, using the icon at the bottom of the screen in actions. And I really encourage you to keep your questions brief so that we can allow for time for the answers, and also to have as many of them from the audience as possible. If you are thinking of a question throughout the talk, please feel free to type it during the talk, because we won't be pausing for questions after each panelist. We'll bring them all at the end.

So now, with that logistical aspect dealt with, I'd like to introduce the panelists. So we have Dr. Sindura Ganapathi, who is a visiting fellow in the Office of the Chief Scientist. He is a pharmacologist, an MBA, and a veterinarian, so we have a really, very esteemed guest with us today. His background is in biomedical research at the National Institute of Health, where he focused on physiology, and he's previously had a variety of roles, including at the Gates

Foundation and was very involved in the Grand Challenges initiative. So really a delight to have you with us today, and thank you for joining us.

We also have from India, Dr. Maroudam Veerasami, who is the founder and director of CisGEN Biotech Discoveries, which is a startup based in Madras, and she is a biotechnologist and One Health expert, and she's been working in this field of veterinary diagnostics and vaccine development for decades. She has quite a few successful commercializations under her belt, including bovine tuberculosis control initiatives, not only in South Asia, but in Africa, and with partners including the Gates Foundation and NIH in the US. We are delighted to have Maroudam with us today, because she's going to bring that very concrete example of One Health in practice.

And from here at Guelph we have Dr. Shayan Sharif, who is a professor of immunology and Interim Vice President, now, of research and innovation. He has in this role had an important function as managing the relationship with the Ontario Ministry of Agriculture, Food and agrobusiness, which is the largest single research partnership and a very important funding source for the university, but also a link to that decision making and policy audience. It's a long standing and very important partnership, and in this role, definitely, Shayan has had really important roles in leading agricultural research on campus at Guelph, including at the Agricultural Research Institute of Ontario, which is operated by the University of Guelph and other research programs in our satellite campuses.

And there's an important laboratory service division at the University of Guelph that is also a close link to policy audiences and an important service function of the university. Shayan's research also focuses on poultry diseases when he's focusing on his own work in immunology, and he and I have had the pleasure of interacting in a variety of capacities advising the Canadian government in response to avian influenza. He's also very interested in developing innovative vaccines to control these infections. And I'm sure we'll be hearing a little bit about that today as well. So thank you very much, all three of you, for joining us, and I'm really looking forward to the conversation today, so I think I will hand it over to Sindura Ganapathi. Dr. Ganapathi, over to you.

Sindura Ganapathi: Wonderful, yeah. Thank you for the kind introductions, and thank you for organizing this. It's always a pleasure to be with such accomplished colleagues, who I just had the chance to meet and exchange notes and information about what is happening in different places, because this area of One Health is quite broad, and even though I have been hands on working on it in the last 3-4 years, and indirectly are somewhat peripherally working for the last 15 years. There is always something new that I find almost on a weekly basis that I had no clue about, and would have big implication for this space. So it's wonderful to be with all of you.

So I have been asked to speak a little bit about what is happening in the Indian ecosystem from a government and broader ecosystem level in the space of One Health which I will try to cover in the next 15 minutes or so, until I have been told to stop whichever comes earlier. So the challenge I always find with the area of One Health is its breadth. It's continuously being expanded to cover more and more things. And as a result, I'm always hard pressed to see what can be done about them, which is nice to have a really broad, all-encompassing vision.

But for me personally, that is what I have tried to use in my current role as well, on what is the utility of this framework of One Health applied to anything? Because at the end of the day it needs to add some value, meaning we are going about our daily things... Things are happening in the world as they are, and then comes the framework of One Health. Does it add something new and something complementary that makes it better in some ways? To me, that's the yardstick to say where the role of One Health actually is. So that's the sense I have tried to do with that.

With that sense I've been working in setting this up in India. As the introduction said, I work as a fellow in the Office of the Principal Scientific Advisor to Government of India, which is an entity headed by a principal scientific advisor, chief science advisor, to those of you who may have different nomenclatures in other countries, and the goal of our office is to provide forward looking science and technology advice to various stakeholders of the government, both from the cabinet to various ministries, to the stakeholders outside of the government, including private sector and other academic settings, and especially where it requires multiple sectors and ministries to come together. So One Health happened to be a very classic example where we had to bring multiple groups together.

And I'll try to also highlight some of the other things that complement this that have been involved in the last five years of working there, and you have four and a half years I've been there now. The example of where I said One Health brings a unique perspective and added value is exemplified for me in the infectious diseases, which is the most obvious, and that's where I will try to make the case in how it is being worked out and then move on to other more challenging areas where this might have value.

So, as I mentioned, infectious diseases are many, and dozens of them impact each of these sectors, whether it's humans, domestic animals, or wildlife, and beyond, and a very few of them are restricted to, for one reason or the other, individual sectors. But as the more I have thought about, most of them actually move across, and move across reasonably, seamlessly, and some far more than others. And some of them move across multiple sectors like the example of avian influenza, which we will come back to, which is a very good example of where, why this is needed. But there are some that are limited to only 2 sectors, for example, lumpy skin disease or foot and mouth disease, or many of the veterinary diseases of priority.

That being said, the usual way of looking thing at things has been administratively focused on sector for a very good reason that when you have a polio program you can't be thinking horizontally about all the other things that may have implication, and you have to get vaccinations done. You have to run the program surveillance or other preventive measures. So as a result, these focused efforts, whether it is very disease specific or even sector specific, for human health, the lens, that... with which it is looked at is the health, whereas in animal elementary the predominant lens is productivity. Whereas in wildlife, it is conservation.

Now, it doesn't mean that other lenses are not important. It is that these are the predominant anchors which define what happens in a given sector in India. What has been happening is, in each of these sectors there are large scale programs that are underway in various stages. Whether it is in the human health side where a national level, originally called as National Digital Health Mission or Ayushman Bharat Health Mission or Digital Mission, and with a unique ID for ABHA ID. That is, the electronic medical record, uniquely defined to individuals, which follow them regardless of where they move from one healthcare settings to the other, and that being linked to the entire insurance system, care system. So there is an entire major initiative underway that has been in various stages of being rolled out.

And this will have a very big implication for this concept of how to build an integrated system for disease management, because surveillance and all of the other things will now need to be looked at in a very different way. And similarly, on the livestock side, one slide up just to give an there is a national effort, National Digital Livestock Mission, which I was involved in early setting up of it, which is now already well underway in implementation, where individual animal IDs are linked to farmer IDs that define the entire sector.

And similarly, there is a wildlife management system which is much further behind. Like in most sectors, what I see is human health predominates the system, or the ecosystem, and followed by animal husbandry or livestock, and wildlife being the furthest behind. So the entirety of One Health mission that we were working on was not about trying to do something new, but more about, as the shaded area shows how to bring them together, how to connect them better, because, this is an important nuance in that, in the name of One Health, if you start an entire new vertical with lot of money and a department or a program to ensure One Health, it eventually will lead to another silo, called One Health, which is ironic and counterproductive to the very concept of it. So, therefore, very consciously, the efforts in India have been to see where the linkages can add value, where it is currently not happening, and I will provide some examples to what is happening in that space.

Now, the most important thing is the governance. So I have been very keen to see how different countries are looking at this governance, whether it is Thailand, whether it is Vietnam, whether it is us Europe, Australia, whatnot. In India, the current central governance involves the highest level at an executive committee which is chaired by the Health Minister, and co-chaired by the Principal Scientific Advisor and the Scientific Steering Committee chaired by the Principal Scientific Advisor that brings all the secretaries of various departments.

So in India, the bureaucratic head of any given ministry is called a secretary, and we brought together pretty much all the science funding agencies, and I'm not going to go through all of them. It's just to say that all the science funding agencies, all the key departments related to human health, livestock, Ministry of Environment and Forest bringing the environmental sector and also the biosecurity version of it, the departments that are involved in it. And I have to say each month or so, or week or so, when we were setting it up, we would figure out "Oh, we left out this department. We left out these key stakeholders."

So the office memorandum, the file that created it originally has seen many amendments because we keep learning. "Oh, we need to add these people to be to the governance structure, add as stakeholders." So that's a lesson in that. When you think comprehensively, oftentimes we believe that we have everybody, but we have left out somebody. Even this picture is not fully comprehensive, as in India, there are agencies such as Panchayat Raj, which are very involved in local-level administration, which need to be brought together. And that's just the government. And then, outside of the government, there are many stakeholders that are part [or] need to be part of it.

And India being the host of G20, the Presidency last year was a useful forum, where it was also very active topic, and we had multiple tracks that even Canada participated in, I believe, in trying to set up.

What does it mean to have an international convergence on these One Health ecosystems? And we had a communique, and we had to come up with certain concrete points which need to be followed up, and a personal lesson for me is it's hard enough to get convergence when you have diverse stakeholders, but it's even more difficult when you actually try to implement them. So, worth keeping those in mind as more and more initiatives under the name of One Health is taken up.

This national One Health Mission, which is specifically focused on, to begin with, infectious diseases, I'll come to other areas that are also important. It is cabinet approved now, has focused on all aspects of it, whether it is surveillance, whether it is how to handle outbreaks in a joint way; so that, for example, there is a Nipah outbreak in a given state, how to coordinate

outbreak investigation, instead of different sectors showing up to investigate it from their perspective and not have a coordinated approach; have an upfront framework on, for any such disease outbreaks, how these multiple sectors will operate simultaneously together with pre-approval, so that they don't have to keep going back to take permissions to go investigate together.

So these kind of frameworks have been put in place and are being tried out, as we speak for investigating multiple disease outbreaks. Whether it is avian influenza, Nipah, or others, R&D is a big area, how to develop vaccines for diseases that are emerging, that may not be an issue today, but will eventually become big issues, such as avian influenza or Kyasanur Forest Disease or Nipah, and so on.

And some of the activities that have happened involve testing this mechanism, which involves mock exercises. So, basically simulate outbreaks in some place and then have a very structured way of assessing how outbreak investigation happened, how the sample was collected, how it was sent, where it was sent, how the communication happened. So we've had one such national level exercise conducted a few months ago, and then another one being planned, and these are very useful in actually identifying gaps.

Obviously, there are lots of gaps when you do it in the beginning. With time, it ends up being better, if we do it in a continuous improvement. Before I move on, I just would like to point out one major theme in that is this strengthening routine prevention program. So, for me, any pandemic preparedness or One Health, or all of this, the foundation of it is regular routine care, whether it is humans or livestock or wildlife, and it may have nothing to do with pandemic diseases, or it may have nothing to do with even diseases. It may be in wildlife side, it has something to do with, say breeding, conservation, or even preventing forest fires, whatnot.

The question is how these routine programs can be strengthened and have a long-term view on [how] these programs can pivot to support addressing any future issues. So, therefore, you essentially turn this whole thing upside down and focus on routine programs and strengthening them and linking them and that is how it is being thought out. As you can see some of the keywords here, whether it is linkages of data systems or laboratory systems.

So, under this National Health Mission, that one of the key efforts has been to identify, select high risk pathogen laboratories in India, across India. And currently, there are 22 that have been identified, BSL-3 labs, and obviously anything above BSL-3 are automatically part of it, BSL-4 labs, and have common protocols, have trainings across sectoral trainings, and regardless of the labs being located in either in any of these sectors, them being able to do basic things, regardless of which sector it comes from.

The idea is that when an outbreak happens, a sample shows of you don't know what it is, and you almost have to assume you don't know. So all of them have to be able to do basic of all of these and then obviously specific, referral, highly specialized labs can be identified for things that require follow up. But most important area that I think still requires work is at the bottom how to have data standards, how to build capabilities in analytics, especially in disease modelling.

There, in India, few good centres are emerging who have now disease modelling capability. They're working closely with the government to help refine the programs. And I think this is one area where Canada and India may have a opportunity to work together, collaborate, build relationships on, because these priorities also tend to be common.

Dominique Charron: Dr. Ganapathi, I just want to let you know 3 minutes or so.

Sindura Ganapathi: Yeah. Okay. So I mentioned how livestock side, there is an entire national ecosystem that is underway where unique identification of individual animals and an entire digital architecture. While it is important for many things, for disease, surveillance, and One Health, this is serving as the basis and foundation for it, and similarly, in the wildlife side, we did not have a national system, so you probably have seen at least the Indian side may have seen these announcements.

A national institute is being created, and it is part of the overall One Health mission and ecosystem. But it's mainly focused on having central, regional and local level of wildlife management, health management, overall and having a funded, well-run national ecosystem for it, and that will actually plug an important gap that has existed in this concept of One Health where we talk a lot about it, but mostly if you really open the doors and ask about "what are you doing?" it falls into one human health side of things.

So I was very happy, and I'm have been very happy to be part of shaping this one up and hopefully, this will see the light of the day very quickly. And another area is how to do environmental surveillance, sentinel surveillance, using samples, not from the individuals, but from the environment, soil, milk, slaughterhouses, sewage, whatnot, for varieties of diseases of human, animal or wildlife importance. And a lot is happening in India on that in each of these areas, in terms of refining sampling methodologies, defining laboratory assays of varieties of methodologies, whether it is sequencing, CRISPR based or others.

PCR based, and also modelling, how to make sense of what you find in the environment to actually what it means. And that's a very important area. And that's, I think, another area for India and Canada to think about what is happening and share lessons and build collaboration, because this is one of the most, easiest way for me to think about pre competitive, that is, if you have already worked out a protocol, it makes sense to share it, because there isn't a sense of competition in this space. So a good place to get started.

On antimicrobial resistance, there is a national effort in terms of building both the policy and the research in terms of identifying alternatives to antibiotics, both in human sector, but also in especially in under recognized, like fish and prawn and other aquaculture, in addition to livestock. So that's an active area, both in terms of surveillance as well as how to address it. And an important area is the regulatory system which I'm now currently engaged in working very closely with that ministry, overall transformation of the regulatory ecosystem.

But for One Health, how to ensure that we have the regulatory systems ready, and be aware, and some of the things in place, so that if a future pandemic comes or even, forget pandemics, how to handle drugs and vaccines and other aspects from different sectors like. Right now, we are working to see how to handle applications for a fish vaccine or aquaculture vaccine, for which there is no precedence, for example.

And a completely, another under recognized area is how to build these kind of things for diseases that impact plant, regardless of whether those issues concern humans directly, such as mycotoxins. But even otherwise the diseases that impact all the plants have huge agriculture, productivity implications, how to build the similar ecosystem of surveillance control of outbreaks and preventive measures. So I think I've touched, like this is a menu and hopefully, this will raise questions or thoughts in maybe other speakers' mind or audiences' mind, and happy to have a follow up discussion on it, as I mentioned, meant to be very high level, and I think it ended up being a high level in the short amount of time.

Dominique Charron: Yeah, you've given us a real taste as well of what it looks like in in in the specific programs and areas, whether it's wildlife surveillance, or the R&D work around medical countermeasures for pandemic preparedness and everything in between. So really lots to think about as we move the conversation back to Canada, and have Dr. Shayan Sharif give us his perspective on this. I'm really looking forward to engaging all of the panel and the audience in questions. But we'll move right into to the talks just so that we have the flow and have the time at the end for the discussion. So over to you, Dr. Sharif.

Shayan Sharif: Fantastic. Okay, so I'm just going to get started. And first and foremost, thank you very much for inviting me to be here today. You've given me a whole lot of, I would say, compliments which I don't necessarily deserve. But thank you very much for all of those, I take credit. As soon as I see some credits, I just embrace that credit. So I appreciate that.

And I also wanted to say thank you to Dr. Ganapathi, because he provided a really good high level information about what One Health is and what India is doing. Unfortunately, in my case, I'm just not at the level that he is in terms of providing a good perspective on One Health at a national level. So what I'm going to do is, I'm going to talk about one of the topics that he brought up, which is highly pathogenic avian influenza, for two reasons. Number one, because it hits close to home for me. I've spent significant amount of my career as a scientist on avian influenza viruses.

That's number one, and number two, I cannot really think of any other one health issue that really, you know, highlights the importance of why we need to have a One Health approach towards solving one of the biggest issues that we've ever faced in animal health, which potentially has implications for human health. And that's why I've decided to talk about avian influenza.

And just for the audience, who may or may not be quite familiar with avian influenza, avian influenza is basically like any other influenza virus, there are two major proteins on the surface of this virus, the so-called neuraminidase and the haemagglutinin. I don't know if you can see my cursor, but if you can, I'm just trying to point to the neuraminidase, which is this club-shaped protein on the surface of the virus and haemagglutinin based on these two molecules or proteins. You can essentially subtype the virus and based on hemagglutinin of the virus, there are 18 different types of haemagglutinins and based on neuraminidase, there are 11 different types of neuraminidases.

If you take a keen look at these two pictures showing haemagglutinin and neuraminidase, one thing is going to emerge from that, and the fact is, most of these viruses actually reside in in birds, either in poultry or in waterfowl, seabirds, shorebirds, birds of prey, even sometimes in songbirds, so avian influenza is essentially, I would say, most viruses within the influenza family are related to avian influenza viruses. Why? Because their natural reservoir is indeed in birds, and, in fact, if you look at a host range of viruses within the family of influenza viruses, you can see significant amount of host range. It has a very wide host range, but the reality is that birds act as the main reservoirs for avian influenza viruses.

There are 4 different types of influenza viruses influenza, A, B, C and D. Influenza A viruses, as I said, generally speaking, they reside in birds; influenza B and C viruses, generally speaking,

reside in humans. Influenza D viruses reside primarily in ruminants and also in pigs. But there is significant amount of transmission capacity for this virus. So viruses can jump from poultry, from domestic poultry to wild birds, from wild birds jumping to domestic poultry, then domestic poultry can transmit the virus to a wide variety of different species, including pigs, including dogs, cats, you name your favourite mammals, they can get infected by the viruses that are shed by either wild birds or by poultry. So that's why I would call this probably perfect storm for a One Health issue.

And unfortunately, if we've been facing this one health issue for the last two and a half to three years, two and a half in some countries, three years in Canada, perhaps a little bit longer in Europe, but the reality is that this has been unprecedented from a wide variety of different angles.

Angle number one is that usually when influenza viruses hit, including avian influenza viruses, they can only last, maybe for a few months, and then they go away. And we would not hear back from them up until a time that some other events happen, and they emerge again. Unfortunately, in this case this virus hasn't really gone away. It's been with us for the last, in some countries like I said, more than three years, in Canada for almost three years now, and some countries, maybe for the last two and a half years or so. It has changed our understanding of what this virus is capable of doing.

Up until almost a year ago, we had no idea that this virus can jump to deer and cattle. We knew from some of the studies done 70 years ago or so that the virus can reside in mammary gland of cows. But we had absolutely no idea that it can not only reside, it can propagate quite readily, and then it can shed in copious amounts in the milk, which is extremely, in my view, concerning. So now we have this significant amount of activity of the virus that's been jumping around from birds to birds, from birds to mammals, from mammals to birds, and so on. And in some cases it's also been jumping to humans. So that's why I said, if this is not really, truly the best example of One Health, I'm not quite sure what else is.

But where did this virus come from? We don't exactly know why this virus emerged, but we do know that the virus emerged for the first time in '96, '97, and this was in a goose in Guangdong, in China. It wasn't necessarily such a bad virus up until the time that it started spreading in China and Hong Kong. And it's also started jumping to humans. So for the next, I would say seven, eight years or so, up until the early 2000s, approximately 860 people got infected.

There could have been many, many more human infections that remain undiagnosed. So as a result of that, we don't really know exactly how many people got infected. But what we do know is that 860 people were confirmed for infection with that particular H5N1 virus. That was

the ancestral virus of the one that is circulating here in Canada and across the globe, to some extent also in India, even though in India there are other types of clades of virus that are spreading.

So the virus was basically going quite rampant up until the early 2000s, and then it went away. It didn't really cause a whole lot of damage in the world, but by that time it has already spread from China to other Asian countries. It also started spreading in the Middle East, in North Africa, and also in Europe. It also caused mortality in humans. So the 860 people that got infected approximately half of them unfortunately succumbed to complications of this disease. So unfortunately, case fatality rate in this case was over 50%.

So sometimes when we hear about H5N1, and why it's important for human health, usually we get the percentage or the fatality rate, that was approximately 50%. The number is coming from 860 human infections and half of them died eventually because of that infection. But, like I said, we don't exactly know how many people truly got infected. So the virus was in peacetime with human beings up until 2014, 2016, that a few other viruses emerged. One of those viruses ended up coming to Canada, and eventually it went to the US. And it wreaked havoc in the US. But it went away. We didn't actually hear back from the virus up until 2022 and 2023. I'm sorry. 2021 and 2022. Up until then, we didn't really hear about the virus.

In 2022 that for the first time in Canada we were able to isolate the virus. Actually, it was late December of 2021, and in 2022, it came to Ontario, the province that I'm currently speaking to you from, and it hit wildlife in Ontario, and the first case was isolated not too far away from the location that I'm speaking with you from. But since then this virus has really crisscrossed the country, my country, Canada, many times over, and also it has caused significant amount of impact on the poultry industry in the US. In the US, over 150 million birds had to be put down, that's the number that you see on the top, 147 million. It's a little bit old, old as of beginning of this year, but by now, it's more than 150 million birds that have been impacted.

All of the States in the US have reported presence of avian influenza, and it's not quite done yet. It's still moving forward and causing outbreaks across Canada and also across the US. But, more importantly, it's also not only causing outbreaks in poultry operations. It's also causing outbreaks in mammals, both wild mammals and also domestic mammals. And also it has started jumping to humans. So for example, in the US, 63 human patients have been identified with H5N1, one of them was lethal, not that long ago, it was actually earlier this year, and I understand that it's also causing infection in humans in other jurisdictions, including in Asia and also in India. If I understand correctly, there was just one recent death caused by H5N1. Not necessarily the same H5N1 that is going around here in North America. It's more an Asian version of the virus. Nevertheless, H5N1 is capable of jumping to humans.

Thankfully, there is no evidence for human-to-human transmission, so if there is any silver lining here, is the fact that the virus hasn't actually been able to jump to humans on a regular basis and then cause sustained transmission from humans to humans in Canada. Up to now, we have had 15 million birds that had to be put down. And I'm talking about domestic poultry had to be put down by because of H5N1. But this is just the beginning of the story, because this virus has proven to be completely unprecedented. We would have never expected anything like this before. Up to now we know that approximately 41 terrestrial mammal species have been infected, and 13 marine mammal species. We already knew that H5N1 or other influenza viruses can cause infection among mammals, domestic or wild mammals. We just didn't realize how vulnerable some of these species are. And I also understand that in India there's been significant amount of activity in wild feline species, like, for example, tigers. That is really truly disconcerting.

But at the same time, as I said before, this reemphasizes the importance of dealing with highly pathogenic avian influenza as a One Health issue because it's really, truly working at the interface between the environment, animals, and humans. It is quite disconcerting that this virus is capable of doing all of those, because some of the species are, such as, for example, domestic dogs and cats that live with human beings, and as a result of that they can increase the risk of transmission to humans. And, in fact, in Ontario, two years ago we had one dog dying of avian influenza, more recently in Poland there have been outbreaks of H5N1 among Polish pet cats, and also more recently in the US, we've had significant mortality in pet cats caused by avian influenza.

This is just getting more and more disconcerting, because, you know, up to now we had some idea that the virus can jump from randomly and erratically. It can jump from birds to mammals, but could it sustain transmission from mammals to mammals? And the question is, it might actually be able to do that, at least in the case of ferrets. There is a possibility that it can have mammal to mammal transmission in case of elephant seals in South America. There is some evidence that it might have actually been able to do that, and also in case of dairy cows, there is some evidence that there could be some mammal-to-mammal transmission. Not necessarily directly, but perhaps you know by through fomites it can be transmitted from cow to cow.

Could it be transmitted to humans? It might. As I said, 63 individuals have been identified as H5N1 positive in the US, one of whom died, unfortunately. In India there's been at least one recent case of a small child that succumbed to disease. In Canada in November of 2024, we had one case of H5N1 in a teenager in Western Canada, there was a lot of work done to understand better where exactly, the teenager contracted the virus. I don't really think that we have a very clear answer for that. But the teenager was in the hospital for weeks and based on what I gathered, the teenager received the best possible care, and still the teenager was in the hospital for two weeks. So we are really dealing with it with an extremely potent and lethal virus. And if you look back at all the pandemics that we've witnessed over the last several decades, most of

them, if not all of them, have had different components and genetic material from avian influenza viruses, including the pandemic in 1918, the so-called "Spanish flu" which wasn't really originating in Spain. But you know, erroneously, they called it "Spanish flu", that also had bits and pieces of avian influenza virus.

So that's why many of my colleagues and myself, we've been advocating for taking a One Health approach towards avian influenza, and we've tried as much as we could to educate our politicians and educate our partners in industry, that, taking a One Health approach is critical. Dr. Charron talked about the fact that she and I are providing advice to governments, and we try as much as we could to promote the idea that taking a One Health approach is not a nice to have, it's a must have.

Why is it important to take a One Health approach? Number of things come to mind, number one is that climate change and environmental impact on transmission of AIV is becoming more and more clear. Just to give you an idea, this is what happened in 2015, 2016, in Canada and in North America. We believe that in 2014, there was a congregation of Asian birds, migratory birds, that had their wintering site in somewhere in Korea, probably the virus. One of the H5 viruses emerged in Korea, and then it was transferred by those migratory birds to their breeding site, that would have been in Siberia, probably around Kamchatka. That's the site that's also being impacted by climate change. So the theory behind this is that maybe in Kamchatka, some of the migratory birds, Asian migratory birds, that usually do not meet their counterparts from North America, all of a sudden, because of impacts of climate change, and because of the warming of their breeding site, all of a sudden they had the opportunity to interact with some of the North American migratory birds, and that basically caused transmission of the virus from Asian birds to North American birds, and that caused the transmission of the virus into an introduction of the virus into North America.

Dr. Charron, do I have two minutes or three minutes? Two minutes? Okay. So that's basically the theory behind it. And as a result of that, the virus came to Canada, and then eventually it went to the US and it wreaked havoc. But that was nothing compared to what the US is witnessing at the moment. Dr. Ganopathi talks about a surveillance system. I could not agree more with him. We need to have a highly integrated surveillance network for wildlife, both for avian and mammals, for domestic poultry and for domestic animals in general, and also for humans. And he also talked about variety of things that India is doing, and in Canada, we are also doing some of it in pockets, in small pockets, and in silos, such as, for example, creating a digital surveillance system, using AI for prediction of risk for domestic and wild animals, and also for humans.

Lastly, I could not jump over the topic of vaccination. We need to look at vaccination against H5N1, both for animals and also for humans. We need to take into consideration a lot of aspects of ecosystem and biodiversity, because H5N1 has become a calamity for our ecosystems that

have become quite fragile. There are a lot of global health considerations and socioeconomic aspects of H5N1.

Importantly, H5N1 has an impact on food security. So, for example, in Canada, some of our indigenous communities are highly impacted by H5N1, and that has really had an impact on their food security. And in this day and age, given what we are hearing around us with tariffs and so forth, food supply chain resilience is going to be of utmost importance, and I believe H5N1 has had and will have more impact on food supply chain resilience, and that caused for the call to action is to have a multi-sectoral approach, again Dr. Charron talked about a multi-sectoral approach. As an example, the Public Health Agency of Canada has put together an expert panel on avian influenza. Both of us are part of that, and it's really focusing on taking a One Health approach towards H5N1. But I think I'm running out of time.

Also, I think we are running out of time with avian influenza because the time to act has passed. We really need to catch up. So I'm having said that I'm just gonna close my slides and ask my other panelists.

Dominique Charron: Dr. Sharif. So we are a little bit behind time. Not your fault, mine, but so I am going to thank you very much for that really deep dive into, as you say, the perfect case study for why we need a One Health approach. But now we need to hand the floor to Dr. Maroudam Veerasami, so that she can tell us about the exciting work around vaccine development and countermeasures from a One Health approach, and I'm going to hand it over to you, and I'll be pretty rigorous with the time, so that we have time for some questions at the end. Thank you, Dr. Veerasami, over to you.

Maroudam Veerasami: Good morning, good evening, to everyone. Thanks, Dominique, for a nice introduction, and my previous speakers, Sindura, for covering the overview of One Health, and again, the previous speaker, Shayan, for giving an avian influenza virus. So it's my turn to go into TB, which is bacteria. So the next 15 minutes, I will be covering the results which we have developed in a global bovine TB network program in collaboration with Penn State University, USC, APHA UK, and our startup CisGEN, which is mostly supported by Gates Foundation.

So this bovine TB is in need of a One Health approach. What we know, in bovine cattle, is that more than 20 million cattle in India is infected with TB. So yeah, what we know is more than 20 million Indian cattle are infected with the TB, and the human burden is well known in India. That is, one person in India is dying of TB every 2 minutes. So this is, what I'm showing is a zoonotic and reverse zoonotic cycle of bovine TB, which clearly explains the public health significance of

this disease. So animals transmit the infection to humans through unpasteurized milk, undercooked meat and also through infected air droplets.

And there is a spillover from animals to wildlife and wildlife to humans, and vice versa. But most of the work is concentrated towards humans in controlling human TB, and the bovine TB is neglected. Leaving the source behind here, we cannot eliminate human TB completely. So we need a bovine TB control program. So a decade back, I worked with Dr. Soumya Swaminathan when she was the director of NART Chennai. We selected three cattle farms in Chennai, and we studied both the cattle and its animal handlers. What we found is that the cattle in that form are infected with the mycobacterium tuberculosis and mycobacterium orygis. What you see here is the typical lesions in cattle in various organ, including mammary gland. And animal handlers, in this form, is also infected with mycobacterium TB, which is of same lineage and strain which we isolated from cattle. So this clearly shows there is a public health significance. That is, 10% of human TB cases is of animal origin.

So, but what is less concerned and forgotten is that horses also suffer terribly, and farmers suffer with a huge production loss. Altogether, the global economic loss due to this bovine TB is 3 billion US dollars annually. So why not then there is no bovine TB control program in India, why it is not eradicated from India when Western World eradicated successfully this more than 50 years ago, especially US and some European countries and Australia? They all eradicated this successfully.

So, when you go into their control program, the eradication program, if you see the eradication program, they inspected each cattle in the country, and whichever turned skin test positive, they immediately slaughtered those cattle, which means test and slaughter policy. So they roughly slaughtered, 4 million slaughtered cattle in their country. So what is the benefit of this control program in US is that there was spectacular success in reducing the human TB deaths due to zoonotic origin and parallelly. The farmers also benefited economically, that is, 10 times the cost of the actual program cost, the economic benefit resulted.

So then why not, what are the challenges our India is facing in controlling this bovine TB? The first and foremost challenge, what we are facing is our social and economical reasons, because this, even in our home, cow is considered as God. And this single cow is going to be the sole income source for a farmer. So, in this condition, the test and slaughter policy which Western world is following is not viable or practicable in India. Because of this, more than 94% of human population lives in an environment where there is a risk of a spillover.

When we did the initial study on prevalence, nearly 7.3% of Indian cattle were infected with bovine TB, which meant more than 20 million Indian cattle infected with bovine TB, which

meant this population was more than the dairy cows in the US. So what we need is an urgent and sustained action to control bovine TB. The second major challenge for this, India is a greater opportunity for zoonotic transmission. This is because of two reasons.

One is that more than 80% of farms in India are unorganized or do backward farming, where a two to three cows reside in the backyard of a house, and they share a common habitat, so there is a higher chance of a spillover. And also, more than 70% of milk supplied in India is unpasteurized milk, this also increases the risk of a spillover. And when we did the study, even we isolated mycobacterium tuberculosis and mycobacterium orygis from cattle and pasteurized milk sample. So we wanted to confirm this again, and we conducted a recent prevalence study in slaughterhouses in Tamil Nadu, where we collected 500 cattle tissue samples, of which 16 were culture positive, which meant 3.2% of it was positive, having a live TB organism in cattle tissues, which was 15 times higher than the prevalence rate occurring in humans. Out of this, 1613 were M. orygis and three were M. tb.

And what is alarming is that in the three M.tb., two already developed resistance to multiple drugs. So this needs a lot of awareness and public health concerns. And we need to do a lot of extension activities to educate people for boiling milk and controlling bovine TB. So when I was discussing in the last few slides I was saying that cattle TB is caused by (and what we isolated from cattle) mycobacterium tuberculosis and mycobacterium orygis, but I never mentioned mycobacterium bovis. So this raises a question, what MTBC lineages are circulating in India?

So when we mapped all the strains which are published globally, we found M. orygis is restricted to India, whereas M. bovis occurs outside India. So then why no M. bovis in India? We need to know a little bit about cattle domestication, and also the trade and colonization. The two cattle originated from ancient cattle, one is bos indicus, the humped cattle, which came to domestication for India, whereas bos taurus went to Western world, and they distributed [to] all the Western world, and also to Africa. By 1950, as I told, they eradicated M. bovis in Western world.

Only after 1950, due to white revolution, after eradication of M. bovis, bos taurus came into India, so, whatever the original strain, M. orygis, which is circulating in India, is the only circulating strain in India, and there is no chance of M. bovis in Indian cattle. So one other question which then arises is that, is M. bovis associated with zoonotic TB in India, because we are saying that in cattle there is no M. bovis. So for this we formed a zoonotic TB network program, where Dr. Joy from CMC Vellore, and Dr. Marcel from McGill University, Canada, they collaborated, and PhD candidates Shannon and Sree worked on this.

And they took around 1,000 MTBC human isolates, and did a genome surveillance. What they found was, most of them were *M. tb*, and 7 were *M. orygis*, and 5 BCG, and some are 15 NTMs, but there was no *M. bovis*. So now we need to reconsider *M. bovis* as a proxy for zoonotic TB in India. So this was published in Lancet Microbe, and this study, where we did a biased study of South Indian or northeastern samples, we want to make it a bigger study.

So now, again with the same partners, we selected 44 sites in India and around 4,000 samples were collected, and genome surveillance was completed. And again, this also shows there is no *M. bovis* in humans, only *M. orygis*, and also *M.tb*. So this publication is underway. So then, what *M. orygis* is doing in humans, it's causing a severe extrapulmonary tuberculosis, and all the 7 isolates are linked to extrapulmonary tuberculosis, though it is a very small number. We are now again working with various collaborators, with NART Chennai and the CMC Vellore, and we are screening the entire district, the Vellore district, of humans who own livestock, and then we want to give a concluding evidence that *M. orygis* is linked with extrapulmonary TB or zoonotic TB transmission is happening in Tamil Nadu district.

So it is now time to change the definition of zoonotic TB. It is a century old definition that zoonotic TB is caused by human TB infection with *M. bovis*. Now, the definition in WHO goes, based on our finding, that it is TB, caused by MTBC complex, by animal adapted strains. So the third challenge, in animal TB control program is that there is no animal TB vaccine. Though BCG is an animal strain which is an *M. bovis* strain, but it is not practiced in veterinary field. Why? Because the test and slaughter policy which was practiced long back interferes when we use this vaccine. So because of this, this vaccine efficacy is also not studied.

So what we need is that we need to develop a differential diagnosis, a DIVA test to differentiate vaccinated animal from infected animal. And again, in our bovine TB network, we partnered with various collaborators, with Ethiopia, Canada, US, and UK. We studied the natural transmission model, how the BCG works in cattle. So we found an interesting result, that BCG is showing a vaccine efficacy, of total efficacy of 89%, which not only reduces the severity of lesion or infection but also reduces the transmission.

So now the vaccine is ready. What we need is a DIVA test to differentiate infected from vaccinated animals. So we identify a pool of novel, patented peptides which are molecularly defined, and which are confined to the deleted region of BCG, so now we have a diagnostic octane which can be used in the face of vaccination. So our network program now come up with a technical tool to control global bovine TB control program, which is nothing but animal BCG vaccination with companion DIVA diagnostics, because this is only going to be scientifically driven, culturally accepted and economically viable for low and middle income countries. This definitely reduces the zoonotic TB and improves animal welfare. And now we are speaking with

global vaccine manufacturers, and we are also speaking with the government and seeing how to implement this in future.

So the fourth challenge is intensification of dairy sector. The demand needs [that] we are housing the animals close to each other. And again, the disease spreads more. So, this also we published that buffalo intensity is significantly associated with increased risk in TB households. But while doing this modelling studies, what is the difficulty? What we are facing in interpreting this result is that in Indian condition there is no prevalence. Data is available. So that is the one thing we need more, and this part is completely neglected. The human and wild TB interface is completely neglected and not studied at all. Unlike the Western world, in India we have a close association with wild animals, especially elephants, and monkeys. So with the help of Tata Trust, and with the help of Government of India, we developed a point of care test with multiple antigens, and we found there is a high prevalence of TB even in wild animals in India.

So with these five challenges which I discussed, I want to end the discussion and go for questions. This is the final slide which I want to discuss what happens if we don't control bovine TB, assuming we are eliminating human to human transmission by a good national level TB elimination program, but neglecting bovine TB. The zoonotic TB is predicted to increase in the absence of any interventions. So we need to deeply understand the burden of TB in reservoir hosts and reduce the spillover with a good strategic action plan by implementing BCG vaccine with the companion diagnostic kits.

So with this I will end by thanking on behalf of the Bovine TB Group, mostly from Ethiopia, India, UK, and US, and funding agencies. And also thanks from the Zoonotic TB Group, India, most of them Medical Colleges and Veterinary Colleges, and CTB-WHO India, Canada, McGill University, UK, PHA, University of Cambridge, and US, Penn State and USDA - Thank you. Thank you very much. Any questions? I made a compiled presentation of what I spoke on 15 slides, why we are doing what we are doing, how we are doing it, and how it is going to impact the nation. Thank you.

Dominique Charron: Oh, I love that. That's a great final slide. Thank you very much, Dr. Veerasami. And really, such a compelling case for increased collaboration and emphasis on what is considered a neglected disease, and one for which there has not for some time... there is now, but there had not been all that much attention on vaccination as a solution. So it's really, advances in vaccinology have made it possible to begin thinking about these tough problems for vaccine solutions that way.

And yet, we have the challenges with avian influenza, of evading the vaccine, as we saw with SARS, and we've seen with many influenza strains. So even with the new technologies, there are

still challenges with finding really effective solutions to these neglected and longstanding infections like Flu and and TB but also emerging types of problems.

Awesome. Thank you, all of you, for your presentations while we wait for maybe some questions to emerge from the audience, and I invite the audience either to raise your hand, using zoom or put it in the chat, let me ask you each to maybe in a minute or two, give me your perspective on what the biggest barrier or challenge is to moving ahead with a more integrated approach, whether it's to TB Or flu, or any one of the really excellent challenges that you described in your presentation. Dr. Ganapathi, we had, you know, everything from the R&D types of challenges, but also wildlife management and wildlife disease prevention, and all of that exciting work as well around environmental surveillance that you described. So perhaps. You can each [speak], and maybe I'll go to you first. An obstacle, or maybe an enabler, if you will. If there's... they're usually two sides of the same coin.

Sindura Ganapathi: Yeah, certainly. Thank you. So I mean, there is one hand raised already, so I'll keep my remarks brief so that we can take more questions generally. What I find this obstacle is, our barrier is just that it's easier to continue to do what we are doing. Anything that you want to change, the famous exercise in one of the workshops as change management, he asked us to fold our hands, and we all folded it in one way, and he then asked us to fold it, you know, the other way, and it was very uncomfortable, right? So because we're not used to doing that. So I find that's generally the case.

Let's take the avian influenza. It's a fantastic talk, I quite enjoyed it. I couldn't agree with you more on the urgency of this. And you said, just the tigers in India, multiple species are impacted, and we probably don't know which ones are more \ impacted because we don't have a system as robust in there to catch all the possibilities. There again, like, in terms of surveillance alone, forget about vaccine development or diagnostics whatnot, it would be great to have a solid next step. What are we not doing today. I mean, it's great that you know, it's a big problem. We should all be thinking about it. It would be great if as a result of this discussion and collaboration, even to have a simple collation of what different countries are doing to address in terms of the surveillance alone, because I had a chat with the head of the Apex BSL4 Laboratory from Australia.

She (Dr. Vidya,) was mentioning, about what they are doing and how they are doing with bird surveillance, which I found quite helpful and interesting, because doing that alone, where do you sample, what works already, and she was mentioning just droppings alone, they found it to be quite informative. So you don't need to sample water, doing wetland surveillance seems easy, but it's a broad, big space. So that makes me think like, we probably should be very specific and concrete in terms of what needs to be done, and what are others doing so that we can learn from others. Because if we all have to do the same iteration and figure out that this

works, this does not work, we will all be in a very slow trajectory. And this is one place, I think that's greatly right for building on each other's work and moving fast, so we don't repeat everybody's mistakes.

Dominique Charron: Great. And maybe I'll go to Maroudam Veerasami for her perspective on what's a key thing that needs to happen for better intersectoral collaboration in the TB situation, in your case, and then I'll go to Dr. Sharif, and then to the questions in the audience.

Maroudam Veerasami: Yeah, it's a good question. Not only TB, for all the zoonotic kind of diseases, we need a multi-sectoral collaboration. Especially, if we want to study the transmission of the disease either from humans to animals or from animals to humans, we need collaborating institutes and multidisciplinary research needs to be carried out, because without that we will not come up with any solutions. The people working individually may bring the prevalence rate, at least initially. Because most of the zoonotic diseases, when we take in Indian conditions, the prevalence data itself is lacking, so that is the first thing we need to do to generate the prevalence data. Then, with the primary data, we have to collaborate together and apply for the research work. And One Health is needed now. So I think a lot of questions are coming.

Dominique Charron: Great. Thank you. A quick thought from you, Dr. Sharif.

Shayan Sharif: I'm just going to go, you know, right to the heart of the matter. And Dr. Ganapathi, you know, talked about, you know, collaboration, multi-sectoral collaborations, etc., I think you know, for the most part, government organizations, departments, agencies, and also academia, we are all created in form of silos that are absolutely vertical, we are not horizontal. I think, for something like this, you know, like TB, for example, in India and across the globe, or for avian influenza here in North America and across the globe, you need to have those sorts of horizontal structures which don't actually exist without those horizontal structures. I don't really think that we are going to be able to solve an issue which is a societal grand challenge that we are facing.

Dominique Charron: Great. And really, we're going to go to Dr. Parmley, and there's a question in the chat as well around the treatment approach which came during your presentation, Dr. Sharif, but I think we're looking at how medications are administered across countries, and if there's any light on that, maybe the person who asked the question, Jagan Sikhar, you might be able to clarify that for us, so that when we get to you we can give a more specific answer. This business of the horizontal structures, even in Canada, where we have very

siloed funding councils for medical research and social science and natural science, there's a move, now, recognition that these need to be brought together to work together in order to fund that interdisciplinary research. So there's something, maybe to be learned from how India is taking, bringing everyone together into the One Health framing.

I'm going to go to Dr. Parmley, Jane Parmley. You had your hand up.

Jane Parmley: I did, and then I figured out how to take it down. So that's good. And I didn't put it in the chat because I wasn't sure how to ask the question. But thank you, all three of you for your presentations. They gave me lots to think about, and I think it comes back to something you said in response to Dr. Charron's question, Dr. Ganapathi, about it's easy to keep doing what we're already doing right. It's hard, change is really hard. And so how do we inspire our countries, our academics, to do different things?

And I guess in that space I'm thinking about right. We talked about bovine TB, we're talking about highly pathogenic avian influenza, but we're always responding to the next disease and not really thinking about how to build health and health capacity ahead of those. We're constantly in this response sort of setup. And I'm just curious about your thoughts on if or... if we should, and if we, if you think we should, how can we use a one health approach to actually build health capacity and be less reactionary in this disease space?

Dominique Charron: Thank you. Thank you, Jane. Anyone want to jump in on that?

Sindura Ganapathi: I can, I can give my thoughts. I mean in general, how to get people to do our, whether it is ministries or stakeholders to do things differently. And I wish I had a magic wand. One thing that I've seen seems to work is when I have spent the time understanding their needs. And that worked, say, in wildlife as well. We constantly used to go to them, and we, in the general sense, all these 75% diseases come from you, all these statistic, whatever number it is, and it keeps changing. So it's very important.

So that's almost like saying, we have a problem coming from you. You address it, it's true for rabies, it's true, for other... But, when we, when I spend time understanding their needs, rabies is not their highest priority disease. For human health, it is, but for wildlife, it is not canine distemper is a bigger priority, and there are diseases that I had not even heard about that are of high priority. So, going and spending time in their shoes, and say what drives them, what are their main challenges and what might get them excited and then helping build it, basically. And that has led to better outcomes and general talk of multi-sectoral collaboration. I even I don't

think I even mentioned it in my talk, because it doesn't go anywhere. It has stopped meaning anything to me at this point, for example, foot and mouth disease, so, a big issue in India.

So right now, all our eyes and efforts are on how to build a better surveillance for it and using emerging technologies, environmental surveillance, disease modeling, for government and for the country, it's a high priority. So when there is energy, just, I would say, go with that, build that so, and those systems are usually transferable. If you have a surveillance system for one disease, and if you have analytic system modeling, whatnot, laboratory systems are generally transferable, so building that where there is already energy and resources are priorities, but with a long-medium to long term view, so that we don't build it too siloed. But be a little more useful.

Dominique Charron: I need to jump in because we only have a couple minutes left. And there was a question in the chat regarding the approach to treating avian influenza, as opposed... And in, is there any approaches to antivirals, and how we're maybe advancing, and I think it was specifically to Dr. Sharif. And I apologize because I don't think we'll have time to follow up on Dr. Parmley's question as a panel, depending on how quick you are.

Shayan Sharif: I'll try to be quick, but maybe just in one minute and a half, so there is no treatment, per se, for animals. Avian influenza is not something that we can treat in animals. Obviously, you know, for humans, that's a totally different story. As an example, the patient in British Columbia here in Canada was under antiviral treatment for extended periods of time. Unfortunately, one of the issues with H5N1, this particular strain, is the fact that it causes encephalitis, and when it goes to the brain, and it causes inflammation of the brain. Then you have a hard time getting drugs past the blood-brain barrier. So antiviral therapy may be impactful, may be effective, it may not be effective. However, if you're really talking about prevention, or when there is an emergency of avian influenza and how different countries react to it.

In Canada, it's a stamping out strategy. So all animals are called. And then there's going to be disinfection, decontamination, etc. Other countries have adopted different strategies. For example, China has been vaccinating for the last 2 decades. In France, they have just recently started vaccination in October 23, only in some segments of the poultry industry. Mexico has been doing vaccination. North American poultry industries have been resistant to the idea of vaccination up until quite recently, for a number of reasons, one of the biggest ones was international trade barriers. But those international trade barriers are being lifted. So as a result of that, probably there would be more countries looking at vaccination, and I know that India, as an example, is also looking at vaccination, but not quite there yet for highly pathogenic avian influenza for low pathogenicity, H9, I think there is potential vaccination. I don't know much

about India, but I think there are talks about vaccinating against low pathogenicity, so as promised a minute and a half.

Dominique Charron: Thank you very much. Dr. Sharif. Thank you. All the three speakers, Dr. Veerasami, Dr. Ganapathi, and Dr. Sharif, for kicking us off with, really, this Canada-India One Health conversation, really interesting perspectives. I hope the audience agrees that we've had a lot to think about. I see a comment there from Dr. Liz Finnis, the new director of the One Health Institute, exactly, that we're all stimulated to think about One Health in practical and the different contexts in the different countries.

Thank you to the audience for joining us. Sorry we didn't have a little bit more time for questions. My own bad time, management and such interesting presentations and talks. Please do check the CIRCLE website at the University of Guelph for more forthcoming talks in this MS Swaminathan Research Foundation-University of Guelph collaboration in future. We are really excited to be building this relationship and look forward to more conversations. Thanks to the team, the working group team, that helped put this together and to the people in the background who helped create this event. I know it's always more work than it seems. So delighted to have been here with you today, and thanks very much, and look forward to our next opportunity.

Sindura Ganapathi: Thank you very much.

Shayan Sharif: Thank you so much.