

# Interventions to Reduce Risk for Pathogen Spillover and Early Disease Spread to Prevent Outbreaks, Epidemics, and Pandemics

*[Announcer] This program is presented by the Centers for Disease Control and Prevention.*

[Sarah Gregory] Hello, I'm Sarah Gregory, and today I'm talking with Dr. Neil Vora, a physician with Conservation International in Arlington, Virginia. We'll be discussing pathogen spillover and ways to reduce the risk of spillover events.

Welcome, Dr. Vora.

[Neil Vora] Thank you so much. It's a pleasure to be here.

[Sarah Gregory] David Quammen wrote a book called Spillover. That may be the beginning of it entering our common usage. The advent of COVID pandemic has certainly made it an everyday word. But I think many people might not understand what it actually means. Tell us what it is and what happens in a spillover event.

[Neil Vora] Broadly speaking, spillover refers to the movement of pathogens across species. So let's take an example of a person coming in contact with a bat and, as a result of that contact, a virus from that bat ends up infecting the person. In that scenario, we would say that a spillover event has occurred. But it is also important to note that not every spillover of a pathogen into humans will lead to an epidemic or a pandemic. In some instances, a virus that spills over into people causes no illness at all in the person despite infection, as in the case of simian foamy virus.

And there are other viruses that can spill over that can cause very severe human disease, such as rabies virus. But fortunately, rabies virus does not spread readily between people outside of specific circumstances. Then there are even other viruses that can also spill over that can cause both severe disease and also spread between people after that spillover event has occurred, as we've seen with Marburg virus, Ebola virus, and some coronaviruses. So the point here is that spillover is a very important set of circumstances in public health that we have to be mindful of because of the wide array of public health consequences.

[Sarah Gregory] Do we know how many diseases are caused by spillover? Is it even possible to know?

[Neil Vora] Recently, there was a study out of Southeast Asia that showed that over 60,000 people are infected with SARS-like coronaviruses each year in that area of the world, largely related to spillover. So that shows that in some areas of the world, for a variety of different reasons, spillover events are occurring frequently.

Fortunately, not every spillover event leads to devastating consequences. Sometimes a spillover will lead to only a limited outbreak in people that can be controlled quickly. Sometimes spillover events, however, can change the entire course of human history, as we have seen with HIV. In that example, spillovers from primates into people probably happened a handful of times early in the 20th century and that led to the establishment of this virus in human populations, which has sadly killed so many people over the last 50 years, in particular.

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Another way of looking at the question you just asked was just looking at the total number of infectious pathogens in humans, and we know that over 60% of infectious pathogens in humans are zoonotic, meaning that they are transmitted between animals and people. So back to your original question, spillovers happen frequently and are the underlying driver for many infectious diseases.

[Sarah Gregory] How does this happen? What makes a disease jump from an animal to a person, and then person to person?

[Neil Vora] As my colleague Raina Plowright and others have described before, spillover is actually a complicated process that takes place over several steps. It generally begins with a pathogen in an animal, often a wild animal, on a landscape. Then, that animal has to shed the pathogen so that it can actually be passed on to other organisms. So under the right conditions, that pathogen may get transmitted to people. And in some instances, once a person is infected with that virus, there is fortunately only limited onward transmission between people, as in the case of rabies virus. But in other instances, the pathogen is able to spread with relative ease between people, as in the case of some coronaviruses, and this can result in epidemics or even pandemics.

[Sarah Gregory] Does it go the other way? Can people spread diseases to animals?

[Neil Vora] In fact, yes. Spillover can happen in both directions, meaning from animals into people, but also from people back into animals. And we've seen this actually with viruses including the virus that causes COVID-19. In fact, there are over 25 different animal species that have been found with natural infection with the virus that causes COVID-19. And this type of reverse spillover can have major implications for the health of those affected animals because sometimes they have no pre-existing immunity to the virus, so they are very susceptible to the consequences of that illness. And this reverse spillover can also have implications for the health of people if that same pathogen that spills back into animals and then spills over again into people, this time with new mutations that it has developed that make it even more dangerous for people.

[Sarah Gregory] Are spillover events increasing?

[Neil Vora] Unfortunately, yes. A study published maybe in 2008 showed that emerging infectious disease events have been increasing since at least the 1940s, and most of these emerging infectious diseases originated in animals and then spilled over into people. And when I say the term "emerging infectious disease", I basically mean new infectious diseases or infectious diseases that we've known about, but whose incidence is increasing. And recently, in the last few years, there was a report from the World Health Organization that showed that in the last decade alone in Africa, there has been an increase of over 60% in diseases that are spread from animals to people on that continent.

[Sarah Gregory] Do we know why?

[Neil Vora] These spillovers are increasing largely because of human activities that increasingly place humans and domestic animals in close proximity to wildlife. That proximity creates opportunities for pathogens to then jump species. Examples of human activities of particular concern include, firstly, how we manage land. That's probably the largest driver of emerging infectious diseases of zoonotic origin globally, and among all ecosystem types, the clearing and

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degradation of tropical and subtropical forests likely carries the highest risk for spillover. Secondly, how we raise farm animals, which has implications for pathogens such as influenza virus. Thirdly, how we trade wildlife commercially. And when I talk about wildlife markets and trade, I'm not referring to the use of wildlife by Indigenous peoples and local communities; rather, I'm largely referring to the sale of live birds and mammals in urban centers. And then in the backdrop of all of this is climate change, which is further increasing the risk for infectious disease spillover based off of a study published just in the last two or three years. We can also expect the frequency of pandemics to increase severalfold in the coming decades if we do not address these underlying drivers.

[Sarah Gregory] Why do some pathogens create this spillover scenario where other types don't seem to? I'm thinking, for instance, like arboviruses; they are increasing dramatically in kinds, but not jumping to people, so the people become vectors. Why not?

[Neil Vora] Each pathogen has its own unique biological properties that then impact how it can be transmitted to a susceptible host. So some pathogens are spread through respiratory droplets, meaning that the pathogen can be transmitted between people through the mere act of coughing or sneezing, such as the virus that causes COVID, and this means that spread can happen quickly enough under the right circumstances to even cause an epidemic or a pandemic. Others are spread through contact with contaminated body fluids but not through air, as in the case of Ebola virus. And so, this makes the likelihood of a pandemic occurrence of such a virus less likely. But again, with infectious diseases, I also like to say that we can be surprised, unfortunately, in many ways. And so, never say never.

But then there are other pathogens that tend to concentrate in the blood of an infected person. And so, for these types of pathogens, sometimes transmission between people requires exposure to contaminated blood as might happen with intravenous drug use. But others of these pathogens that concentrate in blood have the ability to be transmitted via certain mosquitoes, which might happen if a mosquito bites a person when the person has that pathogen in their blood and then that same mosquito goes on to bite another person.

So the point here is that different pathogens have different biological characteristics, and that determines how the pathogen can be transmitted. And while this might sound scary, the good news is that with accurate information, we can then take steps to protect ourselves from getting infected with these different types of pathogens.

[Sarah Gregory] Your article discusses five ways we can stop or at least slow spillover events. Tell us about each one of those.

[Neil Vora] That's right. We know that infectious diseases are increasingly emerging, and that's because of human activities that put us in contact with animal sources of disease. With that knowledge, we can then work backwards to identify steps we can take to prevent those spillovers. The point of our article was to give very clear recommendations on how to prevent spillovers by stopping the clearing and degradation of tropical and subtropical forests, improving the health and economic security of communities living in emerging infectious disease hotspots, enhancing biosecurity in animal husbandry, shutting down or strictly regulating wildlife markets and trade, and fifth, expanding pathogen surveillance so that we can quickly detect outbreaks when they happen.

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We describe specific interventions within each of these five categories that can then be implemented on the ground and through policy. And it's important to note that these interventions require transdisciplinary coordination, because no one person, discipline or institution has all of the knowledge and resources to implement these interventions. And that's why, as you can see from the author list on this paper, there's a lot of different institutions and people involved with many different expertise so that we could together come up with a proposed set of solutions.

And I'll give you an example of what I mean. Let's take the recommendation around stopping deforestation. Well, it's very easy to say that, but how does that actually get done? And here we're talking about preventing infectious disease emergence, but what does an epidemiologist like myself know about stopping deforestation? But in this paper, we cite the example of the Brazilian Amazon, that from 2004 through 2012, with dedicated resources to implement policy, had a 70% reduction in rate of annual deforestation. So the point is that while some of what we are calling for may sound aspirational, the reality is that we can actually implement these actions through collaboration and through dedicated work and resources.

[Sarah Gregory] What has the last three years of COVID and then mpox showed us? What are the weaknesses in preparedness?

[Neil Vora] The last three years have been so challenging, especially when considering the millions of people who have died from COVID and the suffering and also deaths from mpox as well. Experts have been warning for decades that it's a question of when a pandemic would occur, not if one would occur. And so, there's very little silver lining from COVID, and if there is any at all is that at least now at the highest levels of government, there are actions being taken to reduce morbidity and mortality from pandemics going forward. And that will require investments in pandemic prevention, which is about avoiding another pandemic, and also pandemic preparedness, which is about increasing our ability to respond if a pandemic occurs.

A lot of the discussion right now, however, in the public health space is focused only on the pandemic preparedness side of the equation rather than also talking about prevention. And that's a dangerous mistake, because we're only as strong as our weakest link, and ignoring prevention will carry grave consequences. Why is that? Well, we know that a reactive approach to pandemics rather than an approach that also combines prevention, is an imperfect approach, as we've seen with COVID and mpox. There are equity issues around just waiting for pandemics to occur rather than trying to also prevent them, because the tools of preparedness and response such as vaccines and medicines are often inequitably distributed, whereas prevention benefits everyone, particularly people in resource-limited settings.

And this underscores the need for a multi-faceted approach to a problem as big as pandemics, which means that we have to invest in both prevention and preparedness. Neither approach by itself is going to be perfect. But when we combine these approaches, we can minimize the risk of an undesirable outcome from occurring. And so, this paper that I published with my colleagues is focused on the actual interventions that can be taken right now to put prevention into practice.

[Sarah Gregory] Is it possible, on that horrifying note, that there's another pandemic following right on the heels of COVID?

[Neil Vora] Unfortunately, yes. We've seen in the last decade alone Ebola, Zika, COVID, mpox. We're also seeing around the world infectious diseases that we thought were well under control reemerging, including measles and polio. And so, the point here is that given the ongoing pace of the destruction of nature, we are continuing to find that spillover events are occurring. And some models show that the pace of pandemics will only increase severalfold in the coming decades, unless we do something to address those underlying drivers.

Sometimes people say that COVID is a once-in-a-century pandemic, but that's actually not true. In the last 105 years, approximately, we've had five other pandemics (four of them had been flu pandemics), then there was an HIV pandemic (there is an HIV pandemic), and of course, there's COVID. So there's been six pandemics in approximately the last 100 years. And again, we might see another pandemic soon, but this is not a reason to despair because we have tools to help us prevent and prepare for the next pandemic, and we must invest in those tools. In fact, research shows that the cost of investing in prevention only will be about 20 billion dollars a year, which is drop in the bucket compared to the millions of lives and trillions of dollars lost from a pandemic such as COVID.

[Sarah Gregory] Going back to your comment about preparedness, say there's another pandemic next week. Are we even remotely ready for it?

[Neil Vora] One of my concerns is that we, in fact, might be less prepared for the next pandemic than for COVID. And the reason I say this is because we've seen in the last three years how polarized societies around the world have become, and there's a widespread reputation of science and evidence-based measures to protect ourselves. And so with that reaction to the science, coupled with the fatigue that we have generally across the global population have experienced of pursuing additional public health measures, whether it be wearing masks or getting the next booster of a COVID vaccine (if one has access to it), I do fear that we are in a worse place in some ways for the next pandemic than we were back in early 2020.

But there's also many, many great minds at work right now to help us do a better job with the next pandemic when it occurs, and also prevent the next pandemic from even occurring in the first place. And that gives me hope. I see every day how hard people are working, and I'm seeing a lot of political will at the highest levels of governments around the world to do a better job. And that is reason for hope.

[Sarah Gregory] Are there currently any likely contenders for the next pandemic or do you think it will come out of the blue like COVID did?

[Neil Vora] So some people, they would say that COVID came out of the blue. I have a slightly different opinion, and I think many of my colleagues in this field would agree, that COVID was actually unfortunately an expected event, not with exactly this virus, but just the fact that a pandemic of a respiratory virus would occur. And as to the question about the contenders for the next pandemic, one of my greatest concerns is around influenza virus, which is another virus that can be spread through a respiratory route. And there are different variants of influenza viruses circulating in wild animals and spilling over into domestic animals, sometimes spilling over into people.

And so, we have to be ready for that next pandemic occurring. It's not a question of if it will occur, it's a question of when it will occur. But through the actions that we describe in this paper,

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we can also decrease that frequency of pandemics. We're probably never going to prevent every pandemic from occurring. But we can decrease that frequency and we can be better prepared for the next pandemic, whether it's from influenza virus or from a new coronavirus or from a different virus entirely. There are things that we can do to better prevent and prepare for the next pandemic.

[Sarah Gregory] So you mentioned global partners. Who are the global partners addressing these issues and what is being done and how are people working together?

[Neil Vora] One of the reasons why I'm so hopeful, despite the answer to my earlier question, is that I am seeing so much action happening on local, national, international, and global levels. And so let me give you an example with regards to global partners, but firstly within the World Health Organization, there is right now an ongoing negotiation for an accord around pandemic prevention preparedness and response. So this accord is going to help improve global coordination around pandemics. And the zero draft of this accord was released maybe back in early February of this year, and it had a lot of promising text to help us do a better job with pandemics going forward. It wasn't perfect, but that was the initial draft, and these negotiations are going to play out over the next year.

So that's one multi-level organization doing incredible work to help us better address the next pandemic. There's also the Convention on Biological Diversity. Biodiversity is a critical defense in preventing the next pandemic. When we destroy biodiversity in, for example, tropical spots of the world, we actually increase the risk of pathogens spilling over into people. But just in December of 2022, the Convention on Biological Diversity (which is basically a body of the United Nations) came out with a global biodiversity framework that was agreed upon by over 150 different countries of the world, and this framework sets the agenda for the next decade on conserving the world's biodiversity. And that is going to be so important as a tool for pandemic prevention. And one specific target within that framework specifically mentions the need to prevent spillover.

Another example is within the World Bank that recently created a new fund for pandemic prevention preparedness and response. And so, that's helping to create a pot of money to help countries around the world better address pandemics going forward. So I feel really hopeful that there's all these major political agreements that are being forged that will work together to bolster our ability to prevent and prepare for a pandemic.

[Sarah Gregory] What are your hopes for the immediate future? What would you like to see implemented? And what kinds of research?

[Neil Vora] I hope that we continue to talk about the need for an all-of-society all-of-government approach to pandemics. Pandemics are not purely issues of public health. We've seen that with COVID where every aspect of society was impacted by COVID. And that underscores the need for an all-of-society all-of-government approach to preventing and preparing for the next pandemic. So we have to emphasize the need for transdisciplinary solutions to this threat of pandemics. And again, I'm seeing that in the work being done on the global stage and also at national stages and local stages. So that to me is a major area for hope.

I do also wish that going forward, we will invest in more research for transdisciplinary solutions. All too often, the focus of research questions and research funding is around very narrow

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questions which have a very important purpose in science for answering specific questions. But sometimes what gets lost in that deep dive is the bigger picture and the need for syncing across sectors to develop the necessary solutions for global problems. And again, as my colleague Jonathan Jennings from Health in Harmony has said before, no one person, institution, or discipline has all of the tools and skillsets necessary to address a problem as big as pandemics. And so, we have to start bringing people together to better address this threat going forward.

[Sarah Gregory] I know you've talked about optimism and pessimism here, but what does the long-term picture look like? How bleak is it?

[Neil Vora] There's a lot of reason for hope, in my opinion. It's easy to get weighed down in despair. But one of the best antidotes to that despair is by taking action, and all of us have a role in that. Whether you are a scientist or a policy maker, you clearly have opportunities to contribute to the global efforts to prevent and prepare for pandemics. But people, even in other sectors, whether it's business or the arts or citizens who are doing advocacy in their own time, all of us have a role to play in advocating for a better future to address pandemics.

I would underscore that if we don't think about the upstream drivers that are leading to more pandemics, however, we are going to not be able to best address this threat. And many of the underlying drivers that lead to pandemics also contribute to climate change and biodiversity loss. So we are infracting a convergence of existential threats, but that right there means that we have common solutions to address these multiple threats that we can then be pursuing.

[Sarah Gregory] What are some of the benefits of preventing spillover events beyond pandemic prevention?

[Neil Vora] One of the major recommendations that we provide for preventing spillover events is around stopping deforestation, because that in and of itself helps to reduce the risk of spillovers through a variety of different pathways. But we also know that when we conserve force (when we protect force), we are fighting climate change and we are fighting the loss of biodiversity. Climate change has been called perhaps the greatest threat to human health in the coming century, and we're already seeing the devastating effects of climate change here, right now, across the world, and those effects are only going to get worse.

But when we invest in something like stopping deforestation, not only do we prevent spillover events, but we can help fight climate change. 30% of the solution towards stabilizing the global climate comes from nature-based solutions such as keeping trees standing within forests. Unfortunately, such nature-based solutions get less than 3% of overall global funding for climate change mitigation. But that means that every dollar we spend towards fighting climate change is also a dollar that can help prevent the next pandemic, that can help prevent biodiversity loss, if we are strategically investing those dollars. And so, it's really important, given the scale of the threats that we face today, that we start investing wisely and investing in options that can immediately confer benefits. And as we describe in this paper, the actions that are in the paper are things that can be done right now (today), and they will help us fight climate change, biodiversity loss, and pandemics.

[Sarah Gregory] Let's talk about One Health here for a second. How is this approach used currently and how do you think it can be improved?

[Neil Vora] One Health is a term that maybe was coined in approximately 2004, and I'm so glad to see it gaining traction in public health spaces and also in many other sectors as well. It's a term that is used to describe a collaborative, multisectoral, and transdisciplinary approach with the goal of achieving optimal health outcomes, and it recognizes the interconnection between people, animals, plants, and their shared environment. And that type of One Health—or some people also call it a planetary health—approach is absolutely what we need today to address threats such as climate change or pandemics. And one One Health solution that I'd like to highlight that we describe in this paper is through work that's been led by the organization Health in Harmony. This organization has shown that when you invest in healthcare for communities living around and in rainforests, you can actually lead to not only amazing health benefits for those communities, but actually decrease rates of deforestation, because many of these communities are socioeconomically disadvantaged and they engage in illegal logging in some instances to generate income to secure essential services such as healthcare. But this organization (Health in Harmony) has shown that when you invest in that healthcare for those communities, you can improve their health and decrease deforestation, which confers benefits for everyone around the world.

And so, that's a One Health-type solution that we need to be identifying and highlighting and pursuing more broadly around the world—listening to local communities and applying locally devised solutions or helping those communities implement those locally devised solutions. One other comment I would make about the One Health approach though is that quite often I see that there are generic calls for a One Health approach, and I would urge people who are working in the One Health space to move from generic calls for a One Health approach to actually giving very specific details on the actual actions that need to be pursued for One Health. And that's what we try to do in this paper, where we try to talk about the actual actions that should be taken that would put One Health into practice.

[Sarah Gregory] So I think this speaks to what you've just been talking about in your article, it says, quoting here, “Zoonotic pandemic risk is heightened by humanity’s broken relationship with nature.” That's quite a quote. Tell us what that means to you.

[Neil Vora] Well, it certainly indicates that we have seen massive improvements in human well-being related to the resources that we have taken from nature, right? We've seen human mortality go down in recent decades, childhood survival increasing, and these are all characteristics that we want to see improving. But we're now at this tipping point where the ongoing extraction of resources is actually meeting to adverse health outcomes, and we're seeing this because of climate change, or we're seeing this because of (what we describe in this paper) how deforestation or raising farm animals in unsafe conditions leads to the destruction of nature and also leads to the spillover of pathogens. So we need to start thinking going forward, given what has happened to nature over the last few centuries, about how ongoing extraction of resources will continue to, at this point, lead to adverse human health outcomes.

Ultimately, everything we derive as humans for our survival physically comes from nature. And if we continue to degrade nature as we've been doing, those benefits are going to start disappearing. I like to say that conservation is public health. Often times people see conservation as a very distinct field from public health, but whenever you're saving nature, you're also improving human well-being if that conservation is done in the right way. And I'm referring to saving water, saving or improving air quality, addressing climate change, right? These are all

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factors that, when we pursue those actions to improve air or water quality, we are also not just improving nature, but we are improving human well-being. So the point I'm trying to make is that it's time to start thinking about joint solutions to optimize outcomes for both people and nature.

[Sarah Gregory] Dr. Vora, tell us about your job, where you work and what you do, and your particular areas of interest. You were an EIS officer at CDC in 2013, when we did a podcast, you and I, about *Salmonella* in childcare settings. Does that relate in any way to what you do now?

[Neil Vora] I am so grateful for the experiences I've had, thanks to so many people including family, friends, and mentors and colleagues along the way. And my time at CDC—I was with CDC from 2012 through 2021—and those were some of the most important experiences of my professional life, and it was a privilege of a lifetime to serve my country in uniform through the US Public Health Service. A lot of my work for the CDC focused on outbreak response to zoonotic diseases. I helped respond to the two largest Ebola outbreaks ever in West and Central Africa. I led New York City's COVID Contact Tracing Program with a team of over 3,000 people, and numerous other experiences. And what I noticed, though, in public health we often are not talking enough about the upstream environmental drivers that lead to pathogen spillover in the first place.

And so, I did make the decision two years ago to join Conservation International so I can, in my own way—and many others have also been doing this for a long time, and now I get to contribute to that effort—but I'm trying to help link the conservation of nature to human health. We need nature to survive, and that's the focus of my work. I largely work in the area of policy because there's so many important policy opportunities right now, globally and nationally, to save nature and to save people. So that's the focus of my work. But I couldn't be doing this work without the experiences I have had through my time at CDC, and I also have the great fortune of seeing patients one day a week in a public tuberculosis clinic here in New York City, which I greatly enjoy. You know, I'm first and foremost a physician, and it's such an honor to be able to provide care to patients.

One thing I just wanted to add is that one of the things that I miss the most about my work at CDC are the amazing people. The colleagues I had from CDC and other public health institutions in the US and around the world are some of the most dedicated and selfless people I know. And these are people who work behind the scenes, often with little recognition (and frankly, with lower salaries than they could make elsewhere), they do this because they care. I am so thankful for these folks who continue to work so hard to save lives here in the US and elsewhere, as well.

[Sarah Gregory] You are also on the Editorial Board of our EID journal. How long have you been on the Board and what does that involve?

[Neil Vora] I have been reading the EID journal for over a decade. I had maybe my first paper in EID back in 2013, I think, when we did that podcast together. And it's such an important journal for sharing information, the latest data, on infectious disease emergence. And so, I jumped at the opportunity to serve as a volunteer on the editorial board of this journal approximately two years ago, and it's a pleasure to see the wealth of science getting done around the world and to help support that cause. It's so important that we keep generating knowledge and evidence-based solutions towards addressing emerging infectious diseases. And one thing I would like to see more of is more research on addressing the upstream drivers that lead to spillover. This is still a

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field that has a lot of room to grow, and so my call is for investigators around the world to please do research in this area and please submit your manuscripts to us. It will be a pleasure to review such manuscripts.

[Sarah Gregory] Well, thank you so much for taking the time to talk with me today, Dr. Vora, and for all that you do for public health.

[Neil Vora] Thank you so much for the opportunity to be here. And I just to again thank you for this chance, and also my colleagues who wrote this paper with me. It would not have been possible without them. It was a real team effort.

[Sarah Gregory] And thanks for joining me out there. You can read the March 2023 article, Interventions to Reduce Risk for Pathogen Spillover and Early Disease Spread to Prevent Outbreaks, Epidemics, and Pandemics, online at [cdc.gov/eid](https://cdc.gov/eid).

I'm Sarah Gregory for *Emerging Infectious Diseases*.

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