DISCUSSION

Considering the crucial place of Animal and Environmental Health in understanding Prevention

The PREZODE roundtable discussion on the 3rd of October 2024 highlighted the need for a shift in mindset for effective zoonosis prevention. Stakeholders, particularly funding partners and policymakers, must prioritize animal health on par with human health. Embracing a One Health approach and fostering collaboration is key. Below is the full transcription of the discussion.

Panelists:

- **Dr Casey Barton Behravesh**, Director, One Health Office, Centers for Disease Control (CDC) and Prevention, Member of the One Health High-Level Experts Panel (OHHLEP)
- **Dr Ana Riviere Cinnamond,** Pan American Health Organization, World Health Organization Representative in Panama.
- **Dr Osman Dar**, Consultant physician in Global Health, UK Health Security Agency and Director, One Health Project, Centre on Global Health Security, Chatham House
- **Dr Daniel Masiga,** Principal Research Scientist, and Head of the Human and Animal Health Theme at the International Centre of Insect Physiology and Ecology (ICIPE).

Moderation: Dr Wim Van der Poel (Wageningen University & Research and member of the PREZODE Steering Committee).

Introduction by Elsa Léger, PREZODE Science Officer. It is a great pleasure to welcome you to the second PREZODE panel discussion webinar today, which will address the definition and assessment prospects of prevention. Professor Wim van der Poel will moderate the discussion. Wim is a senior scientist and a special professor of emerging and zoonotic viruses at Wageningen University and Research in the Netherlands, a PREZODE Steering Committee Member. Wim is also a diplomat at the European College of Veterinary Microbiology and coordinator of the Epizone European Research Group, the largest network on epizootic animal disease research. He is also actively involved in the ERASE program at WUR, in which health disciplines work together on

pandemic preparedness. You will have during this webinar the opportunity to ask a question, in the chat box on Zoom. I wish you fruitful exchanges. And I now leave the floor to Wim.

Wim - Thank you very much, Elsa, for introducing me. Following the coronavirus pandemic, the PREZODE initiative was started to better cope with emerging zoonoses, because after the coronavirus pandemic, it was concluded that we should be better prepared for emerging zoonosis. Public health organizations tend to primarily focus on controlling emerging zoonosis. But looking at the global changes, wouldn't it be better to do more on prevention rather than responding to outbreaks? What will it take for the world, for world leaders, countries, organizations, and communities to understand that prevention is very important and how should we organize and communicate this? The topic of this webinar to discuss the prevention of emerging zoonosis is therefore important. What lies behind the concept of prevention is our central question. To discuss this in a broader sense, we have four panelists, which I'm happy to introduce to you.

Dr Casey Barton Behravesh, Director, One Health Office, Centers for Disease Control (CDC) and Prevention, Member of the One Health High-Level Experts Panel (OHHLEP). **Dr Ana Riviere Cinnamond,** Pan American Health Organization, World Health Organization Representative in Panama. **Dr Osman Dar**, Consultant physician in Global Health, UK Health Security Agency and Director, One Health Project, Centre on Global Health Security, Chatham House. **Dr Daniel Masiga,** Principal Research Scientist, and Head of the Human and Animal Health Theme at the International Centre of Insect Physiology and Ecology (ICIPE).

We will start discussing n, with the definition of prevention, and in the end, also an open discussion about sustainability and other aspects that may arise during the discussions. To start off the discussions, I think it will be good to make sure that we know what our guest panelists see as prevention. According to your expertise and perspective, what is your definition of prevention in just a few words?

Casey - To be as simple as possible, prevention means to keep something bad in check or to stop a problem from happening in the first place. That can apply to a crime, a disaster, or a disease, and **in the context of preventing the emergence of zoonotic diseases, if we can get ahead of the curve and stop a disease from emerging in the first place, we can stop an outbreak or even a pandemic; that will help us better protect human and animal lives and the environment.**

Ana - I do see prevention in the same ways as Casey has mentioned. **One of the keywords in here is being ahead before everything happens**. For that, **we need to have certain criteria and certain indicators** in order to be able to identify what is going to be and what is going to happen: predictors. That's how I would add to the definition of cases: **finding predictors, knowing predictors, and seeing predictors.**

Osman - I, of course, agree with Casey and Ana. I will **add a little bit of detail**. I think it is important to make the **distinction between primary prevention and secondary prevention** and also to state that, when it comes to health, we have **wider determinants of health. These are the biological,**

social, and ecological drivers that have an impact on health and human health outcomes. **Primary prevention relates to all the interventions that you can put into place to address those different drivers of poor health and prevent disease events from happening in the human population.** Then, secondary prevention is how you best contain the disease when it has happened, mitigate it, and minimize its harmful effects. F**or the individual, that means early diagnosis and early treatment** to minimize the impact and the harmful effects of the disease. And **for a population, that means limiting the spread of the disease** to other members of the population.

Wim - So secondary prevention is actually very close to controlling diseases.

Daniel - When I look at zoonosis, for example, prevention is stopping pathogens from spilling over from animals to humans. And one would look at, I mean, that would also depend on a number of things. What pathogen is it? Is it spillover from livestock or is it from wildlife? So the measures that we operationalize to stop that spillover is prevention, is part of prevention. That would mean that **part of your prevention activities is also investigating what you need to prevent and what would be the best control points for action or points for prevention**.

Wim -I'm glad that the panelists seem to be agreeing on prevention quite clearly. Here is the **One Health high-level expert panel definition. "Prevention includes addressing drivers of emerging disease, namely ecological, meteorological, and anthropogenic factors, and activities that increase spillover risk in order to reduce the risk of human infection".** Casey, could you explain how this definition was built by the panel?

Casey – Within the **One Health High-Level Expert Panel**, we are talking about how to better prepare for and safeguard against the next pandemic and recognizing that the term prevention has been used differently in different contexts. It was **essential to define prevention in the context of spillover** for preventing outbreaks, endemicity of diseases, epidemics, and pandemics, so we could **ensure alignment with prioritization of actions and resources**. So looking at zoonotic spillover of pathogens from animals to people, that being recognized as a predominant cause of emerging infectious diseases and the primary cause of several recent pandemics, the OHHLEP has to work **to increase awareness of the need for this enhanced prevention of zoonotic spillover within the context of pandemic prevention, preparedness, and response, and put together the definition that was shown on the screen to incorporate a One Health approach and highlight how we urgently needed to most effectively work together** to understand how to prevent the next pandemic.

Wim - Prevention is stated in PREZODE as the most cost-efficient way to avoid pandemics. What activities does the term encompass and what scope of action does it cover? What important actions or activities associated with prevention do we need to work on harder or need to put more effort into as it comes to prevention, in your opinion?

Casey -It's very important to have a One Health approach for prevention. There's no single person, organization, or sector that can tackle prevention alone. And if we want to be successful, we have

to apply the One Health approach and involve all the relevant partners as a foundation of our work. Yes.

Ana - I would like to add that when we talk about prevention through a One Health approach, we also need to think about how we would finance that prevention. First of all, it needs to be structured. **We need to clearly understand what we need, and how we will be funding the cost of that prevention**. That would depend on very different types of levels of funding, which can come from national resources up to international level. I think it is important to ground a little bit more this concept of prevention through a One Health approach because it's not that simple. As Casey mentioned, it goes through different sectors. And when we talk about different sectors, we talk about different sources of financing and different allocation of funds, which are not always compatible with working through the sectors. So that's one of the main factors that I would like to highlight.

Osman - I think that's why it's so important to understand **when it comes to this prevention dimension or this prevention element, is the human-animal environmental interaction**. What is bringing them into closer contact with each other? What are the **societal factors** causing increased competition, increased risky behavior, and increased risky interaction between humans, animals, wildlife, and the ecosystem that they are within? This is where you can start to make a distinction between what you might consider upstream prevention versus downstream, **so the proximal event that causes the spillover, versus what it is that might be a human endeavor**, for example, around intensifying agricultural production nationally. That might be the human endeavor upstream, but the downstream effect is that you then have these intensified systems with poor biosecurity, poor biosafety standards, and then a spillover event because of inadequate IPC or whatever within the agricultural sector. **The upstream human activity was the desire to intensify or increase that agricultural production**. So **at what point within the life cycle of that product or that pathogen or that population behavior do we intervene to prevent the eventual negative outcome, which is the spillover** event itself. And that's where you can use things like environmental impact assessments when it's a big industrial project, health impact assessment where it's a big, public sector project where you can use things like hazard analysis and critical point analysis to look at the entire life cycle of not just a pathogen, but an industry or a product and understand these are the risk points where we can intervene or where there's, where we're significantly increasing the risk of a spillover event occurring, and then design interventions around that.

Wim - Thank you. So, this would mean that we really need research to assess or to increase our understanding of the transmission routes, and also assess the risks and use that information to incorporate our prevention activities.

Daniel - When you look at a pandemic like COVID-19, it emerged from somewhere, but you could have pathogens of pandemic potential emerging from multiple places. **For prevention to be effective, we really need in-country capacity developmen**t. We have to think of the last mile as the first mile. And so you strengthen systems at that point to not only recognize a potential

emergence but also to deal with, to prevent it from spreading. So we need in-country capacity in terms of human capacity, but also systems that can be operationalized. When, for example, you have fevers of unknown etiology at a primary healthcare facility, what do you do with it? Does a patient just go away or do you escalate that so that it's further investigated? **I think prevention requires a lot of capacity building, a lot of information sharing, a lot of data sharing, and trying to make operationalization as cost-effective as possible at the last mile. And the last mile is also the first mile. So, we have to look at it from a bottom-up and also at both national and local levels.**

Wim - Thank you, Daniel. In the chat, I also see the remark that with prevention, we also need to consider community engagements. That adds to what Daniel is saying. And I also see a remark, **prevention needs to take into account hazards and risk cost efficiency**. Trade-offs, but caution about the precautionary principle. Is preparedness part of prevention? I would say that these sort of overlap prevention and preparedness. I think your prevention activities should be, part of your preparedness. Is prevention activity part of preparedness?

Daniel - Osman talked about secondary prevention. That's how you respond once an event has started. When you think about the COVID-19 response, **vaccine production was only possible because there was preparedness. The technology was in place to develop those vaccines as quickly as it was done. In that regard, I think preparedness is part of prevention.**

Casey - **Prevention and preparedness are definitely linked**. As we just heard from Daniel, that's a really important piece. **And in order to help with both prevention and preparedness, we need a strong and trained workforce and also cross-training with people from different sectors as part of the workforce** to help with all of our prevention, preparedness, and response needs.

Wim - Ana, you would like to add something?

Ana - I just wanted to mention that, of course, these two concepts are very much interlinked, but **you won't be able to prevent anything if you are not prepared for it**. So you need to have a different type of analysis identifying what would be the most likely, disease coming and try to prepare for it. Easy to say, much more complicated to do, but I do think that's how it's linked.

Wim - It's clear that we need to have good knowledge of what's really happening in circulation of pathogens and spillover of pathogens to take good prevention measures.

Osman - I think it is important that we clarify the distinction around prevention of spillover: what's happening is that a lot of the preparedness investment then just goes into the human health sector. And **we're not putting enough financing or support into the animal health sector, the environmental ecosystem sector, to prevent that spillover event happening in the first place**. Therein lies a problem, whether it's the Pandemic Fund or what's being negotiated through the Pandemic Accord. The **pandemic accord**, for example, when it relates to countermeasures around diagnostics, vaccines, and therapeutics, is **only talking about that in the human health sector**. So, if you came up with some amazing **vaccine, that would stop the spillover event but meant that**

it's an animal vaccine, for example, that wouldn't be covered by it. Or you wouldn't look at diagnostics within the animal sector or within the part of the life cycle of the pathogen that is perhaps in the ecosystem or the environment. And therein sort of lies the problem. I think that's why it's important: **when we think about prevention, we are thinking about it before the spillover event takes place and what investments are needed on that side because there's a difference in investment in the human health sector versus animal health or environment is tens of folds of magnitude and difference.** There is no comparison in how much money goes into each of these sectors. And I think that's important to remember.

Wim- You can make prevention measurements all along the chain of transmission. I agree that it's really important to at least make sure that you try to prevent from the basis. So, that's more focused on primary prevention.

Ana - I just wanted to add to what Osman was just mentioning, and it's something that we tend to forget. **We always think and we always talk about funding healthcare systems and making them strong and resilient, but nobody talks about how to improve animal health systems and veterinary services in countries**. If you don't have strong surveillance and strong capacities at the country level to identify what is happening, it is going to be very difficult to identify anything that can come, for example, from wildlife or from animal production. **Besides the fact that you also have some private interests interlinked to releasing information about what circulates in animal, intensive animal production.** We never think, and we never focus on how to fund those systems and how to make them stronger. And I think that's the basis for prevention. **If we don't have good capacities at the animal health system level, it's gonna be very difficult to identify what circulates in the animal health sector, independently, whether it's intensive production, backyard production, or wildlife.**

Wim - In the veterinary health sector, controlling measurements are mainly focused on animal diseases and not so much on zoonosis. If we cannot make that work also in the veterinary field to have more attention to zoonosis, prevention of zoonosis is probably very difficult to have these measurements, these prevention measurements in place from the very base.

Catherine - How can we evaluate prevention efficiency?

Daniel - **It's difficult to value prevention when you do not see what you have prevented.** However, some examples **show us that we can actually evaluate** prevention in certain places. I think of **Rift Valley Fever virus (RVF)**, which is one of those mosquito-borne viruses that originated or were first detected in the East African region. RVF was detected in the 1930s in Kenya first, and it has been detected in other countries as well. RVF is very linked to climatic events. **Mosquitos are the primary vectors of RVF, and RVF outbreaks are associated with floodwaters. Those are predictable events.** In 2023 and 2024, the Kenyan Metrological Department issued flood warnings. Kenya is divided into into counties which are sub-national administrations**. Some regions vaccinated their livestock**. **RVF is fast detected by livestock before, by the time humans are showing up with it, livestock are already infected. The primary way that humans get these**

in high enough doses is by handling infected animals. So prevention can be achieved by vaccinating animals and there's a really good RVF vaccine for animals. This is one exception where **there's a good vaccine for animals, but not for humans. And so prevention is possible at that stage. And it was seen that in the counties that did their vaccinations in 2023, and 2024, did not experience outbreaks of RVF in humans. And those that did not vaccinate were more likely to showcase in humans of RVF. I think also Kenya vaccinated in 2023, whereas Uganda did not. And there were outbreaks in Uganda that were not experienced in Kenya.**

So that's one example. I could also refer to another disease now, **yellow fever**. A **vaccine for the yellow fever virus has existed for more than 100 years**. So the vaccine is available, but **there are not enough doses to go around**. V**accination is usually prioritized** when there is justifiable risk. How do you measure justifiable **risk? In 2023, there was an outbreak in Kenya with fatalities. That was because it followed a period of prolonged drought, where animal pastoralists were forced to have closer interactions with sylvatic risks of transmission, which occurs mainly in primates.** So that's an event that could have been predicted because drought led to those closer interactions, but vaccinations were not undertaken at a level that could have prevented the disease from being transmitted to humans. **In short, it's possible to evaluate, but it's really dependent on the disease system we are talking about.**

Wim - The Rift Valley fever is a really good example where vaccination can be evaluated. it's very important to try to evaluate our prevention measurements because, by doing that we can show that it has good results. How can we evaluate and monitor prevention activities?

Casey - With all of our work, monitoring, and evaluation are very important to track progress, show value, and help inform future plans as well as policies. So that is also highly relevant to prevention.

Wim - Can we provide data on a return on investments to donors and funding agencies regarding prevention? If we do, can we show that it works and that they have good value for their money? Do we have examples of that?

Ana - Indeed, that's always the conundrum of trying to identify if I, the most cost-effective activity in order to prevent. That really depends on how we define costs and how we define effectiveness or benefits in that sense. **And there's a lot of controversy in the different types of methodologies that can be used to do that, especially when we talk about avoiding deaths, human deaths because that means that you have to stake costs to human life.** So there are many different types of options through which you could evaluate that. But if what we are doing is trying to prevent deaths**, I think prevention will always outweigh the cost of human deaths.** Having said that, there are activities that can be done, of course, with costs that might help avoid a certain number of deaths, human deaths. But as was mentioned before by Daniel, **it's always difficult to evaluate the cost of prevention because if you have been extremely successful, the event has not happened or will not happen. So, you will always be criticized for having invested too much in prevention while there was no event**. As they say in the U.S., it's a catch-22.

So what we have to do, from my point of view, is to **invest in activities that will have not only preventive benefits in terms of spillover or zoonotic diseases, but that could either avoid deforestation or prevent diseases that come from the whole food chain from farm to fork. That will have benefits on other areas, not only just on preventing human deaths.** There are a lot of articles and quite a few studies done on costing those activities. **There is one which I would recommend done by the World Bank. It's a One Health business case done in 2022**, where you have quite a list of good examples of how much could be invested, for example, in terms of avoiding deforestation and how much it needs to be invested per hectare, for example, or at high-risk forest areas where you know that there's a lot of zoonotic agents. That would limit the number of spillovers and human deaths, but it will also enhance biodiversity which has other positive productive outcomes. On the other side, in this document, you have also quite a list of different types of studies done on the **costs of preventing diseases that go through the food chain, either from wildlife hunting that can jump from one continent to the other, or from farming, as we were mentioning before, intensive farming production, or back here, pig, poultry, ferrets, or even bovine.** But definitely, **methodologies of evaluating costs vary a lot**. It depends on what are the criteria that you use in the cost section and what are the criteria that you use in the effectiveness or the benefit side. And definitely that is something that has a lot of space for discussion. We could eventually at some point think about trying to identify the framework that we could use for evaluating those activities. But definitely, that is a very, very rich discussion topic.

Wim – It will also help probably to do more research on the parameters that are important for evaluating prevention. Do other panelists like to add something to this about how to evaluate prevention and look into return of investment of prevention?

Osman -The classic examples like **dog rabies vaccination and Nipah virus control in Southeast Asia**, which we know where there's good evidence; and there's good cost-effectiveness analysis that's been done. But it is important to just lay out the process and the principles behind how this is done as well. You want to evaluate the process, and it is important to first set a baseline. What is the baseline around cross-sectoral primary prevention activities within a country or a setting? How is that being operationalized? How are you measuring and monitoring the process of primary prevention strategies, using a cross-sectoral One Health approach? Are you adhering to all the sort of principles of the One Health approach? Are you looking at issues around equity? Are you looking at inclusiveness? Are you looking around issues of access to the most marginalized, vulnerable groups? Are you thinking about the socioecological equilibrium? Are you thinking about stewardship? Are you thinking about having a transdisciplinary approach**? Everything related to the process needs to be monitored and evaluated. Then there's the impact side of the evaluation**. Are you evaluating outcomes across the three sectors: human health, animal health, and environmental health? Are you looking at the economic benefits of the intervention? Are you looking at the social, the net social value, the net social capital that's being accrued? What is your approach or methodology around co-benefit analysis? **And then finally there's the element of trade-offs.** There's always an opportunity cost. If you

invest in one intervention, what other services are you compromising as a result of it because you have limited human capital and have limited financial capital, what is the trade-off that's taken place by you investing in a particular intervention? That's the way you do a **holistic proper analysis of it. At the start** is that you have to always get good baselines done, particularly when you're trying to assess something like prevention where you do have this issue with **a prevention paradox**, how do you measure something when you've prevented it? It is important to have a baseline. How many outbreaks have been occurring in the past? How many people have been dying of X, Y or Z zoonotic diseases in the past? **Getting that baseline data is important before you benchmark any intervention.**

Wim - That also means that we have to make sure to study what preventive measurements would encompass, and what would be the positive effects, but there can be also negative effects of prevention activities that we have to look into. Are there any other comments about evaluating and return on investment? And if not, I suggest we continue with the next part of the discussion, sustainability. Future emerging disease prevention activities will have to be incorporated into sustainable agricultural production, not only environmentally sustainable but also economically sustainable -looking at global changes like climate change, the loss of biodiversity, and the growing world population. This looks like an important aspect to discuss. How do we reconcile sustainability and economics regarding agricultural practice and livestock management?

Daniel– In the evaluation process, we have to integrate the consumption of meat. As the human population continues to rise, the demand for meat and fish increases. Production systems continue to get more intense, with additional inputs, antibiotics, growth-related factors, and so on. In the same time, the conflict remains between sources of animal feed that are also used as human fees. If we consider fish stocks, for example, part of it goes into poultry feeds that are also used for human feeds, and part is used for human food. We also have to think about what production systems. Which one are we talking about? Is it livestock only, which is very common in temperate regions and maybe the tropical highlands? Is it mixed agriculture where we have some crop production as well as livestock keeping? Or is it in the arid and semi-arid areas where livestock are the sole source of livelihood? I will take the example of the Eastern African context, where there are a lot of emerging viruses, such as Zika or West Nile. In Somalia, the food system relies almost entirely on livestock. 80% of its national GDP is from livestock. Though the country has been unstable for the last 20 years, it has keep exporting livestock. In the last five years, the number has reached 22 million herds of livestock (small ruminants, camels, cattle...). Thus, within that political context, the production is still ongoing. Is it sustainable? How does it affect the emergence of antimicrobial resistance, which is very closely linked to livestock production systems? But we also have to look at alternatives. For example, the environmental footprint for the production of livestock is much higher than alternatives, such as insects. There are about 2000 different insect species that are suitable for consumption globally. And yet, people still want poultry and fish and cattle. **In that regard, sustainability is closely linked to rising population demands, and how we deal with it without compromising the environmental footprint or compromising human health through the misuse of antibiotics.**

Casey - In the United States, we work closely across public health, agriculture, wildlife, and environment sectors to address challenges and issues we're facing. It's no secret we're battling an outbreak of highly pathogenic avian influenza, H5N1 virus, that is impacting cattle on dairy farms, and poultry farms. Cats are involved, as well as a number of wildlife species. It occasioned spillover to people who have close contact with those infected animals. That's something we very much use a One Health approach to address and consider the full spectrum of needs relevant to sustainability and economics as well.

Wim - Do you see some changes in the animal production sector related to this kind of emerging infection?

Casey -We have a range of different levels of milk production, in the country through the larger scale farms, but also some of the smaller scale farms as well. And working with industry partners to exchange information and address this problem is critically important.

Osman - In many countries, economic models are consumption-driven economics. You only show success by increasing production, increasing consumption and that's where we're reaching planetary boundaries around. Agriculture is one of those economic systems. It's not just the food system, it's lots of other things within agriculture as well. I sometimes use this example: if you visit a sick relative in your local hospital in the middle of December you want to be able to take fresh flowers that have been grown in East Africa and flown the same day to the Netherlands, and then distributed to the place you are. And you want to pay for that, rather than purchasing local flowers or green plants. You want a kind of fresh flower because you know your relative likes that. This is the same process regarding our food patterns. In Europe today, poultry consumption is vastly different from the consumption 40 to 60 years ago. Within one generation those consumption patterns have radically changed. Until we get a grip on that wider societal issue have those wider societal conversations around what it is that we value and how much we ascribe to that. We're just tinkering around the edges in a sense. We are not going to make the systematic changes that we need until we do that. For example, we had mink outbreaks, and whatever with COVID, it's because we value Mink coats. We've ascribed an artificial value to that, which everybody somehow has. **We need to pay vast amounts of money for these products.**

Wim - We also see from this kind of event that we are running into the boundaries. So that's also why, for example, in the Netherlands, we have stopped Mink production because we think it's not ethical anymore and also dangerous in the case of COVID. And that's probably the same with other agricultural production that we are running into boundaries of what is environmentally acceptable.
How do we bring together human, animal, and environmental health for better prevention? How do we ensure the animal health sector and the human health sector work together on the prevention of emerging zoonosis?

Casey. The environment piece is critical to have the public health sector, agriculture, wildlife and environment really engaged in addressing prevention. And if we want to do that effectively,

we have to build trust, we have to have transparency, we have to have shared priorities, and we need to work together to do this long before there is a crisis. It's very hard to build these types of relationships and build trust during a crisis situation. On the animal health side, in addition to the livestock or agriculture sector, there have been more and more efforts in wildlife engagement, which is really great and important. For example, the World Organization for Animal Health wildlife health framework is very relevant to the prevention discussion here. **There are also some gaps around companion animals, going back to what we're seeing in our dairy farm situation in the United States. There are a lot of barn cats that are dying from H5N1, and often the cats are dying before cases in the cattle are detected**. That's something we can't ignore. That's something we need to pay attention to. On the environment side, there's a wide range of partners that are relevant to this. People are working on air, soil, and water issues, but there are also people working on biodiversity and conservation issues and more that are very relevant here, including some of the safe movement and trade of wildlife and some of those efforts as well. So, for me, a bottom line answer to how to bring together people from human, animal, and environment sectors **is to formalize your One Health coordination, have a platform where you get all the right players involved, work on some shared priorities and activities, and really work to make a stronger and coordinated system there**.

Wim - Also, in the Netherlands, we also have some examples that show that it is important to get the One Health community together to make sure that, when there is a problem arising, you need to work together to try to control the problem as soon as possible. If you start doing that when the problem is there, you're already very late.

Ana - I do think that what we need to work a little bit more on or **give some thought is how we will structure surveillance in each of those sectors and how we will coordinate the sharing of information of the surveillance data between those sectors:** indicate-based surveillance, event-based surveillance, and community surveillance. Depending on which sector we are talking about, we might have a stronger component of one of those types of surveillance, but that's the only way in which we will be able to have data that would allow us to take action. **We need to structure the way the information circulates between these different types of surveillance systems, between animal health, human health, and health and environmental health, and the way that it will be coordinated.** The way that the coordination will have to be done is very much linked to the way it is financed, how much funds there are, and how these funds make all these sectors work together and not compete between them. **One of the issues is that there's a lack sharing information for economic reasons or economic interests on one side.** And on the other side, there is either no information because there's no funding or if there is funding, there's not any incentive to share that information. So, we need to think smartly about how we fund that surveillance with a One Health approach.

Wim - Do you think that there is also an important role there for the authorities, local and or international authorities to make sure that we stimulate these different sectors to work together?

Ana- Definitely. The funding of those systems has to come from different types of sources, either local, national, and even international. As we've seen also in the human health sector, it could come also from private insurance or national health insurances. So, we need to find a structured way in which these funding structures would provide an incentive for these sectors to work together.

Wim -How are local communities decisive to induce major changes?

Daniel - How to raise, for example, awareness and how to get people involved, both locally and maybe also on a wider scale? So, now, if I just pick up from the previous discussion about human and animal health, several countries now have a One Health coordinating office that has, you know, human health, veterinary services, and environment authorities, forestry people, and so on. But very **often it's a coordinating office that is very responsive once events have taken place**. So if there's an outbreak, then they respond jointly. But I think the cooperation needs to happen way before that. When we talk about prevention, it can be done in a more coordinated way than just one sector working separately. In response to your **question about communities specifically, again, I want to give an example of 80s-born viruses, so dengue virus**. For example, in Kenya, we have the coastal region of Mombasa as a place where we have **frequent activities of dengue** and that may be related to the fact that, it's a port city, we have **high-density areas so people are storing water in containers**, which are potential breeding sites. For the management of this breeding sites, it is essential that the community are aware that they are at risk because of those containers. The prevention activities have to start at that point, at the household level, at the community level, at national level, and so on. Dengue and West Nile are transmitted by the same species of mosquitoes, that are breeding especially in urban and peri-urban areas. The communities are essential for prevention activities to be successful.

Wim – It's time to open up the discussion for the wider audience.

Elsa - There was a lot of points in the chat regarding, so we just discussed that, so maybe we can carry on that, regarding community engagement. So thank you, Daniel, for your first responses. One of the questions is on the best practices for prevention through community whether it is bottom-up actions or also feeding back communities regarding prevention. I don't know, Osman, if you have any information on this or an answer regarding that.

Osman - I suppose it's a no-brainer that community engagement is a key important aspect of this, but I think **the trouble is that we don't actually engage with or consult communities in the design stage of these processes**. The decision's already been made that this is the priority or that's the priority, or a donor comes in and says, "I want this to be the priority or that to be the priority", and then that's taken to the communities and the community engagement aspect is done almost as a, in a tokenistic manner, as an add-on, just to show that we did a bit of community engagement. And therein sort of lies the problem. And it's not just about sustainability of outcomes, it's about sustainability of process. So if you really want communities engaged, **if you**

really want the other sectors outside of human health (which is generally better-resourced), animals, and the environmental health sectors properly engaged, you have to look at their primary interests, or what they are concerned about, and what the local issues are. That's often lacking. We run a big cross-border national simulation exercise around One Health emergencies across Kenya, Ethiopia, and Somalia, **the communities come out with a different set of priorities**. It is important to note that those can be a variant sometimes with what external partners, funders, and donors are interested in. **For example, you go to a community and say, "We really think you should be worried about AMR and resistant pathogens." To them, that sounds like quite a ridiculous notion if they don't even have access to antibiotics in the first place or clean water and sanitation and they're repeatedly getting infections because of entirely preventable issues**. To them, that's not the issue. You can still address AMR by addressing those upstream causes of AMR and perhaps increasing equitable access to an antimicrobial; but if your interest is to focus on surveillance of antimicrobial pathogens, for instance, you will not get much traction with the community. So it is always in a sense about first starting with what it is that those, whether the Indigenous communities, vulnerable groups, marginalized groups, or local communities want. What is their priority and are they part of the governance mechanism or the decision-making process where things are prioritized and interventions are designed?

Elsa - What is the current status of transdisciplinary modeling that could be used to justify primary prevention intervention? Something that would require the integration of economics, social, and biological settings. Is it being done currently or even doable? (question from Max Claron)

Ana – This is a good question on transdisciplinary modeling or modeling that can encompass different types of sectors. **As mentioned for other areas such as economic analysis, everything depends on how the model is set.** But definitely, there are groups working on trying to do ensemble modeling where you have different types of models grouped together, where different variables are taken into account, such as, for example, climate variables mixed with entomological variables and virus modeling in order to identify, for example, outbreaks of dengue or zika or chikungunya. These are very valuable. It's a value that we are working on; you cannot simplify that much what's happening in real life. You need to identify all these variables and the proxies that affect the occurrence of diseases. Technically, it is not easy to mix all these models. We need to continue doing this kind of research. Of course, no model will be perfect, and no model will represent the reality perfectly. But the more tools we have that embrace those different types of modeling, the better tools we will have to decide or to identify which actions we have to implement in the field before we have some kind of disease. Of course, it's not a crystal ball and it's not going to tell us what's going to happen in the future, but it can give us thresholds of what are the probabilities of having some kind of spillover event of diseases that we know already exist. Of course, they are not going to identify diseases that are not there. So that we are able to implement actions that can at least, not that much prevent, but lower the health impact on human population and eventually on others.

Wim -. In the chat are a number of remarks about the importance of surveillance: "if you do that, you can also use that data to improve your models". So I think that could be helpful from both

sides, modeling and surveillance and combining that. How do others look at this modeling and surveillance? Are there any other comments about that? Maybe there are some other points.

Elsa - Ana, you are keen on surveillance and early warning systems. So what about early warning systems in the animal and environmental health sectors? What would be the best way to advocate the importance and relevance, and especially to non-technical stakeholders here?

Ana - I do insist on surveillance because if we don't have data, we cannot do much. We need to know what is there. We need to know where it is. We need to know at which point in time it is there in order to be able to lay some plan of action. If we don't know what circulates in any of the fields that we're talking about, animal health, human health, or environmental health, we won't be able to predict anything or to prevent anything. So, that's why I'm so keen on surveillance, so that we don't go towards this One Health approach without something grounded, something that we can touch upon, something that is based on data and facts. Some sectors have better and more structured surveillance and better data, which can be improved, and others that have less. So, we need to improve that area. That's why I do think that there is value in having data in order to prioritize. Otherwise, you become an expert opinion or give an expert point of view, which might be biased when we prioritize on the background of the person, on the work that they've done. We need to be able to be a bit more objective in the way that we focus our work. The only way in which we can do that is by having information.

Wim - in the chat, people argue that, in some cases, we missed predictors of spillover events. But we also could say that we have been better, that the research is helping to improve that, but it still remains very difficult to predict new outbreaks.

Osman - I just wanted to add the specific point about better involving the environmental sector. I think part of it is to support what is already existing legislation and governance around the environmental sector. And part of that is just around **enforcement.** For instance, if you've got a big project coming up, and that environmental impact assessment is a legally mandated process, you have to do it. If you're building a new dam or there's a new industry coming that's developing, you're going to be planting palm trees or some monoculture or something. You are supposed to have that when you are starting a new mining somewhere: you have to do an environmental impact assessment. **Enforcing that, having a particular set of quality standards around that, integrating health impact assessment into it, the risk of zoonosis or emerging infections into that process is a good way of bringing in the environmental sector and giving them their due importance and significance within that space.** Then, of course, alongside that goes all the monitoring and evaluation and surveillance that's required within the environmental sector. **I think empowering them a little bit through legislation and governance and improved enforcement of already existing rules and regulations is one way of doing it.** And then of course also recognizing that again there's a step difference in the amount of investment expertise, and human capital that is put into the environmental sector versus the other sectors. And **whatever sector you're from you have to just acknowledge that and if you want some sort of parity around it you have to have a differential level of investment into it**.

I'll just give you an example to highlight how big the difference can be. This relates to the animal health sector. When we were looking at the One Health platform and coordination in West Africa. In Sierra Leone for example there are only five public sector health vets in the whole country, five or six practicing vets. How can you expect them to work on zoonoses and human-related diseases when they have a whole bunch of animal diseases that they also have to deal with? There are only five in the whole country. So the level of difference in resource and capital experience, expertise, and investment is so vast that is has to be appreciated.

Wim - The level of legislation is also so very different. I understand the argument to include zoonosis as a risk in your assessments.

Casey – I just wanted to address some of the points around community engagement and coordination as well in the chat and offer some additional examples. With engagement, communication is the key underlying factor that's needed there. In the United States, we have a number of communication platforms for One Health partners from various sectors. We have them focused on national or federal-level government officials. We have them for our state, tribal, local, and territorial partners who work in public health, agriculture, wildlife, and the environment. We also have one that's basically for the public, where communities and others can come and hear updates, ask questions, and share information. So, it takes a lot of time and energy to coordinate those, but I think **an important key to success in One Health is communication and ensuring that there are platforms available for people to come and address.** Also, on the community engagement front and working with Indigenous populations, we have a great example from work done in the western United States, working with partners in tribal lands in those communities and developing a project called the Rocky Mountain Spotted Fever Rodeo to address the emerging issue of the brown dog tick coming on dogs that were free roaming on reservations. With increasing human-animal bond with those dogs going in households and sleeping there at night, the project brings the community together to address the human health piece, increase awareness among the healthcare providers, address the animal health piece, and have better husbandry for the dogs, address the vectors and the environment pieces as well. All is being done in a good, strong community effort to help reduce human diseases, and also improve animal health, and protect the environment as well.

Elsa - How can we evaluate if prevention activities or some actions have been successful? Would each of you give us an action of prevention, some activities that we could evaluate as successful past prevention activities?

Daniel - I was just trying to think whether we can learn from the past. So, for example, I think not many people on this call received the smallpox vaccine. If **we hadn't got the smallpox vaccine, what impact would that have had?** I think we need to do an analysis, to get a grip on the cost of not doing something, so that we can present that as evidence that prevention has tremendous value. I think about the COVID pandemic. A lot of things went into preventing that, but we still lost about more than 7 million lives. Now, if that had not been stopped, where would we be now?

You know, **I think analysis like those are needed for people to appreciate better the value of prevention.**

Ana - On those same lines of thought, I mean, it's not a zoonotic disease, but we don't have to forget that we also eliminated rinderpest in 2008. We have to think about how we managed to do that, the different types of strategies that were used in the different continents, and particularly in the last one, which was in Africa. There was a lot of participatory epidemiology that was used in terms of surveillance. It encompasses not all the sectors, but particularly the environmental and the animal production sector and the livelihoods of pastoral populations. **There is value in thinking about those success stories as examples of what we could do to prevent other diseases**. In that case, it doesn't affect human lives, but it does have an effect on human lives, a secondary effect, let's say, in terms of their livelihoods because there is no source of protein. So these are success stories of prevention. W**e should build on the experiences that we've had with those and try to identify what were the key points that helped us get to that successful outcome**.

Wim - There are some examples of eradication. Rabies is already mentioned. In Western Europe, we also have the eradication of bovine brucellosis, and bovine tuberculosis by testing and culling. So these are prevention programs that have been successful. And indeed, I guess we should learn from those and, maybe, be even more inventive in trying **to have our preventive measurements even earlier than the culling procedures**.

Osman - Joint vaccination programs between animal and human health are one area where there has been demonstrable success, both in terms of raising immunization rates in both the animal populations as well as the human populations. These programs focused and framed around hard-to-reach groups, pastoralists, and **nomadic communities, where traditionally you have very low immunization rates amongst the children** and where, counter-intuitively, you often have higher vaccination rates in the livestock population, in the animal population: Because the family, the communities are so dependent on their livestock for everything, from nutrition and food to livelihoods, the vaccination rates are actually higher in the animals than in the children. And having these joint vaccination programs means you reduce costs, use the same cold chain, use the same infrastructure to transport the vaccine, and run the campaigns together. You can demonstrate success, both in terms of process, cost savings, as well as vaccination rates and ultimately human and animal health outcomes. So that's a really good example of this.

Wim - Well, I think we can agree on the importance of prevention. It's clear from what we hear in the discussions that we need to keep working on research and also legislation related to prevention. We have to improve our organization of prevention. The early start of One Health Cooperation was mentioned several times. So that's interesting also to improve prevention. Also mentioned several times, it's very important to connect with the public, also to connect with important stakeholders, to raise awareness on all levels, and also to improve funding for our prevention implementation. I hope you've all enjoyed the discussions and learned some of the discussions. It was a pleasure to moderate such an expert panel. I think the people involved

in the panel were real experts on prevention activities. So, I would like to thank the panelists, and also all the people taking part in the discussions via the chat. We have not been able to cover all the questions in the chat, but I hope we have been able to discuss the main ones.