Nivitha Leena Naveen
Nicola Gabriele Nicastro

Key actions and outcomes in One Health National Action Plans for effective pandemic prevention

A research project on the drivers of zoonotic spillovers and the subsequent preventive measures to be taken from the One Health approach to mitigate future pandemics.

Applied Research Project 2024-2025

Partners: Four Paws – Animal Welfare Organisation

Nivitha Leena Naveen (nivitha.naveen@graduateinstitute.ch)
Nicola Gabriele Nicastro (nicola.nicastro@graduateinstitute.ch)

Nivitha Leena Naveen
Nicola Gabriele Nicastro

Table of contents

Abstract *3*
Introduction *4*
Methodology *6*
Literature review *8*
Which are the main drivers of disease outbreaks and spillovers? **8**
What prevention strategies can be developed to address these drivers? **13**
Adopting a One Health Approach **24**
Research gaps **27**
Case studies *29*
The One Health approach in Kenya **29**
The One Health approach in Bangladesh **36**
Interviews analysis *44*
Policy recommendations *48*
Conclusion and Discussion *53*
Bibliography : *54*
Annex *61*
Interviews transcripts **61**
List of abbreviations **86**

Nivitha Leena Naveen
Nicola Gabriele Nicastro

Abstract

ChatGPT was used to rephrase certain sentences in our project, to enhance the overall quality and comprehension of the text.

This research examines how governments can identify and address the key drivers of zoonotic transmission through national One Health action plans, with the aim of preventing future pandemics. Grounded in the One Health approach, which emphasizes the interdependence of human, animal, and environmental health, this study combines an in-depth literature review, detailed case studies on Kenya and Bangladesh, and a section summarizing our interviews with experts in health and the One Health approach. The literature review identifies the main anthropogenic drivers of disease transmission (such as land-use change, wildlife trade, climate change, and the inadequacy of public health infrastructure) and explores corresponding prevention strategies. The case studies provide concrete examples of national implementation, highlighting both progresses made and the challenges faced in operationalizing the One Health framework. Finally, the interview section fills certain gaps left by the literature review and case studies, offering a more practical perspective on our research and providing insight into current challenges and potential levers for effectively implementing a One Health strategy.

Introduction

One Health, emerged in the early 2000s, promotes an integrated approach between human, animal and environmental health. This approach notably aims to address emerging disease and subsequent possible pandemics by placing emphasis on the interconnectedness between ecosystem functions, socio-ecological practices, and the health of human, animal, and plant populations. The One Health approach is defined by the One Health High-Level expert panel as follows: *"an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems. It recognizes the health of humans, domestic and wild animals, plants, and the wider environment (including ecosystems) are closely linked and interdependent. The approach mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems, while addressing the collective need for clean water, energy and air, safe and nutritious food, taking action on climate change, and contributing to sustainable development"* (World Health Organization (WHO) et al., 2023).
In the Pandemic Prevention, Preparedness and Response Accord, for which negotiations were concluded by WHO Member States in April 2025, One Health is defined as follows : *« "One Health approach" for pandemic prevention, preparedness and response recognizes that the health of humans is closely linked and interdependent with the health of domestic and wild animals, as well as plants and the wider environment (including ecosystems), aiming for a sustainable balance, and uses an integrated multisectoral and transdisciplinary approach to pandemic prevention preparedness and response, which contributes to sustainable development in an equitable manner »*.[1]

The One Health strategy will be essential to tackle the future emerging diseases and pandemics, since the risk of infectious pandemics arises primarily from the spillover of viruses from wildlife to humans (Alimi et al., 2022). The knowledge based on the One Health concept can help to prevent these spillovers by understanding better the interface between humans, animals and environment and minimize the drivers that would increase the risks of pathogens spillovers (Markotter et al., 2023). Spillover events, where a pathogen originating in animals transfers to humans (what is called a "zoonotic disease"), have likely initiated every viral pandemic since the early 20th century. The yearly probability of worldwide diseases could increase several times in the next decades, primarily due to human activities (Vora et al., 2023).

The One Health approach is important to shift the paradigm and concentrate more efforts on the "prevention" of disease spillovers. It enables tackling the various drivers of disease spillovers, such as changes in land use, animal hunting and consumption, etc. (WHO, 2023). Addressing these factors, which drive disease emergence, can minimize the likelihood of human infection (Markotter et al., 2023). With an annual investment of around US$20 billion, the risk of spillover events could be significantly reduced. Compared to the millions of lives lost and the trillions spent

[1] https://apps.who.int/gb/ebwha/pdf_files/WHA78/A78_10-en.pdf

during the COVID-19 pandemic, these US$20 billion are a modest expense (Vora et al., 2023).

It is important not to confuse primary prevention with downstream/secondary prevention. In the context of our research and spillover prevention in general, we always refer to primary prevention, which means preventing a pathogen from transferring from animals to humans. This can be achieved by addressing the drivers of pathogen spillover through a One Health approach at the human-animal-environment interface (Markotter et al., 2023).

Secondary prevention, on the other hand, comes at a later stage, once the pathogen has already transferred to humans. It consists of preventing the development of the pathogen into an epidemic/pandemic (prevention of pathogen spread in humans) (Markotter et al., 2023).

While our research focuses on pandemic prevention, it is important to remember that the One Health approach aims to optimize the health of humans, animals, plants, and the environment, as they are all interconnected. Protecting animal and environmental health is crucial not only to minimize the risk of future pathogen spillovers and subsequent epidemics or pandemics but also for its own intrinsic value, beyond its impact on human health. Animals and ecosystems have a right to health and integrity. This is the core message of the One Health approach.

It is also primordial to remind that addressing spillover risk should take into account, in accordance with the core principles of One Health, specific geographic contexts, as well as the socioeconomic and cultural backgrounds of populations, while ensuring the protection of human rights, including those of indigenous communities (Markotter et al., 2023).

The research question guiding our project is: « Which drivers of zoonotic spillover should governments evaluate to identify the necessary actions in their national One Health action plans to prevent pathogen transmission from animals to humans? ».

In the literature review, we will explore what has been written in the past in relation to our research question, reviewing the main drivers of disease spillovers and the types of preventive actions that government can develop.

In the second part, we will conduct case studies on Kenya and Bangladesh to identify the key challenges governments face in establishing effective national One Health action plans, and to analyze which strategies have proven most successful.

In the final section, we will address the gaps identified in the literature and case studies by conducting interviews with field experts, offering a more practical perspective on the realities of implementation.

Methodology

To effectively address our research question, “Which drivers of zoonotic spillover should governments evaluate to identify the necessary actions in their national One Health action plans to prevent pathogen transmission from animals to humans”, the chosen methodology primarily relies on qualitative research. This includes a mixed methods approach with a desk review of existing literature, interviews with key experts, and the integration and comparative analysis of case studies (two national One Health action plans)."

Research design and approach

As written above, in this project research, we will adopt a qualitative approach and a mixed research design with descriptive analysis (analysis of the existing literature on the drivers of disease spillovers and preventive measures to avoid animal-to-human transmission while considering animal welfare and environmental sustainability) and comparative analysis (analysis of two national One Health action plans to compare the practices of these countries in terms of the One Health approach).

The goal of the literature review is to keep learning about our subject (main drivers of disease spillovers identified; successful actions taken by states to prevent the spillover, etc.). This analysis includes academic papers, data and case studies on high-risk activities favoring infectious disease outbreaks, reports and publications from governments and international organizations, documentation on best practices and lessons learned from past outbreaks and the One Health approach, etc.

Regarding the analysis of the two national One Health action plans, this will be useful to identify how countries have dealt so far with the One Health approach, what actions have been taken, which ones have been successful and which ones not.

Data collection methods

After analyzing the existing literature on the topic as well as the two national One Health action plans, we will complement our research with expert interviews to obtain answers that we were unable to find in the previously reviewed documents, and also to gather insights from field workers who can provide additional practical information on the One Health approach and possible prevention strategies in this regard.

Stakeholder selection criteria

We want to interview at least one person from these three different fields:
1) A key global health actor to gain insights on how to implement actions to prevent disease spillovers and how to convince governments to adopt the right policies.
2) A national health policy maker to help us understand the reality of the field in terms of policy implementation, which will help us to better frame our recommendations.

3) A One Health/zoonotic diseases expert, to gain deeper insights into the One Health approach, the key drivers of disease spillover we should focus on, and the most effective prevention measures.

Analysis framework

1) Descriptive analysis with the interviews and the literature review to identify and analyze the drivers of zoonotic spillover and the following measures suggested to prevent it. The interviews will complement the information found in the literature review and give us insights about the reality on the field. Throughout our analysis, we will consistently consider environmental sustainability and animal welfare in the implementation of these strategies. The role of communities in prevention and equity issues between countries are two important topics that we will also consider throughout our research.

2) Comparative analysis of the two national One Health action plans to identify the main preventive measures implemented in each national action plan, evaluate whether these measures have been successful or not in preventing pathogen spillover, considering the specific context of each country and analyze how each country has integrated animal welfare and environmental sustainability into their actions. The differences of each country will be considered.

The analysis will allow us to determine:

1)Which drivers of zoonotic spillover should be prioritized in One Health action plans.
2)What subsequent preventive actions are the most effective in each country regarding their specific context (always considering animal welfare and environmental sustainability).

Nivitha Leena Naveen
Nicola Gabriele Nicastro

Literature review

Which are the main drivers of disease outbreaks and spillovers?

Emerging infectious diseases in humans emerge mostly from the pathogens in animals (zoonotic diseases). The risk of spillover rises primarily for two main reasons: first, when there are more chances for animals and humans to come into contact. Secondly, the risks also increase when conditions make infected animals more prone to shedding viruses (Vora et al., 2022). In this first part of our literature review, we will examine the main drivers that lead to both situations, highlighting how human activities significantly contribute to the emergence of infectious disease by increasing the likelihood of spillovers.

Land use change

Land use change due to human activities, leading to a loss of biodiversity and ecosystem changes, is known to be the main driver of zoonoses worldwide (Loh et al., 2015). Land use change includes different human activities, such as forest clearing or urbanization, which alter the association of parasites, hosts and vectors, and how species interact (Rogalski et al., 2017), driving viral spillovers and disease emergence (Alimi et al., 2017).

Forest clearing and degradation specifically are often carried out for agricultural purposes. Beyond harming the animals and disrupting ecosystems, these actions bring humans to the forest edge and therefore increase contacts between people, their domestic animals and wildlife, which increase the risk of spillovers and pathogen transmission (Vora et al., 2023). Different studies have demonstrated the link between land use change and pandemic spillover, as a study made by Olivero et al. (2017), which shows that deforestation in Central and West Africa areas increases the risk of Ebola spread. Deforestation also plays an important role in climate change, leading to ecosystem degradation, biodiversity loss, species extinctions and ultimately increasing the risk of zoonotic spillover (Ellwanger et al., 2020). Besides forest clearing and degradation, urbanization and land conversion are also responsible for ecosystem changes and loss of biodiversity, leading to a decrease of natural species assemblage, favoring animals that can survive near humans, which are often species linked to zoonotic pathogens, such as bats and rodents (Vora et al., 2023). Urbanization and land conversion also create new species assemblage from different habitats, which can create new opportunities for pathogen spillovers, genetic diversification and adaptation of pathogens (Jones et al., 2013). Moreover, these different activities drive a decline in the wildlife habitat quality, causing extinction risk in wild species. In addition to disrupting ecosystems, this often eliminates natural predators of zoonotic hosts, resulting in a growth of species' populations capable of transmitting zoonotic disease. These species are suited to survive in modified landscapes where humans are present (Keesing & Ostfeld, 2021). Agricultural drivers are associated with more than 50% of zoonotic infectious disease that emerged in humans since 1940 (Alimi et al., 2021). One of the reasons,

related to land use change, is that agricultural expansion can promote human and farmed animal encroachment into wildlife habitats, creating favorable conditions for the transmission of zoonotic pathogens (Rohr et al., 2019).

Ecosystem changes, due to forest clearing/degradation, land conversion, and urbanization, can also increase the risk of spillovers because they disrupt species' habitats and cause them physiological stress. Consequently, wildlife tends to shed more pathogens since their immune defenses are weakened (Plowright et al., 2021). As these species adapt themselves better to humanized environments, they have more opportunity for contact with livestock and humans (Alimi et al., 2021).

Biodiversity-rich ecosystems are important for the well-being of animals, humans and the environment. A mechanism called « dilution effect » is important to avoid the risk of spillovers: In diverse communities, the fact that many species are present reduces the concentration of hosts carrying pathogens, therefore limiting transmission possibilities to humans (Keesing & Ostfeld, 2021). When there are many different species, the likelihood of a pathogen encountering a host decreases (Keesing & Ostfeld, 2006). Moreover, there is a « barrier effect » of non-host species (which are more present), who limit the transmission of the pathogens to hosts capable of spreading it (Keesing & Ostfeld, 2006).

Animal husbandry and farmed wildlife

These activities also play a role in driving spillover events and disease outbreaks. In intensive agricultural systems, populations of domestic animals often have low genetic diversity. This makes these animals vulnerable to epidemics, as diseases entering a group of genetically similar animals can spread more quickly (Jones et al., 2013). As they are in close contact with humans, they can act as intermediate or amplifier hosts, facilitating spillovers of pathogens to humans (Alimi et al., 2021). Animal husbandry and fish farming (as well as urbanization) can impact the « species abundance ». In areas where host populations are very dense, the likelihood of parasite transmission increases, which in turn increases the risk for an epidemic (Rogalski et al., 2017). Moreover, in denser host populations, parasites may evolve to higher virulence because there are sufficient hosts available to compensate for losses due to increased mortality. This is how the prevalence of the West Nile Virus increased in North America (Rogalski et al., 2017).

Another issue linked to the agricultural sector is the over-use of antimicrobial. In many countries, especially the low and middle-income countries, antimicrobials are used in animal husbandry to prevent animal’s disease and stimulate their growth. However, this leads to issues like antimicrobial resistance in pathogens present in these animals and therefore a multiplication of resistant bacteria (Olaru et al., 2023). These resistant bacteria can then be transmitted to humans via animal’s consumption or manipulation. Moreover, antimicrobials used in food animals are excreted and can persist in the environment. Therefore, residues of antimicrobials, along with emerging antimicrobial resistant bacteria, continuously circulate in the ecosystem, potentially reaching humans and animals and negatively impacting their health. (T Zhang et al., 2024). Another way in which antimicrobial resistance can be strengthened is via the use of antibiotics in aquaculture, which can contribute to the selection of resistant bacteria because antibiotic residues and resistant bacteria can

spread into aquatic environments, therefore affecting other organisms such as humans, but also wild animals, who can act as reservoirs and vectors and facilitate the spread of these resistant bacteria over large distances (Olaru et al., 2023).

Besides the risk of disease spillovers, the impact of modern animal agricultural practices on One Health is evident. First, through their negative effect on animal welfare due to the treatment of the animals, such as isolation and separation from natural environments and behaviors. Second, through their environmental impact, as animal agriculture contributes to both deforestation and greenhouse gas emissions (resulting from the conversion of natural lands into agricultural or grazing areas), exacerbating the climate crisis and, in turn, affecting human, animal, and environmental health. (T Zhang et al., 2024)

Wild animal hunting and consumption

Hunting of wild animals and their consumption has been associated with several viral disease outbreaks, such as the HIV (Alimi et al., 2021). According to Sharp & Hahn (2011), HIV could have emerged in Central Africa following the hunting of primates, as the human hunters contracted the virus after having consumed the meat of the infected monkeys. Food contamination can occur through several venues, and at any stage of the production, delivery and consumption, such as environmental contamination (soil, air or water pollution), but also unsafe food storage or processing (WHO, no date). The consumption of undercooked meat is a major vector of transmission. Activities related to hunting, such as cutting and handling carcasses can also expose humans to infectious bodily fluids (Milbank & Vira, 2022). Culling is another practice that has a direct impact on the spread of viral diseases : if culling increases in a significant way host mortality, parasites can evolve to become more virulent because they don't need to preserve their host to transmit anymore. Targeted culling of infected individuals can preserve the resistance in a host population, because resistant hosts survive and can pass on their resistant genes to subsequent generations. On the other hand, indiscriminate culling reduces resistance in host populations (Rogalski et al., 2017). Butchering can also be a dangerous activity in terms of transmission, due to the direct exposure to animal bodily fluids or the indirect exposure through utensils contamination (Friant, 2024). It is important to remember the fact that in some situations, people will privilege some practices rather than others due to their nutritional needs, even if these practices can increase the risk of diseases. The socio-economic aspect has to be taken into account (Friant, 2024). Cultural practices and preferences can also influence the way of consuming, hunting or trading wildlife, as in China, where eating some wild animals can be seen as a symbol of wealth (Alimi, 2021). This, therefore, can influence the spillovers and outbreaks of disease. Furthermore, people in low- and middle-income countries may be at greater risk of infection from animal consumption due to global gaps in food safety practices. (T Zhang et al., 2024)

Another main driver of disease spillovers involves both wildlife trade and travel. First, wildlife trade leads to close interactions between wildlife and humans, which, again, increase the risks of zoonotic disease emergences (Alimi et al., 2021). These close interactions between wildlife, humans and domestic animals can happen in markets, where these animals are sold, as well as transit sites (which are multiplying due to

the growing global demand for wildlife products) (Shivaprakash et al., 2021). The insufficient sanitary conditions in some wildlife markets increase the risk of spillovers (Milbank & Vira, 2022). It is important to note that approximately a quarter of traded mammals host 75% of known zoonotic diseases (Shivaprakash et al., 2021). Urbanization, particularly in cities in the global South, also plays a role in increasing interactions between animals and humans: for a few years, we have now observed a rapid nutritional transition in many of these cities with a growing demand for animal products, which intensifies the trade and transport of live animals and animal products, both in cities and across national borders. This dynamic leads to increased animal-human contact along major transportation corridors (Ahmed et al., 2019). The WHO, in collaboration with the World Organization for Animal Health (WOAH) and the United Nations Environment Programme (UNEP), issued guidance on actions that governments should adopt in order to *« reduce the public health risks associated with the sale of live wild animals for food in traditional food markets »*[1]. These three organizations called for a suspension on the trade of live wild mammals and the closure of food markets selling them (WHO, 2021). Secondly, wildlife trade, as well as international travelling, can change the genetic diversity of parasites. By moving parasites to new geographical areas, humans increase the parasites' diversity, as populations from different places mix and create new and more diverse strains (Rogalski et al., 2017).

Climate change

Climate change is also a significant driver of disease spillovers. It is a wide and complex driver, as many other drivers are interconnected with it (forest clearing, animal agriculture, etc.) and has a significant number of repercussions for humans, animals and environmental health. We will discuss a few of them here. Firstly, climate change is altering ecosystems and biodiversity, which subsequently affects where and how pathogen reservoirs live. 40,000 species worldwide are already on the move due to climate change (Alimi et al., 2021). Besides the negative effects for these animals, these migrations of pathogen reservoirs can create "geographic overlap" with humans and increase the likelihood of cross-species transmission of pathogens, which can facilitate spillovers (Liao et al., 2024). As written above, biodiversity loss favors the 'reservoirs' of species that adapt more easily to a variety of environments, such as rodents and bats (Alimi et al., 2021). Secondly, climate change can also weaken the health of host populations of pathogens due to environmental stress, which makes these populations more vulnerable to infections. This stress also leads to an increased risk of pathogens transmission to other hosts and subsequent infections escalating into outbreaks (Liao et al., 2024). Thirdly, global warming creates favorable conditions for pathogens and vectors. For example, mosquitos' optimal transmission periods are influenced by temperature. Pathogens transmitted by mosquitoes show a peak in transmission between 23 and 29°C, and this cycle can be prolonged by climate change, therefore increasing the risk of transmission and spillover in new regions (Liao et al., 2024). A good example of the impact of climate change's on the risk of spillovers is the forecast that the annual number of cases of West Nile Virus disease are projected to double in the United States by 2050, notably due to the warmer temperatures. Besides the negative effects on human health (potentially 3'300 additional deaths per year), this

would also have bad economic implications for the U.S., because the rise of this disease would be accompanied by over 3 billion dollars in hospitalization costs (U.S. Global Change Research Program, 2014).

Climate change also leads to changes in human behaviors, which subsequently affect disease transmission. This is the case of climate migration: populations mostly move from rural to urban areas, bringing disease in areas of the world where they were not previously present. Furthermore, it increases the number of people in already high-populated areas, which makes the risk of disease outbreaks higher. Mostly in low-income countries, these rapid and unplanned urbanizations result in the formation of densely populated slums with insufficient sanitary infrastructure, lack of access to clean water and limited access to healthcare services, creating an environment where the spread of infectious diseases is facilitated (McMichael, 2015).

It is useful to underline the fact that, while the impact of climate change on disease spillovers is relatively well accepted among scholars, the complete scale of this risk remains poorly measured (Mora et al., 2022). This is notably due to the fact that there are over 1000 unique pathways through which diseases can result from climate change, via various ways of transmission (Mora et al., 2022). However, the negative effects of climate change on the environment, biodiversity, ecosystems, animals, and human health no longer need to be proven.

We now want to dedicate a few lines about the relevance of all the drivers mentioned so far. While some academic papers emphasize the positive correlation between some human activities and disease spillovers and outbreaks, other studies disagree with this statement. This is the case of urbanization: while some studies mentioned urbanization as a factor contributing to the spread of infectious diseases, a paper released in 2024, by Mahon et al., (2024) found out that urbanization decreases infectious disease. This negative correlation between urbanization and disease could be due to the fact that urbanization brings improved water sanitation and hygiene, as well as habitat loss for parasites and non-human hosts (Mahon et al., 2024). This disagreement proves that more research on some drivers and their effects on diseases need to be conducted.

To conclude this part of the literature review, it is important to note that these drivers don’t act alone but often are interconnected. As mentioned several times, examples include the impact of deforestation on climate change and temperature variations, or the effects of animal agriculture on global warming (Ellwanger et al., 2020). Such interconnections can be observed with nearly every driver. This is why the One Health approach, which recognizes the interconnectedness of animals, humans and environmental health and promotes intersectoral collaboration, is the most effective strategy to address these challenges and reduce the risk of future pandemics.

What prevention strategies can be developed to address these drivers?

In this second part of the literature review, we will use once again the One Health concept to understand the best ways to control the spread of infectious diseases. While essential, current pandemic discussions focus on post spillover measures like outbreak response, health system strengthening, and vaccine development. These measures alone are insufficient for prevention, especially when vaccines are unavailable or face distribution challenges, particularly in low-income countries. To effectively prevent pandemics, there is an urgent need to invest in preventing spillover and controlling early disease spread, consistent with the One Health approach, which aims to balance the health of humans, animals, and the environment (Vora et al., 2023). While public health focuses on social determinants of health and the primary prevention of diseases (intervening before a disease starts or an infection occurs), the One Health approach follows a similar strategy but also considers risk factors at the human-animal-environment interface, given the clear link (emphasized by the drivers discussed above) between environmental degradation, animal welfare and the risk of spillover.

Sustainable Agriculture and Husbandry Practices

The development of modern agriculture, despite its benefits, has brought a series of challenges with negative repercussions on animal, human, and environmental well-being. As discussed in the first part of this literature review, modern agriculture has led to ecosystem degradation, biodiversity loss, an increased risk of interspecies disease transmission (zoonoses), vector-borne diseases, and the growing threat of antimicrobial resistance (Zhang et al., 2024). Modern agriculture is characterized by practices such as intensive farming and the extensive use of agrochemicals. Therefore, to ensure sustainability and the well-being of all stakeholders, safe and sustainable agricultural practices are essential. (Zhang et al., 2024).

Including routine veterinary services and health monitoring of animals is another important practice to adopt. Surveillance systems are essential in animal husbandary to assess the effectiveness of current practices and monitor the potential emergence of zoonotic diseases or antimicrobial use (Zhang et al., 2024). A good example of a national-level surveillance system is the *National Animal Health Surveillance System* in the United States*,* which monitors livestock infections, including zoonoses. Another example is the *National Animal Health Monitoring System,* which collects data and monitors the health management of livestock, including antimicrobial use (Zhang et al., 2024). Sustainable practices in animal husbandry requires management measures, such as quarantining new animals and vaccinating animals against endemic disease, and physical measures, such as enclosures that separate farm animals from each other and from wildlife (Vora et al., 2023). Backyard flocks and commercial poultry systems often struggle with implementing upstream prevention measures due to resource limitations and impractical guidelines. Small-scale and backyard poultry farmers may lack financial resources, infrastructure, or technical expertise leading to challenges that arise when standardized recommendations do

not account for local conditions, production scales, or economic feasibility (Vora et al., 2023).

Underfunded animal health services and chronic food insecurity result in ineffective disease surveillance and risky practices, such as consuming sick or deceased animals (Vora et al., 2023). Investing in animal health services, identifying public health concerns, and implementing targeted interventions are essential for reducing the risk of disease transmission at the human-animal-environment interface (Vora et al., 2023). Surveillance systems also help to better understand and identify the role of animal agriculture in the pathways driving pathogen transmission. Unfortunately, low and middle-income countries still face challenges in developing national surveillance systems for zoonoses and antimicrobial resistance (AMR) due to limited resources and infrastructure gaps (Zhang et al., 2024).

To preserve environmental and animal health in intensive farming and mitigate the risks of zoonoses, governments could also implement policies requiring farms to reduce the number of animals raised and facilitate a transition to products that do not involve butchering or rearing. In this regard, ending subsidies for industries involved in the production of conventional animal meat, dairy, and eggs, while promoting alternative protein sources, could be an effective approach (Stel et al., 2022).

Antimicrobial resistance is also a significant driver of zoonotic spillover, in addition to its detrimental effects on animal health, biodiversity, and the environment. Antimicrobials are predominantly used in intensive livestock farming, where animals are kept in crowded and stressful conditions that weaken their immune systems. As a result, antimicrobials are often employed to compensate for inadequate animal husbandry practices, prioritizing economic objectives (such as maintaining high production levels) over the health of animals, humans, and the environment (Zhang et al., 2024). To address the issue of AMR, adopting strategies based on a One Health approach is essential. This involves implementing good agricultural practices, such as those discussed above: improving animal husbandry, strengthening health services and enhancing upstream prevention. In addition to these technical measures, educating farmers and other stakeholders about the risks of AMR is also crucial (Zhang et al., 2024).

Enhancing Food Security

There are several approaches to fortifying food systems, reducing dependence on unsustainable practices such as bushmeat consumption, which can increase the risk of exposure to potential pathogens (Friant et al., 2020). Measures like promoting sustainable agricultural practices like regenerative agriculture and permaculture can decrease environmental impacts and ensure long term agricultural productivity. (Akhtar et al., 2016). Adhering to hygiene and sanitation standards in livestock production significantly improves food supply, security, and both animal and human health (Bianchini et al., 2019). Moreover, educating the population and local communities on proper food management practices to minimize spillover risks is essential. A good example is a training program organized by the CAN (Community Action Network), which has improved hygiene in animal slaughtering across many

communities in West Africa (IDRC, 2024). This clearly illustrates the importance of such measures in spillover prevention.

Food systems must be at the heart of prevention efforts. The One Health approach places the health of humans in an interconnected relationship with the environment and animals' health. Almost every driver of pathogen spillovers is interlinked with our food system, such as land use change, agricultural intensification, wildlife trade, use of pesticides and antimicrobials etc(Ruckert & al.,2021). Therefore, a change to our overall relationship with animals is needed, in order to shift towards a sustainable food system (The Lancet, 2023).

Ecological disease prevention strategies

Such measures can enhance ecosystem health and curb infectious diseases. Preserving biodiversity stabilizes the ecology of hosts and pathogens by reducing the risk of emerging diseases. Conversely, activities like deforestation, mining, and intensive land use degrade ecosystems, increase human-wildlife interaction, and facilitate spillover events, also raising exposure to disease vectors such as mosquitoes (Ellwanger et al., 2020).

Wetlands can act as a buffer between livestock and wildlife, reducing spillover risks. Wu et al., 2019 studied the link between highly pathogenic avian influenza (HPAI) H5N1 outbreaks and the protection of waterfowl habitats in China. They discovered that safeguarding lakes and wetlands lowers the chances of avian influenza transmission from wild waterfowl to poultry. (Alimi et al., 2021). Ecological niche modeling (ENM) uses environmental data to predict species distributions across geographic areas and time periods, helping forecast how environmental changes will impact these distributions (Daszak et al., 2013). A controlled study found lower infection rates in humans and animals, as well as reduced environmental pathogen loads, in villages using environmental interventions such as removing cattle from snail-infested grasslands, building lavatories for improved sanitation, and providing boats with sanitation containers, compared to villages using standard disease control measures. (Wang et al., 2009).

Other preventive measures in the ecological field include, for example, establishing nature reserves or land rehabilitation projects, to protect and enhance biodiversity. All these measures, which strengthen biodiversity, help prevent the various drivers that could lead to zoonotic spillover and improve the well-being of the animals involved and the environment in general (Zhang L et al., 2024). Biodiversity loss is caused by human activities such as accelerated urbanization industrial agriculture, deforestation, land-use change and global travel. The solution is to shift our paradigm to more sustainable practices.

Reducing Wildlife Trade

The wildlife trade, driven by demand for food, pets, skins, traditional medicines, and ornaments, poses a significant spillover risk (Vora et al., 2023). Reducing spillover

events involves limiting the trade and use of wildlife**,** especially in regions where bushmeat consumption threatens species. The trade of exotic animals as pets also narrows the barriers between humans and exotic pathogens, necessitating intense efforts to combat this trade (Ellwanger et al., 2020). Prevention efforts should target live wild birds and mammals while regulating commercial wildlife markets and safeguarding the rights of Indigenous Peoples and Local Communities (IPLCs) who depend on wildlife for sustenance and livelihoods. Community programs and government partnerships are essential for offering sustainable income alternatives to wildlife trade (Vora et al., 2023). To reduce disease risks, interventions should target farms and live animal markets through market closures, hygienic shelters and improved sanitation (IPBES, 2020).

The WHO, WOAH, and UNEP have called for a global suspension of live wild mammal sales in wet markets due to their high zoonotic spillover risk (IPBES, 2020). However, efforts must also prioritize cultural and traditional drivers to encourage behavior change rather than impose a top-down approach. Given the importance of these markets for food and livelihoods, regulatory strategies should be balanced with community needs (IPBES, 2020). This was seen in Ibadan, Nigeria, when authorities addressed zoonotic risks in Bodija Market by establishing the Ibadan Central Abattoir in 2014, offering modern slaughtering facilities through a public-private partnership. However, attempts to forcibly relocate meat sellers led to resistance and unrest. (Kola-Aderoju and Ityonzughul 2021). Government-led initiatives should apply behavioral science, psychology, economics, and social marketing to reduce demand for live wild birds and mammals. Since wildlife consumption is often driven by luxury and perceived health benefits rather than necessity, lowering urban demand can reduce economic incentives for the wildlife trade. This shift would help preserve wildlife for IPLCs who rely on it for subsistence without enabling the continuation of commercial wildlife trade practices (Vora et al., 2023). Recognizing and supporting IPLC rights can ensure more sustainable and equitable interventions that align with the OH approach.

Forest Conservation Measures

Land use changes, especially in tropical and subtropical forests, are major drivers of emerging zoonotic diseases globally. Species that survive forest clearance often host pathogens that can infect humans and animals. For example, bats carrying Nipah virus in Bangladesh now roost in densely populated areas due to habitat loss. Additionally, deforestation drives climate change, pushing animals like bats into regions where many people live, increasing spillover risk. To address spillovers from tropical forest clearing and degradation, integrated and enforced policies are required (Vora et al., 2022). Brazil's success in the Amazon Basin, achieving a 70% reduction in deforestation, demonstrates the effectiveness of such measures. Notably, nearly half of intact Amazon forests are in Indigenous territories, where deforestation rates are significantly lower.

Regulatory and market-based measures can further reduce forest degradation. For example, Europe is considering import restrictions on commodities linked to deforestation, and numerous financial institutions have pledged to cease investments in activities that contribute to deforestation. (Vora et al., 2023). The success of this strategy has varied across different sites. Better outcomes could be achieved by

focusing on local scales, using in-kind contributions instead of cash payments, and emphasizing equity (Grima et al., 2016). The UN climate summit's commitment to end deforestation in over 100 countries by 2030 is promising, with health outcomes prioritized to maximize impact, effective compliance requires active community engagement to ensure positive impacts (Vora et al., 2023).

Community engagement can significantly reduce reliance on deforestation by providing local services, such as healthcare, to IPLCs living within and near forests. For instance, in Indonesian Borneo, high healthcare costs drove illegal logging. With support to design their own solutions, IPLCs established a medical center and alternative livelihood programs. Over a decade, this led to a 90% decrease in illegal logging, 21,000 hectares of forest regrowth, and $65 million in averted carbon loss. Similar successes have occurred in Madagascar and Brazil. (Vora et al., 2023). As highlighted in the previous section, deforestation and ecosystem degradation contribute to increased human-wildlife interactions, facilitating pathogen spillover. Strengthening forest conservation efforts as a primary prevention strategy for reducing pandemic risks, not only supports environmental sustainability but also serves as a vital strategy reinforcing the need for integrated One Health approaches in global health and environmental policies.

Controlling Emerging Infectious Disease Hotspots

Deforestation in disease hotspots increases human and animal proximity to wildlife, raising spillover risks through trade and unintentional contact. These areas cover only 4% of the global area (10% of tropical areas) but account for 60% of global spillover risk (Vora et al., 2023). Furthermore, reducing anthropogenic environmental changes in emerging disease hotspots benefits both global health and conservation. However, significant challenges exist, particularly in high-risk countries with rich biodiversity, many of which are developing nations. (IPBES, 2020). Many communities in these hotspots lack healthcare, sustainable livelihoods, food security, and education (Vora et al., 2023).

Solutions for environmentally mediated diseases, such as vector-borne and zoonotic diseases, reflect the focus of One Health, Planetary Health, and Eco Health. (Hopkins et al. 2022). Reducing local zoonotic disease risks can be simple. For example, covering shaved palm tree trunks can prevent Nipah virus infection by avoiding bat excrement contamination (Vora et al., 2023). In Malaysia, planting fruit trees a minimum distance from pig sties has effectively prevented Nipah virus outbreaks by reducing bat-to-pig transmission. (Alimi et al., 2021).

Enhance surveillance at human-domestic animal-wildlife interfaces

According to the World Organization for Animal Health & International Union for Conservation of Nature (IUCN) (2024), effective surveillance requires comprehensive planning to ensure cost-effectiveness and proper setup. Surveillance types can include *active (systematic data collection), passive (reporting disease cases), event-based (rapid detection of unusual events), and sentinel (monitoring specific species*

(WOAH & IUCN, 2024). Multisectoral pathogen surveillance improves early detection and response by combining data from human, animal, and environmental health sectors. (Vora et al., 2023).

Rangers, hunters, local communities, and Indigenous peoples are crucial in detecting changes in wildlife health given their unique insights. While surveillance systems for domestic animals are well established, wildlife monitoring remains limited. The IUCN Red List identifies disease as a critical threat to species survival. The interconnected challenges of biodiversity loss, ecosystem degradation, and the emergence of infectious diseases exacerbate transmission risks, highlighting the necessity of comprehensive wildlife surveillance to mitigate future outbreaks (WOAH & IUCN, 2024).

Systematic wildlife surveillance requires significant veterinary medical capacity and enhanced multisectoral laboratory networks for molecular and serologic screening. This includes pathogen-specific assays and high-throughput screening tools. Data from a 25-year study revealed increased Hendra virus spillover from bats to horses during environmental stress, this supports forest restoration as a countermeasure to reduce future spillovers (Vora et al., 2023). Surveillance can identify the diseases, pathogens, and toxic agents present in wild animal populations, along with their geographic distribution and host species. It can detect new or emerging diseases and measure the proportion of affected animals. This builds national capacity to manage urgent health events and supports short and long term species assessment and conservation planning (WOAH & IUCN, 2024).

Integrated disease surveillance is a comprehensive strategy adopted by countries to ensure early detection and timely response to public health threats (World Health Organization, 2022). It is essential for identifying risks across human and animal populations. For example, during the pandemic influenza A(H1N1)2009, "reverse zoonotic" transmission was observed where human cases preceded animal outbreaks, suggesting that human cases could act as sentinels for animal risk (Scotch et al., 2009). We must integrate data from various sources to identify risk factors for disease emergence across wildlife, companion animals, livestock, the environment, and humans. (Ruckert et al., 2021).

There is also a need to develop a global integrated One Health monitoring system via data sharing agreements between governments and others (such as the private sector), ensuring access to surveillance data (Ruckert et al., 2021). Surveillance programs should be co-developed and co-managed with Indigenous Peoples to involve them directly in activities affecting their lands, territories, and dependent species. This ensures transparency for the involved Indigenous community and surrounding affected communities (WOAH & IUCN, 2024). In a randomized controlled trial it was found that communities where both humans and bovids were treated experienced lower human infection rates and reduced environmental contamination compared to those where only humans were treated (Wang et al., 2009). Thus, integrated approach not only ensures a more comprehensive surveillance system but also highlights the interconnectedness of human and animal health, emphasizing the need for collaborative efforts in disease prevention and control.

A preventive surveillance approach should include One Health (OH) risk assessments that monitor infectious agents in various species and the environment to prevent cross-species spillover (Ruckert et al., 2021). Hazard identification and risk assessment help set priorities for surveillance. Risk-based approaches focus on populations or settings at risk, such as areas with gorilla trekking which have high disease transmission risk from humans to great apes. (WOAH & IUCN, 2024). These assessments could be conducted by OH expert networks like the WHO Hub for Pandemic and Epidemic Intelligence and connected to a global One Health structure. The environment is crucial in surveillance as infectious agents can survive outside their natural hosts. Monitoring their presence in key locations, such as water, can help track infection distribution in both animals and humans. (Ruckert et al., 2021).

Cross Sector Collaboration

To effectively prevent future pandemics, the One Health approach must broaden beyond just public health responses post-spillover. This involves implementing preventive measures and layered safeguards to address the complex interplay of human behavior, nature, and spillover events. Achieving this requires significant coordination, collaboration, and substantial new resource allocation across human health, animal health, environmental, and food safety sectors (Vora et al., 2023). Coordination across sectors results in a better use of resources and helps strengthen health systems (T Zhang et al., 2024).

Effective OH preparedness necessitates the establishment of sustainable communication channels across multiple sectors and governance levels, from local communities to national authorities. This requires an integrated and interdisciplinary OH governance framework that fosters collaboration among medical, public health, veterinary, agronomy, social sciences, and environmental sectors while engaging both public and private stakeholders (Ruckert et al., 2021).

Institutional mechanisms, such as OH platforms or multi-sectoral coordination mechanisms (MCMs), can facilitate structured and continuous cooperation, enhancing coordination and information exchange across the human-animal-environment interface, including the participation of private sector actors in the OH approach. (Ruckert et al., 2021). Colombia's agricultural industry established Public-Private Partnerships (PPPs) to combat AMR through a One Health approach. These partnerships enhance collaboration and accountability between the public and private sectors, maximizing results when monitoring is assigned to the private sector. This model aids in controlling animal diseases, promoting food safety, and ensuring fair income for producers (Cediel-Becerra et al., 2024). Successful implementation of One Health prevention strategies and preparedness will require the private sector to fully adopt the OH Strategies in their business models (Ruckert et al., 2021)

Equitable resource allocation is crucial for developing One Health Networks (OHNs) to avoid investment duplication or misalignment. A study of 184 OHNs highlighted disparities, with a concentration in Europe and a focus on emerging infections.

Enhancing effectiveness requires establishing comprehensive databases, addressing resource allocation imbalances, and creating egalitarian networks that tackle diverse One Health issues and serve vulnerable communities. (Mwatondo et al., 2023). Initiatives like the World Bank Pandemic Fund and the World Health Assembly pandemic accord can assist developing nations, but true equity requires primary prevention that prevents spillover. Solely focusing on post-spillover interventions implies tolerance of outbreaks in resource-limited areas. Preventing outbreaks saves lives in vulnerable regions, ensuring equitable health benefits globally (Vora et al., 2023).

Effective public education

It empowers communities to prevent and respond to health threats. Education and awareness of the One Health concept are essential prevention strategies. By integrating One Health principles into their teaching, educational institutions support the efforts of governments and communities, making their practical application easier (Henley & al., 2021). According to Ellwanger et al. (2021) while high-income countries have embraced hygiene practices, low-income nations still struggle due to inadequate infrastructure and education. Improving housing conditions and promoting hygiene education can reduce disease prevalence in these regions. In Iceland, improved on-farm biosecurity and public education reduced campylobacteriosis cases in poultry and humans (Stern et al., 2003).

Patz et al. (2004) recommended Centers of Excellence to prioritize infectious diseases impacted by ecological degradation. These centers inform communities, conduct interdisciplinary research, and support science-based policymaking, highlighting the need for integrated strategies to address disease emergence linked to ecological degradation. *The University of Global Health Equity in Rwanda* is a good example of an institution contributing to a government's prevention strategy. Students at this university are taught to think holistically and to prioritize collaboration and multi-sectoral partnerships in order to develop innovative and equitable solutions to global health challenges. They learn directly from farmers, community members, and livestock owners how to prevent zoonotic disease transmission through practical One Health approaches in the field (Henley & al., 2021). Education, besides building awareness, also offers practical framework for implementing these principles at local, national, and international levels. Providing this practical framework to local communities will support the design and implementation of One Health programs and policies that directly involve them. This is essential to the One Health approach, as community members are among the most vulnerable to changes in environmental and animal health. Their involvement in shaping One Health policies is also crucial due to their networks, which facilitate the practical application of the approach, and their deep knowledge of local conditions. Being aware of shifts in animal, human, and environmental health, their experience is invaluable for monitoring potential zoonotic disease outbreaks and spillovers (Henley & al., 2021).

Economic Case for Conservation

Evaluating the pandemic prevention measures from an economic perspective is essential. Current global funding for advancing OH and mitigating infectious disease spillover remains inadequate. Recognizing this gap, the G20 and the European Union (EU) emphasize the need for stronger political commitment to ensure sustained and increased investment in addressing risks at the human-animal-environment interface. The G20 panel had advocated for a minimum of $75 billion in international public funding to strengthen pandemic prevention and preparedness efforts (Ruckert et al., 2021).

Strengthening the economic case for nature conservation as a disease prevention measure requires better quantification of pandemic prevention costs and benefits. Compensation mechanisms can alleviate disproportionate burdens on poorer nations, while protecting 30% of natural assets yields greater economic benefits than alternative land uses. Proactive environmental management to reduce pandemic risks is far more cost-effective than addressing their aftermath. Real options modeling supports a global One Health strategy by 2041. The OECD estimates biodiversity conservation funding at $78–91 billion annually, a fraction of the zoonotic disease costs. Preventative measures, including regulating wildlife trade, land use changes and enhancing One Health surveillance, cost between $22-31.2 billion, further reduced to $17.7-26.9 billion when accounting for carbon sequestration benefits from reduced deforestation. These costs are significantly lower than pandemic damages, highlighting the economic incentive for transformative change to mitigate pandemic risk. (IPBES, 2020)

Sustainable urbanization

The One Health High-Level Expert Panel (OHHLEP) emphasizes a One Health approach, collaborating globally to prevent zoonotic spillovers (Mettenleiter, 2023). The process of urban planning that prioritizes health infrastructure can control disease spread through improved sanitation and hygiene. (Ellwanger et al., 2021). This One Health approach advocates for the creation of inclusive spaces that coexist harmoniously with nature and its various components, extending from expansive habitats to the micro-scale of urban biotopes. Within this context, the Green In Cities initiative, an EU-funded project, promotes nature-based solutions for urban climate adaptation and mitigation. It focuses on mitigating extreme weather events harmful to both human and ecosystem health, while promoting inclusive urban designs that ensure equitable access to green spaces and climate resilience for all.

Community Engagement and Interventions

As we have emphasized multiple times, the engagement of local communities in the implementation of One Health strategies is essential. First, involving them in the process helps build trust between the various stakeholders of the One Health strategy (researchers, legislators, the executive, etc.) and local communities, making it easier for community members to accept the implementation of interventions in the field. As a result, solutions are more likely to be adopted on the ground and sustained in the long term, as they address real needs. Moreover, local communities play a crucial role

due to their unique knowledge of the field. Their local expertise is essential for identifying priority health issues and finding context-specific solutions (Sangong et al., 2025). By including local communities in One Health prevention strategies, they become more aware of the risks and are better equipped to identify infectious disease symptoms, which helps to better prevent disease outbreaks and spillovers. For this reason, investing in educating the population on One Health principles must be a priority for governments, in order to raise awareness across society about the methods and actions needed to protect human, animal, and environmental health (Sangong et al., 2025). The WHO itself emphasized the numerous benefits to engage with communities to promote health and well-being. The organization defines community engagement as follows: *"a process of developing relationships that enable stakeholders to work together to address health-related issues and promote well-being to achieve positive health impact and outcomes".* (WHO, 2020).

Technological advancements

Technological advancements along with community engagement is essential to effective One Health strategies that prevent pandemics. Digital technology, predictive technologies, AI, and machine learning advance 'precision public health' by improving data collection and outbreak tracking (Bedford et al., 2019). They can help detect unusual health events faster by analyzing large amounts of data from different sources. Effective surveillance requires integrating technology-based solutions with community programs and standardizing systems across regions. Tools like mosquito-recognition apps enhance data collection by involving citizens in public health efforts. (Bedford et al., 2019). Approaches like Translational ecology turns scientific knowledge into policies that protect the environment, requiring the involvement of decision-makers (Ellwanger et al., 2021).

Equity and equality in the One Health Approach

To conclude this part of the literature review, it is important to recall that, to successfully implement the One Health approach nationally and internationally, equity and inclusiveness must be at the centre of One Health policies, legislation and practices. First, all relevant stakeholders must be included to develop and implement context-specific One Health solutions, such as the local communities, as discussed above (FAO et al., 2022). Secondly, health inequities within the same country exist in many states. Therefore, the implementation of One Health policies must be grounded in equity, ensuring that all segments of the population, especially the vulnerable populations are fully considered. Epidemics and pandemics exacerbate preexisting inequities, and policies that fail to address these disparities risk deepening social and health injustices (Rucket et al., 2021). Only a truly equitable approach can reduce inequity within countries and ensure that all populations benefit from One Health policies.

At the international level, it is well known that while low- and middle-income countries are the most affected by infectious zoonotic diseases, they also suffer from a lack of

funding to prevent spillovers. The factors contributing to the increasing frequency of zoonotic spillover events include cultural traditions, but also the encroachment of impoverished settlements onto natural habitats (Haq et al., 2024). As many people in these countries lack access to healthcare services, notably due to funding shortages, the burden of disease is significantly higher than in wealthier nations. The Covid-19 crisis illustrated this inequity, as only 2.5% of vaccines were administered in low-income countries, compared to 45% of the global population receiving at least one dose (Ruckert et al., 2021). The existing vaccine gap exacerbates the situation in low- and middle-income countries, as it allows the replication and the emergence of novel mutant viruses (Haq et al., 2024). Global inequalities are further reinforced by the fact that One Health networks are primarily located and resourced in high-income countries (The Lancet, 2023). Wealthier nations have greater capacity to implement the One Health approach, whereas low- and middle-income countries face resource constraints, compounded by multiple and competing development needs, leaving them vulnerable and reliant on fragmented donor support.

To prevent global pandemics, all countries must have sufficient funding to mitigate zoonotic spillovers, thereby reducing the risk of future pandemics. The WHO plays a central role in international efforts to strengthen healthcare systems in these countries and has launched several programs to enhance disease surveillance, improving spillover prevention (Haq et al., 2024). However, limited resources, weak healthcare infrastructure, and shortages of trained professionals result in suboptimal surveillance (Haq et al., 2024).

To bridge the gap between high-income and low- and middle-income countries, wealthier nations must provide financial support to strengthen healthcare infrastructure and enhance surveillance capabilities. Beyond financial assistance, they should also share technical expertise and knowledge in zoonotic disease surveillance (Haq et al., 2024). Furthermore, international legal frameworks must be strengthened and upheld by all countries (such as the Convention on International Trade of Endangered Species (CITES) and the Paris Agreement) which contribute to global efforts to reduce the transmission of diseases from animals to humans (Haq et al., 2024).

An equitable approach is needed to avoid paternalism or a colonial mindset by dictating what low- and middle-income countries should do. For instance, while closing wet markets to prevent an emerging zoonosis may be technically right, failing to consider those who depend on these markets for their livelihoods would mean that One Health ultimately harms the people it aims to support. The One Health approach requires listening to these countries and understanding their needs (The Lancet, 2023).

Adopting a One Health Approach

To adopt a National One Health Action Plan to limit the risk of zoonotic spillovers, ensure animal welfare, and promote environmental sustainability, governments can rely on documents and action plans developed by international organizations specializing in the One Health approach.

One such example is the One Health Joint Plan of Action (2022–2026)[2], which we will briefly discuss here. This plan was jointly developed by the WHO, Food and Agricultural Organization of the UN (FAO), OIE (WOAH), and UNEP and serves as a guide to strengthen international cooperation and support states in their One Health-related actions aimed at improving human, animal, and environmental health—particularly to prevent health threats and enhance collaboration, coordination, capacity building, and communication among the different relevant sectors.

This plan builds on and complements existing global and regional One Health approaches, providing added value to efforts such as the WHO Global Action Plan on AMR and the Tripartite Zoonoses Guide. These initiatives should also serve as references for states in designing their national action plans.

The action plan emphasizes the interdependence between human, animal, and environmental health, explaining that human activities that harm animal and environmental health ultimately have consequences for humans themselves, including the increased emergence and spread of infectious diseases.
The document highlights that the environmental sector remains insufficiently integrated into the One Health approach at both national and global levels. Another critical issue for governments is the lack of collaboration between the different health sectors (human, animal, and environmental), leading to insufficient information-sharing and a lack of coordination in budget allocations and decision-making processes.

The One Health Joint Plan of Action aims to eliminate these obstacles through the "theory of change", which is structured around three pathways for change.

The cornerstone of this theory of change is the six interdependent action tracks of the Joint Plan of Action, which are distributed across the three pathways mentioned above:

-Action Track 1: Strengthen One Health capacities to enhance health systems.
-Action Track 2: Reduce the risks of epidemics and pandemics caused by emerging and re-emerging zoonoses.
-Action Track 3: Control and eliminate endemic zoonoses, neglected tropical diseases, and vector-borne diseases.

[2] https://openknowledge.fao.org/server/api/core/bitstreams/fc522db2-9619-4f70-b6ba-64177f4865e6/content

-Action Track 4: Improve risk assessment and management related to food safety, as well as risk communication, to ensure that humans, animals, and ecosystems remain healthy in their interactions within and along the food supply chain.
-Action Track 5: Curb the silent pandemic of AMR – Take joint action to preserve antimicrobial efficacy and ensure sustainable and equitable access to antimicrobials for responsible and prudent use in human, animal, and plant health.
-Action Track 6: Integrate the environment into the One Health approach – Restore biodiversity, prevent ecosystem degradation, and strengthen environmental sustainability to jointly support the health of people, animals, plants, and ecosystems.

By implementing the actions associated with these six objectives, governments can contribute to building sustainable health systems, reducing health threats, and improving ecosystem management, ultimately advancing the impact sought by the plan.

While the One Health Joint Plan of Action is a global strategic framework that sets out the broad priorities and goals of the One Health approach, another complementary document has been developed by the same four organizations to translate this strategy into concrete actions at the national level, assisting states in developing and/or strengthening their National One Health Action Plans. This is the Guide to Implement the OH JPA at the National Level[3]. Below, we will list the essential components of what a One Health National Action Plan should include.

This guide explains that a National One Health Action Plan must include activities linked to the six action tracks featured in the OH JPA to address key health challenges at the human–animal–plant–environment interface.

At the regional, national and international levels, there must be collaboration, communication, coordination and capacity building between the environmental, animal and human sectors and disciplines (to avoid a siloed approach) and collaboration, communication, coordination and capacity building between these sectors and the society, and within the society itself (rural, urban, mobile communities at a local, national, regional and global level).

Minorities, such as women, must be included as stakeholders in the One Health process.

A country must use the three pathways of the theory of change (which are interdependent) to design its national One Health action:

1) **Governance, policies, legislation, financing and advocacy**: this pathway focuses on establishing a national multisectoral coordination mechanism for One Health. This includes intersectoral governance, policy development, high-level advocacy, regulatory frameworks, dedicated financing, and raising awareness among stakeholders. This mechanism could be a national-level One Health committee. The committee must include diverse stakeholders with expertise across

[3] https://www.woah.org/app/uploads/2023/12/guide-to-implement-the-oh-jpa-v19-web.pdf

sectors and ensure gender equity and consider national vulnerabilities and cultural sensitivity. It should also ensure that sociopolitical and multicultural parity is achieved by engaging communities and marginalized voices.
The adoption of the appropriate policies, which recognize the intersection between components of human, animal, plant and environment health, can enhance the One Health approach. National laws may need to include a One Health approach by creating legal frameworks that promote cross-sector collaboration. This can involve rules for data sharing, integrated surveillance, and joint early warning systems.
In terms of financing, siloed funding approaches, which lead to fragmentation of effort and competition for funding between sectors, must be avoided.
In terms of advocacy, joint communication and advocacy efforts are needed to promote the wider recognition of One Health, especially among policymakers and governments. To do that, a multistakeholder communications working group can be established. Advocacy is critical to attract more funding.

2) **Organizational and institutional development, implementation and sectoral integration**: this pathway focuses on putting One Health into action. This includes building multisectoral and multidisciplinary capacity, engaging communities, mobilizing action, and ensuring equitable sectoral integration. In terms of organizational and institutional development, it is essential to develop the capacity of the key personnel involved in One Health implementation within sectors, with joint training activities being the ideal approach. The One Health approach should also be teached to primary school's students and at the University. In terms of implementation, the implementation of a One Health plan requires the creation or adaptation of concrete action plans (considering national and local priorities). These plans must include several common actions between the human, animal and environmental health sectors, such as wildlife and environmental monitoring or joint efforts towards reducing AMR. Sectoral integration must also happen beyond the national level with the national multisectoral, One Health coordination mechanism. Sectoral integration is also important at subnational and local levels where One Health implementation occurs on the ground. Public and communities, including indigenous peoples, must be integrated in activities at local level.

3) **Data, evidence, information systems and knowledge exchange**: This relates to strengthening scientific evidence and information systems, fostering knowledge creation and exchange, enabling technology transfer and continuing education, and using data and evidence to inform best practices and innovation. It includes translating knowledge into practical tools and guidelines and promoting data sharing across sectors, stakeholders, and countries. Data collection can include areas such as disease incidence, emergence, prevalence and spread, wildlife and environment monitoring programs, and tracking of the drivers of health threats at the animal–human–plant–environment interface, such as biodiversity loss, degradation of soil and water resources. Collecting and analyzing gender disaggregated data is essential to understand the effects of health issues on different groups and therefore informing the development of targeted interventions. Regarding the information systems, countries should develop national One Health surveillance and early warning systems to track diseases, AMR, and other health threats. These systems

should collect, analyze, and report data while ensuring required reporting to international authorities. Community involvement is also essential for effective information gathering and response. The sharing of data generated from One Health data initiatives across sectors in both public and private domains and across different levels, organizations, sectors and society, including One Health networks or communities of practice is critical. Tools for knowledge exchange include for example joint online platforms and websites, joint surveillance and information sharing databases, and a joint database of One Health case studies.

To regularly assess the progress made in the three pathways, a periodic feedback mechanism, to inform each of the pathways, should be envisioned as part of monitoring, evaluation and learning (MEL) frameworks. The MEL is also useful to identify and address challenges that are impeding the progress of activities and to re-adjust programs and activities accordingly.

A national One Health action plan should feature workplans for prioritized activities, allocation of roles and responsibilities by stakeholder group, time frames, indicators, costs and funding sources

National authorities are encouraged to engage with nongovernmental stakeholders in further workshops and consultations at national and subnational levels to refine their One Health frameworks and workplans and check its impact in the short to long term.
National authorities should create a One Health investment strategy for resource mobilization, understanding both monetary and non-monetary resources at national and international levels, including public, private, and development partners.

Research gaps

Although we have been able to gather a lot of information, a few pending questions exist in the literature regarding our two chapters.

First, disagreements persist in the literature regarding the positive correlation between certain drivers and disease spillovers and outbreaks. This includes urbanization, as well as other drivers not addressed in our literature review, as we decided to focus explicitly on the most extensively studied ones. Additional research should be conducted to better understand certain drivers and their effects on diseases. Second, while the positive link between certain drivers and the spread of diseases no longer needs to be proven, some specific mechanisms underlying the increased risks of spillovers and outbreaks require further investigation. Climate change is a good example: over 1000 distinct pathways, involving various ways of transmission, can lead to disease emergence. These diverse transmission mechanisms make the interactions more complex and less straightforward.
Third, interconnectedness between drivers exists and plays an important part in disease outbreaks and spillovers. However, certain links are so complex that the way these drivers interact remains unclear in the literature. Fourth, some of these studies are anecdotal case reports, which are considered weaker evidence

according to the Centre for Evidence-Based Medicine's Levels of Evidence Criteria. Therefore, they cannot be generalized in a broader context, and conducting statistical analysis for some of the disease actions remains challenging. Fifth, implementing public health measures requires communities to change their behaviors, but cultural beliefs and resistance can create obstacles. For these measures to be effective, it's crucial to engage communities and ensure they understand and accept the importance of these changes. However, given the diversity of cultural contexts, a universal approach to achieving this remains unclear.

Case studies

To illustrate concretely how a country can operationalize the One Health approach in its national policies, we have chosen to analyze the case of Kenya and Bangladesh. These two countries, often cited as pioneers for the application of the One Health approach, offer an example of both good practices and persistent challenges. These case studies complement our literature review by showing how some theoretical recommendations are implemented, or not, in the field, and under what conditions.

The One Health approach in Kenya

Kenya, located in East Africa, is a high-risk country for zoonotic diseases due to its geographical location, growing demographics, and the proximity between livestock, wildlife, and humans (in addition to other drivers like climate change, new farming practices, etc.). Moreover, Kenya is a hub for tourism, trade, and travel, and has porous borders, which puts the country at risk of external disease transmission (ZDU, 2021).

To address these risks, Kenya established an institutional framework based on the One Health approach, as well as two Strategic Plans for the Prevention and Control of Zoonotic Diseases in Kenya, aimed at reducing the burden of zoonotic diseases while also strengthening food security, wildlife conservation, and other objectives linked to the One Health approach.

Kenya has become a champion of One Health implementation at the national level. Measures implemented so far have improved outbreak response, generated statistics to enhance preparedness for epidemics and pandemics, and strengthened global health security. Despite this, gaps still exist, particularly at the subnational level (Munyua et al., 2019).

The first step in implementing One Health nationally occurred in 2004, with the Global Disease Detection Division within the Centers for Disease Control and Prevention (CDC) Kenya. In this division, the One Health approach was identified as key to developing effective interventions to reduce the impact of infectious diseases, particularly zoonoses (Munyua et al., 2019).

The One Health approach was formally adopted in 2006 in Kenya, where a multisectoral committee was established to coordinate preparedness efforts to prevent the spread of HPAI in response to the global spread of H5N1 (Munyua et al., 2019). This approach proved its benefits during the 2006 RVF outbreak, where faster diagnosis and a coordinated response between the Ministry of Health and the Ministry of Agriculture, Livestock, and Fisheries resulted in fewer cases and deaths compared to the 1996 outbreak. This success demonstrated the advantages of One Health and strengthened collaboration among governments, researchers, and international organizations to mitigate future outbreaks and enhance animal health surveillance (Munyua et al., 2019). Since 2006, CDC Kenya has actively supported and worked with Kenyan government agencies to develop a sustainable One Health program at both national and county levels.

The absence of a formal collaborative framework between the public and animal health sectors led to the creation of the Zoonotic Disease Unit (ZDU) in 2012, a national One Health coordinating office shared between the ministries responsible for human and animal health. The ZDU's mandate was as follows: serve as a collaboration hub between the Ministry of Health (MoH) and the Ministry of Agriculture and Livestock department (MALF); Establish structures and partnerships to promote One Health; strengthen zoonotic disease surveillance; coordinate control measures and support public health research in Kenya (Munyua et al., 2019).

The ZDU serves as Kenya's One Health office and secretariat to the Zoonoses Technical Working Group (ZTWG). The ZTWG includes experts from various government institutions, public health agencies, veterinary departments, and research organizations, and is responsible for developing strategies for the prevention, surveillance, and management of zoonotic diseases in Kenya, promoting a One Health approach (ZDU, 2021).

In 2013, Kenya became a decentralized state with 47 counties. Public health and animal health functions were delegated to these counties. This allowed the implementation of the One Health approach at the subnational level: The ZDU and its partners established County One Health Units (COHUs), aimed at enhancing surveillance and reporting of zoonotic diseases, ensuring swift joint investigation and response to outbreaks to mitigate their impact (Munyua et al., 2019).

In 2015, a multidisciplinary team conducted a prioritization of zoonotic diseases in Kenya from a list of 35 zoonotic diseases. According to the results, prevention and control plans for high-impact priority zoonoses have been developed and implemented, alongside collaborative research and surveillance to generate national data and assess control strategies. This prioritization also plays a crucial role in strategically allocating resources (Munyua et al., 2019).

In Kenya, the ongoing animal health surveillance initiative focuses on developing and implementing a syndromic surveillance system for domestic and wild animals, using a mobile phone-based application: the Kenya Animal Biosurveillance System. This app allows animal health workers to report specific syndromes (sudden death, animal bites, oral/foot lesions, etc.) in real time. The collected data is transmitted to an online server, where it is analyzed and visualized to quickly detect outbreaks of public health interest (Munyua et al., 2019). More broadly, the Directorate of Veterinary Services (DVS) is responsible for monitoring notifiable diseases in animal health. Additionally, meat inspectors conduct foodborne disease surveillance at slaughterhouses and notify the DVS of any suspected notifiable diseases. For wildlife, the Kenya Wildlife Service carries out opportunistic surveillance by investigating disease outbreaks in wildlife across the country and reports these events to the DVS (ZDU, 2021).

This summarizes Kenya's institutional framework related to the One Health approach.

To strengthen the institutionalization of One Health in the country and enhance its preparedness and response capacity for zoonotic diseases, Kenya adopted its first One Health Strategic Plan in 2012 (Kenya One Health Strategic Plan 2012-2017). The plan's three objectives were:

1. To strengthen Kenya's capacity for zoonotic disease prevention and control,
2. To enhance collaboration between the animal health, human health, and environment sectors in areas of common interest,
3. To conduct applied research at the interface.

The Kenya One Health Strategic Plan (2012-2017) unified efforts across ministries, professionals, and NGOs to address zoonotic, emerging, and re-emerging diseases. Key achievements included:

- Integrating One Health principles into veterinary and livestock policies and university curricula (medicine, nursing, veterinary programs) through AFROHUN,
- Deploying One Health champions via mentorship programs for graduate interns and FELTP fellows,
- Prioritizing zoonotic diseases by updating national guidelines and creating evidence-based prevention strategies,
- Strengthening preparedness and response capacities through contingency plans, and
- Promoting joint responses to zoonotic outbreaks, with the ZDU playing a central coordinating role (ZDU, 2021).

In 2021, a new One Health Strategic Plan for the Prevention and Control of Zoonotic Diseases in Kenya (2021-2025) was adopted. Its development was based on achievements, challenges, lessons learned, and best practices from the 2012-2017 plan. This plan was implemented through collaboration between MOH, MALF, the Ministry of Environment and Forestry (MOEF), the Ministry of Tourism and Wildlife (MOTW), and other stakeholders involved in zoonotic disease prevention and control, coordinated by the ZDU and ZTWG, using a One Health approach and guided by international best practices (e.g., the tripartite guidelines) (ZDU, 2021).

The plan's goal is to alleviate the burden of zoonotic diseases in Kenya, through three objectives:

1. Strengthen One Health implementation at national and county levels
2. Strengthen prevention, surveillance, response, and control of priority zoonotic diseases
3. Promote applied research using the One Health approach

Through these objectives, the plan aims to contribute to Universal Health Coverage, improved livelihoods, food and nutritional security, biodiversity conservation, and enhanced animal and human welfare (ZDU, 2021).

Under this new plan, the ZTWG was transformed into the National Zoonoses Technical Committee (NZTC), becoming a permanent One Health coordination forum for zoonotic disease prevention and control. The Director General of Health and the Director of Veterinary Services alternate as chairs of the NZTC, overseeing the ZDU. At county and sub-county levels, One Health Units collaborate with coordinating committees to implement the plan (ZDU, 2021).

AMR and food safety are also addressed in this plan: coordination between the ZDU/NZTC and other AMR/food safety committees is strengthened. Additionally, the ZDU enhances collaboration with Kenyan universities for One Health workforce development and capacity building (ZDU, 2021).

Unlike the previous plan, this strategic plan envisions a stronger integration of ecosystem and environmental expertise within the ZDU to enhance the impact of the One Health approach. For example, within the framework of this One Health Strategic Plan, the involvement of the Ministry of Environment and Forestry is strengthened within the ZDU (ZDU, 2021).

A stakeholder analysis has been done to plan, implement and refine an effective communication strategy, among other things. The professionals working on this national plan examined the stakeholders in the country based on their roles, attitudes, and implementation of the One Health approach. The analysis also looked at ways to engage different stakeholders, the key messages to communicate, and the champions to focus on. Moreover, the PESTLE (prevailing Political, Economic, Social, Technological, Legal and Environmental factors) in the country has also been analyzed (ZDU, 2021).

The implementation of the strategic plan for the prevention and control of zoonotic diseases through a One Health approach is estimated to cost approximately 2.5 million dollars. The costs for the implementation of the eleven strategies have been estimated. Funding is expected to come from the Government of Kenya, county governments, other governmental agencies, and implementing partners. To support the execution of this plan, the ZDU has developed a resource mobilization strategy.

The ZDU/ZDWTG also developed a Monitoring and Evaluation plan for this Strategic Plan, tracking ongoing efforts to prevent and control zoonotic diseases, assessing their efficiency and effectiveness. Evaluations periodically review progress toward objectives (ZDU, 2021).

Assessment of the One Health implementation in Kenya

In terms of Research & innovation, several interdisciplinary studies on OH have been carried out in Kenya, notably on emerging zoonotic diseases. These joint efforts across various One Health fields have enhanced Kenya’s research and innovation initiatives, which was one of the goals of the National Plan. However, these collaborations faced challenges such as coordination issues, limited funding, and conflicting priorities. Kenya's One Health research and innovation are growing but require greater investment, stronger partnerships, and community engagement (Bukachi et al., 2024).

Even though Kenya actively promotes transdisciplinary research and innovation to tackle emerging and neglected zoonotic diseases, fostering collaborations among researchers from different health disciplines, partnerships between government agencies and external stakeholders (and interagency cooperation) in research and innovation remain irregular, often relying on personal connections rather than structured, systematic approaches. This is a lack of structured collaboration. This lack of coordination between relevant disciplines hampers the effective implementation of the One Health approach in the country. There is a need for formalized mechanisms, standardized protocols, and clear policy frameworks to ensure consistent and effective joint efforts in advancing One Health research and innovation (Bukachi et al., 2024).

External funding, particularly from international organizations and collaborations, has played a pivotal role in developing surveillance systems, interdisciplinary studies, and capacity-building programs, which have been key in advancing the One Health program (Bukachi et al., 2024).

Kenya has implemented several effective initiatives for disease surveillance and monitoring. The country has invested in integrated surveillance systems, including the Kenya Animal Bio-Surveillance System (KABS) for monitoring animal health and the Health Management Information System for human diseases, enhancing data collection and analysis. The use of digital surveillance has helped identify neglected zoonotic diseases and has strengthened early detection and rapid response to priority outbreaks. However, challenges remain. A lack of training on surveillance tools, the absence of real-time data, and insufficient equipment limit the effectiveness of existing systems. The integration of technologies is still inadequate, particularly in remote rural areas where surveillance is difficult. Additionally, setting up these systems is costly, and the lack of funding and partnerships impedes their expansion. The scarcity of data on the burden of zoonoses makes it challenging to convince policymakers to invest in animal health surveillance, especially when the threat is not immediately apparent (Bukachi et al., 2024).

In terms of AMR prevention, some good points can be credited to Kenya, such as the implementation of a National Action Plan on antimicrobial resistance, surveillance of antibiotic consumption in humans, and public awareness campaigns on AMR risks. Kenya acknowledges this problem and its links to the One Health approach. Research on AMR in livestock is being carried out, with some data on the most affected species, although this could be more extensive. However, there are still too few studies on how AMR spreads within the human population in Kenya and a lack of in-depth research on the social and cultural determinants driving AMR. Research also focuses too little on the economic impact of AMR for farmers, as most of it is centered on the biological aspect of AMR. Finally, the role of the environment in the spread of AMR is poorly explored. The national AMR strategy adopts a One Health approach, but remains fragmented and separated from other One Health issues, as it is managed outside the ZDU and has separate funding (Bukachi et al., 2024).

Several negative points regarding the ZDU should be noted. First, the ZDU did not receive a dedicated budget from relevant ministries to implement the 2012-2017 plan. Lack of government support threatened sustainability. Secondly, The ZDU was also understaffed during this period (only two government employees), limiting effective coordination. Then, the absence of expertise in areas like environment, ecology, and knowledge management further complicated implementation. The ZDU overlooks important aspects of the One Health approach, particularly the environmental aspect, even though its role is precisely to facilitate collaboration between OH sectors. Another issue is related to the fact that while the ZDU is Kenya's central One Health office, its mandate is limited to zoonotic diseases, leading to separate coordination mechanisms for other One Health issues (e.g., antimicrobial resistance) (ZDU, 2021). Lastly, although the ZDU's work continues at the national level with progress, this is not the case at the sub-county level where lack of coordination and conflicts of interest hinder progress (Bukachi et al., 2024).

Regarding COHUs, the significant diversity in county administrations, the high staff turnover, and the absence of a One Health devolution strategy hampered progress in institutionalizing COHUs (ZDU, 2021).

In general, the limited awareness of the One Health approach among senior government officials at national and county levels can represent an obstacle to a proper implementation. High turnover of officials also necessitates continuous advocacy efforts (ZDU, 2021).

It is important to note that Kenya has established a legal and policy framework to support the One Health approach, with laws and policies covering human, animal, and environmental health. While multisectoral policies also exist, collaboration between the various sectors remains insufficient for a complete implementation of the One Health approach (Bukachi et al., 2024).

The issue of food security represents a major gap in Kenya's One Health approach, as there are no distinct coordination mechanisms for the One Health. (Bukachi et al., 2024).

In terms of education, Kenya has made progress in integrating the One Health approach, particularly in higher education, through AFROHUN, which has facilitated multisectoral collaboration in Kenyan universities. AFROHUN supports the integration of OH programs into curriculums, offers training, career development, and creates platforms that enable students to receive pre-professional training. However, integration of OH into primary education remains insufficient. It should also be noted that programs in higher education are not optimal: existing courses often provide only a partial understanding of OH, neglecting the transdisciplinary knowledge essential for effective OH solutions. (Bukachi et al., 2024).

There are also training programs, such as field and laboratory epidemiology training, aimed at strengthening public health systems by developing skills in epidemiology and laboratory practice. These types of programs are valuable in a One Health approach because they aim to train public health professionals so that they can respond effectively to outbreaks, conduct surveillance, and contribute to public

health research. However, these programs face challenges related to limited resources, both financial and technical, which slows down the establishment of solid laboratory infrastructures and surveillance systems (Bukachi et al., 2024).

Kenya has invested in regional laboratories and diagnostic facilities to ensure rapid disease detection and effective treatment within the One Health approach. However, challenges remain, including a lack of trained personnel and appropriate equipment for AMR, as well as coordination issues between laboratories due to incompatible information systems, inconsistent testing protocols, and limited resources. Strengthening collaboration and investing in laboratory staff training, particularly at the county level, could improve disease management and response to health challenges (Bukachi et al., 2024).

Concluding remarks

To conclude this case study on Kenya, it is important to put this analysis into perspective with our literature review, which discussed the best measures to adopt as part of a One Health approach.

Kenya's robust institutional structures, such as the ZDU and the NZTC (or ZTWG), align with the recommendations regarding the creation of key intersectoral mechanisms, based on the principles of collaborative governance.

The establishment of COHUs responds to the recommendations from our literature review on the importance of anchoring implementation at the local level, where spillover risks are most tangible.

Regarding animal surveillance and technological innovations discussed in the review, KABS is a perfect example of innovation. Inter-ministerial and multisectoral collaboration is also a good example of integrated surveillance and corresponds to the transdisciplinary approach emphasized in both the review and the OHJPA.

One of the most advanced elements in Kenya's case, which directly aligns with the primary prevention strategies identified in the review (such as acting upstream or conducting risk assessments), is the prioritization of high impact zoonoses and the development of interdisciplinary research.

Despite all of this, weaknesses identified in Kenya reflect the obstacles mentioned in our literature review. As highlighted several times, the environmental pillar is often neglected in the One Health approach. This is also the case in Kenya. Institutional fragmentation and siloed approaches (such as the fact that AMR efforts are not integrated into the ZDU) go against the recommendations made in the JPA. The same goes for the lack of data integration and limited coordination between laboratories. Despite their existence, the underfunding and high turnover of COHUs highlight persistent inequalities between national and local implementation. Moreover, despite the establishment of university-level programs, the central role of education emphasized in our literature review remains too limited in Kenya. This is also linked to a lack of funding and prioritization by the government. Lack of funding is one of the major obstacles (such as the absence of a dedicated budget for the

ZDU, weak financial support at decentralized levels, and reliance on external aid) to the integrated and sustainable implementation of the approach in Kenya.

Both of Kenya's One Health Strategic Plans primarily focus on surveillance, coordination, and outbreak response. Kenya can be considered a leader in these areas, particularly with structures such as the ZDU, COHUs, and surveillance strategies like KABS. However, primary prevention as such remains underrepresented in the strategic plans. While some measures are mentioned, such as syndromic surveillance in animals or the early prioritization of zoonotic diseases, Kenya's approach places less emphasis on addressing upstream drivers of zoonotic spillovers, such as deforestation, ecosystem degradation, intensive livestock farming, and wildlife trade.

The One Health approach in Bangladesh

History of One Health in Bangladesh

The One Health approach in Bangladesh represents a pioneering effort to integrate human, animal, and environmental health, recognizing their interconnectedness in disease prevention and health management. The global panzootic avian influenza that started in South Asia in 2003 was the important driving factor in the development of the One Health approach in Bangladesh. In 2006, Bangladesh's public health, animal health, and wildlife sectors collaborated to create the Avian and Human Pandemic Influenza Preparedness and Response Plan, its first pandemic preparedness strategy. (IEDCR,2025). Initiated in 2008 by a group of visionary professionals, One Health Bangladesh emerged as a civil society forum dedicated to advancing this holistic health model. At present, it has around 1,500 members, actively supporting the government and society by organizing conferences, workshops, and knowledge-sharing initiatives to address health risks arising from environmental degradation, intensive agriculture, urbanization, and transboundary movements. Since then, Bangladesh has taken significant steps to institutionalize One Health within its national health policies (IEDCR,2025).

The first One Health strategy called the Strategic Framework and Action Plan for a One Health Approach to Infectious Diseases in Bangladesh was developed in 2012, focusing primarily on controlling infectious diseases through cross-sectoral collaboration. The second edition in 2017 was developed in a collaborative model and incorporated antimicrobial resistance (AMR) as a key concern. It received formal endorsement from the Inter-ministerial Steering Committee on One Health, reinforcing commitment to a more comprehensive approach to public health. The latest third edition reflects insights from COVID-19 and the Quadripartite One Health JPA. It was developed after several consultative workshops drawing members from the Ministry of Health and Family Welfare (MoHFW), Fisheries and Livestock (MoOFL), Environment, Forest, and Climate Change (MoEFCC), Agriculture (MOA), Ministry of Food (MoF), UN agencies, development partners, academic institutions, research institutions and civil society organizations emphasizing on multidisciplinary collaboration.(IEDCR 2025)

Importance of OH in Bangladesh (IEDCR,2025)

Bangladesh is in the low-lying Ganges delta. It is one of the world's most densely populated countries, with 165.16 million inhabitants in 147.6 thousand square kilometers. The country is shaped by major river systems (Brahmaputra, Ganges, Meghna, and Karnaphuli) which can both a boon and a bane to the country.
Since achieving lower-middle-income status in 2015, Bangladesh is about to transition out of the UN's Least Developed Countries (LDC) list in 2026. Even though urbanization is rising, agriculture remains the primary occupation for 27.40% of households. Bangladesh also has an exceptionally high livestock density, with 26.53 million cattle, 31.02 million sheep and goats, and 396 million poultry.
The poultry sector has expanded significantly in the recent years, particularly with the Sonali breed, which now accounts for 41% of total poultry trade. This growth is evident in the rise of Live Bird Markets in Dhaka between 2008 and 2022, which is reflected in the increasing human-livestock interactions in both rural and urban settings. This has also led to significant zoonotic disease risks, transboundary livestock movement, and encroachment on wildlife habitats. A rapid assessment in 2017 revealed that most of the livestock imports into Bangladesh came from West Bengal and Uttar Pradesh in India. They were mostly concentrated in Dhaka. This when combined with rapid urbanization, deforestation, and ecosystem degradation, significantly increases the risk of disease transmission. Another cause for concern is the wildlife trafficking especially the illegal trade in felids. Bangladesh also faces severe environmental challenges like pollution, climate change, and biodiversity loss which are exacerbated by the country's geography.

Frequent floods, cyclones, rising sea levels and extreme weather events threaten livelihoods, infrastructure, and food security, making sustainable environmental policies and climate resilience measures the need of the hour.
Bangladesh has included six zoonotic diseases (anthrax, brucellosis, Nipah, rabies, zoonotic influenza, and tuberculosis) in its priority list and has recognized climate sensitive zoonotic diseases such as Japanese encephalitis, leishmaniasis, and salmonellosis. The government has also set up sentinel surveillance to detect and control Nipah virus, which has a case fatality rate of up to 70% and poses as a major threat in the Nipah Belt (Rajshahi and Rangpur divisions).

Regional Problems of Implementing One Health in South Asia

South Asia has made a lot of progress in institutionalizing One Health, but disease management policies remain largely ad hoc. Following outbreaks like H5N1 and SARS, a tripartite collaboration involving WHO, FAO, and OIE was established under the Asia Pacific Strategy for Emerging Diseases (APSED). While this helped facilitate intersectoral cooperation, sustained collaboration is still difficult in the region due to its political climate. Though efforts such as the WHO's rabies control program, FAO's Regional Support Unit, and Massey University's One Health capacity-building initiatives improved epidemiological training and networking, most of these activities ended due to funding cuts, leaving gaps in long-term impacts. Good examples of One Health in the region are Bangladesh and Bhutan, both having developed operational One Health strategies, while other countries have variable progress.

Lack of information sharing, weak regional coordination, and insufficient political commitment are major barriers for effective One Health governance in the region. (IEDCR,2025)

Bangladesh National Action Plan: Development & Effectiveness

During the period of October 2023 to February 2024, Bangladesh conducted a qualitative desk review and participatory workshops to update it's One Health Strategic Framework (OHSF). It used the One Health Assessment Tool (OHAT) to assess the OH capacity of Bangladesh and to define its scope in a national and a global context using a problem solution tree approach. The process aligned 11 strategic components with OH JPA action tracks and ensured that the outputs fit into three pathways: policy and financing, sectoral integration, and data-driven decision-making. A Theory of Change was created to outline long-term and intermediate outcomes and visions of OHSF. (IEDCR,2025)

Let us explore some of the Key Strategic Components and their role in Primary Prevention:

Bangladesh has focused on addressing zoonotic spillover through measures like conducting risk analyses to identify the drivers of spillover from livestock and wildlife, such as habitat encroachment, wildlife trade, and risky farming practices. The Bangladesh Forest Department has introduced the Spatial Monitoring and Reporting Tool (SMART) in protected forest areas, including the Sundarbans, to combat illegal wildlife trade and poaching. The 2025 framework advocates for strengthening animal health regulatory capacities, which includes monitoring, reporting, and certification systems for farms, companion, and wild animals. It also emphasizes the development and enforcement of upstream prevention through initiatives like developing biosecurity training modules for finfish farming and the STOP Spillover project in live bird markets. They want to establish standards for farms, as well as provide further guidelines and monitoring systems for wildlife handling, trade, and movement to mitigate risks. They aim to proactively reduce the risk of zoonotic diseases emerging and spreading to human populations. (IEDCR,2025)

Bangladesh has strengthened its biodiversity and environmental strategies by using comprehensive conservation measures which includes strategies like protected area expansion, ecosystem restoration through projects like OISCA Mangrove Restoration Project in Chittagong, and development of wildlife sanctuaries. The integration of One Health coordination involves linking public health, animal health, and environmental sectors while enhancing climate resilience and multi-sectoral collaboration. Bangladesh aims to develop practices like sustainable forestry, fisheries, and agricultural initiatives to support ecological balance and food security, while focusing on pollution control efforts such as air quality monitoring, wastewater management, and heavy metal reduction to improve environmental health. Additionally, there is emphasis on green and blue space expansion, ecosystem valuation and stakeholder engagement to ensure community participation in conservation and sustainable development. (IEDCR,2025). Bangladesh’s National Biodiversity Strategy and Action Plan emphasizes preserving ecosystems and

wildlife, which can indirectly aid disease prevention by maintaining natural checks and balances, Over the past decade, Bangladesh has expanded its protected area network and launched community-based conservation programs.

Effective AMR mitigation requires coordinated surveillance, stewardship programs, and rational antimicrobial use in medical and veterinary practices. Only by reducing antimicrobial spillover from hospitals, pharmaceuticals and livestock farms will we be able to limit the environmental spread. The Government of Bangladesh (GOB) wants to use the OH approach to ensure prudent use of antimicrobials and its gradual reduction. The AMR containment strategy in the new draft framework focuses on strengthening One Health coordination by improving surveillance and laboratory capacity and enhancing antimicrobial stewardship and reducing environmental spread. Multisectoral collaboration, including regular National Steering Committee meetings and policy updates, supports strategic planning. While an Integrated AMR surveillance is to be established to ensures quality-controlled diagnostics, data sharing, and public-private partnerships for effective monitoring. Improved hygiene through the establishment of national level Infection, Prevention and Control Committees (IPC) can minimize antimicrobial reliance, while waste management and effluent treatment can reduce AMR spillover into the environment. Most importantly, stakeholder engagement drives community awareness and participation, reinforcing risk communication efforts to raise awareness and drive behavioral change. (IEDCR,2025)

Food security in Bangladesh is tightly linked to how food is produced and handled. They face challenges such as traditional wet markets, slaughtering practices, and lack of food hygiene infrastructure. Bangladesh aims to develop a robust One Health system for food safety, ensuring effective governance, surveillance, risk analysis, and community engagement. Led by the Bangladesh Food Safety Authority (BFSA), policy updates aim to strengthen legislation and coordination across sectors. The strategies focus on ensuring safe food production by implementing good agriculture, aquaculture, and animal husbandry standards to reduce contamination risks and maintaining proper sanitation, hygiene, and ensure upstream prevention at farms and processing sites to strengthen food safety and further spillovers. Implementing food standards aligned with Good Manufacturing Practices (GMP), Hazard Analysis and Critical Control Points (HACCP) to enhance compliance and consumer safety. They are developing a coordinated laboratory network to support food safety analysis, data sharing and a food safety emergency response mechanism to improve preparedness and rapid containment of foodborne illnesses. The framework also focuses on addressing food safety measures related to environmental contamination by strengthening waste management in food production facilities, including slaughterhouses, farms and processing plants. It also includes preventing antimicrobial and chemical spill over into water bodies and agricultural lands through the practices like the Rice-Duck farming. Additionally, there are community awareness programs by the government in partnership with civil societies like the Sensitization workshops by Bangladesh Safe Agro Food Efforts (BSAFE) Foundation, to educate farmers, food producers, and consumers on hygiene and food safety practices, alongside risk communication strategies to ensure safe food handling and responsible consumption. (IEDCR,2025)

The strategies for an effective OHAP must emphasize a multisectoral approach to disease prevention, which focuses on high-risk practices and can address root causes before an outbreak occurs. For the first time, One Health is included in a legally binding instrument, reinforcing global commitment to early intervention.

Bangladesh OH Framework must overcome multiple local challenges along with fragmented policies, limited workforce capacity, and resource constraints. At the policy level it is important to have a robust governance structure for coordinating between ministries, development partners, and community stakeholders. Policies should be balanced across ministries, thus ensuring a unified approach. Efforts for this has been made in the ongoing draft of the strategic framework 2025 to update and integrate some policies into a cohesive framework to avoid redundancy. The One Health (2025-2030) draft framework includes a costed action plan for implementation. The government has committed to sustained operational funding, enabling resource planning and mobilization, while the Secretariat will lead monitoring and evaluation to track progress. To enhance the operational efficiency of the OHS, it is crucial to strengthen its governance framework by establishing clear mandates, defined responsibilities, expedited approval system and effective communication channels across relevant ministries and departments. [OHPH,2024; IEDCR,2025]

One Health relies on multidisciplinary collaboration that integrates clear guidelines, best practice exchanges, technical support, and financing that ensures implementation is effective. It also requires inclusive policies and cross-sectoral partnerships to engage diverse stakeholders. The findings from the One Health Assessment Tool (OHAT) show there are both strengths and gaps in the implementation of One Health policies across sectors. It was found that coordination mechanisms, national strategy and action plans are moderately strong, while challenges persist in human resources, financial support, data sharing, policies, risk communication, and workforce development. Another major concern is the sectoral disparity, with human and animal health sectors who are long term partners being actively involved, while wildlife, environment, and agricultural sectors, as newer participants, remain less integrated into the system. Their recent addition to the One health approach and limited institutional capacity may have contributed to this gap. Expanding involvement to sectors like Planning, Finance, and Education can further improve sustainable funding and intellectual support. Bangladesh's 3rd National Avian and Pandemic Influenza Plan (NAPIP 2022–2026) recognized the need to address farmers' economic constraints so they can adopt better practices. Such plans should be fully funded and implemented, with regular monitoring of compliance on farms

Strengthening coordination with CDC Bangladesh, DGHS, and DGDA through direct engagement can enhance implementation of OH strategies. Similarly, engaging marginalized communities through culture sensitive communication, participatory research, and empowering community health workers can foster wider ownership. This can improve primary prevention and environmental management at the grassroots level. Also, for long term sustainability it is essential to develop a skilled and diversified One Health workforce like the trained local women who work as

Community Health Workers (CHW) called the Shasthya Shebikas (SS) in Bangladesh. There are also NGOs like the Arannayk Foundation which has used communities to patrol forests and reforest denuded areas. Projects like the biodiversity conservation along the denuded hills Sitakund & Mirsharai, Chittagong have helped restore habitats for birds and fruit bats and create green belts that separates human settlements from wildlife. The goal should be to make pandemic prevention a people's movement.

It is important to prioritize education, interdisciplinary collaboration, and professional development to develop an expertise across sectors. Through establishing multi-sectoral training programs, such as the Field Epidemiology Training Program (FETP), and a university network like Vietnam's model (VOHUN), Bangladesh can also foster an action-oriented next generation workforce. The government in its 2025 draft framework also plans to integrate OH content into medical, veterinary, and environmental science curricula, supporting OH diploma and postgraduate programs. It is also important to educate the public about community engagement in disease prevention through One Health awareness and capacity-building campaigns. Establishing multi-sectoral OH working groups at subdistrict, district and divisional levels will foster collaborative action, while training and equipping grassroots workers will strengthen local implementation efforts. [OHPH,2024; IEDCR,2025]

A major component of the new OH draft paper is enhancing strategic communication and advocacy through a structured strategy. It involves developing a comprehensive engagement plan, conducting capacity-building programs, and creating targeted communication materials. Advocacy efforts will be strengthened via issue specific packages, policy dialogues, and evidence-based success stories, ensuring effective outreach to policymakers and opinion leaders to advance One Health goals.

Bangladesh has begun to make the economic case that investing in One Health is far cheaper than dealing with a full-blown pandemic. It had lost billions in economic wealth due to the impact of COVID 19 on the garment and transportation industries. Integration of the One Health approach into national health and development strategies requires structured planning and sustainable funding mechanisms. For funding and investment, Bangladesh receives support from Gavi, CEPI, World Bank, ADB, USAID, EMPHNET, MPTF, and US CDC etc. Another major investment source is FAO's One Health Resource Partner and Investor Profiles. However, reliance on external funding, primarily short-term grants can pose challenges to long-term sustainability and restricts flexible fund allocation across sectors. Strengthening domestic investment is essential to ensure the continued stability and effectiveness of the One Health approach. Establishment of short- and long-term work plans and budgeting strategies will ensure effective resource allocation, multi-stakeholder engagement, continuous monitoring and learning. A pooled funding model that involves contributions from multiple ministries, along with memoranda of understanding (MOUs) between ministries and sectors, as seen in Thailand and Vietnam, can enhance multi-sectoral collaboration. A working budget (short- and long-term) that prioritize One Health approach's strategic goals and developing an

effective budgeting strategy with a flexible budgeting plan, can allow for adaptable funding, ensuring responsiveness to changing health needs. [OHPH,2024; IEDCR,2025]

An effective One Health research platform should focus on different sectors like AMR, food production and safety, environment and pollution, waste disposal, animal welfare and emerging infectious diseases, fostering cross-sectoral collaboration. Linking multi-sectoral research activities with the One Health Secretariat will enhance coordination. Individual or institutional partnerships should be encouraged to develop innovative future research that can unite students, academics, and stakeholders on a shared platform. To maximize the impact of these collaborations, efficient One Health data sharing and seamless integration of cross-sectoral datasets is key. Instead of manual uploads, utilizing advanced technology like blockchain can streamline processes, enhance security, and improve accessibility, ensuring real-time, automated data linkage across all sectors. However, technology alone isn't enough, it is important to foster trust and collaboration for smooth intersectoral data exchanges. Establishing clear ethical guidelines, nurturing strong professional relationships, and promoting transparent communication will help to create a culture of cooperation among the different stakeholders. [OHPH,2024; IEDCR,2025]

To realize the full potential of One Health, we need regular evaluations and inclusive assessments. Only by engaging diverse stakeholders, identifying emerging concerns, and integrating new innovations we can ensure the continued relevance and adaptability of the One Health approach. By exchanging best practices, member states can enhance global health equity and strengthen early pandemic prevention efforts, ensuring that all nations have the resources and strategies needed to mitigate outbreaks effectively. Most importantly, prioritizing accountability and transparency will strengthen public trust and policy support, making One Health a resilient and sustainable solution for tackling cross-sectoral health challenges. [OHPH,2024; IEDCR,2025]

Limitations (IEDCR,2025)

- Bangladesh does not have a dedicated One Health law, but various existing laws address relevant issues. However, overlapping regulations, limited awareness, and resource constraints hinder effective enforcement.

- Most laws are developed from sectoral perspectives, with only few integrating multisectoral aspects, but a coordinated One Health framework is yet to be fully incorporated into legislation.

- The second Strategic Framework (2017) addressed governance, surveillance, outbreak investigation, research, partnerships, communication, and capacity building, but pandemic preparedness, food safety, and environmental health were not explicitly covered.

- The WHO e-SPAR assessment indicates that while food safety mechanisms are established, they currently function at 60% capacity, highlighting the need for further enhancements to align with international standards.

Nivitha Leena Naveen
Nicola Gabriele Nicastro

Interviews analysis

To complement the analysis of the two national action plans and our literature review, we conducted interviews with six experts from complementary fields related to the One Health approach, in order to better understand the practical conditions for implementing prevention strategies. These interviews helped confirm certain trends observed in the literature, fill factual gaps, and provide practical insights into current challenges and possible levers for action. In the section below, we have summarized the main ideas emerging from our five interviews with: Dr. Elsa Léger and Dr. Manon Lounnas; Dr. Sophie Masika; Dr. Yewande Alimi; Dr. Nitish Debnath; Mr. Neil Vora. The full interview transcripts, along with the interviewees' affiliations, can be found in our annex.

One of the key points that emerged from our interviews—and which confirms the findings of our literature review—concerns the drivers of zoonotic spillovers. In each interview, the same drivers were mentioned, reinforcing the need to address these activities in order to prevent spillovers from animals to humans. We particularly appreciated the term "super driver", introduced by one interviewee, which encompasses land use change, climate change, and global trade, each containing more specific drivers. For instance, deforestation and urbanization fall under land use change, while animal trade and human mobility are part of global trade.

Regarding the driver of urbanization, our literature review had revealed some debate among authors about its direct correlation with zoonotic spillovers. It is important to emphasize that all the experts we interviewed confirmed the role of urbanization as a driver of spillovers. This is due to the fact that urbanization increases contact between humans and animals, especially when urban areas expand into natural habitats, thus encroaching on ecosystems. The argument that urbanization reduces contact between humans and animals only applies to highly urbanized environments. Similarly, while some claim that urbanization improves access to healthcare, this depends on the context and, more importantly, does not prevent spillover. One interviewee highlighted that to address urban-related challenges, it is essential to recognize the limitations of a solely national-level approach. In Bangladesh, for example, governance structures have been expanded to include local entities, involving city corporations, municipal bodies, and local governments in the One Health governance system. A decentralized approach like this allows for tailored interventions that address specific urban challenges, such as vector control, sanitation, and public health education.

One of the major challenges regarding the implementation and adoption of One Health measures worldwide is the lack of data and evidence. We need more benefit analyses and data to convince states to invest more in prevention of spillover strategies. This was one of the most frequently mentioned points across all our interviews. The more evidence we have that adopting One Health measures will also be financially beneficial for governments, and that it can save money in the long run—in addition to protecting human, animal, and environmental health—the more

states will want to invest in it. The main difficulty is that prevention and its benefits are inherently hard to measure, because you're measuring something that didn't happen. Some of the experts we interviewed explained that efforts are currently underway to develop indicators and methodologies to assess cost-effectiveness. To show the benefits of One Health prevention measures, evidences include publications, case studies, cost-benefit analyses, operational research, and more. One of the experts we interviewed emphasized an effective strategy that consists of highlighting the co-benefits of interventions to prevent spillovers. For example, besides preventing spillovers, stopping deforestation also helps combat climate change and protect biodiversity. Emphasizing these co-benefits increases the efficiency of investments, because by broadening the scope of consequences, you also broaden the support for halting that driver — by showing the various reasons a driver must stop, you gain support from climate advocates, health professionals, biosecurity experts, and others. Nevertheless, prevention often generates less revenue than treatment. Therefore, it is up to governments to create incentives or obligations for investors and companies to engage in prevention.

Still regarding data, there is a crucial need to invest more in data sharing, both at the national and international levels. At the national level, this means that different ministries and agencies—those dealing with the environment, animal health, or human health—must increase the sharing of their data.
These exchanges of data and information are essential for anticipating spillovers. One interviewee emphasized that this need for information exchange between ministries is a clear recommendation. Such exchanges help create a common language among professionals from different sectors and align their vision around a shared objective, which is crucial for effective policy development. One of the interviewee explained that the main challenges related to data sharing are often due to negligence or bureaucratic barriers. To address this in Bangladesh, efforts are being made to overcome these obstacles by advocating for open data policies, in order to foster a culture that values data sharing. Data is a cornerstone of the One Health approach. It helps convince governments and businesses and enables the development of the best possible policies based on reliable information, to prevent spillovers. Often, data generation happens from the ground up, at the local level, with governments setting up platforms where farmers and agricultural workers can report anomalies. Central platforms, in which various stakeholders (such as government agencies, non-governmental organizations, and community-based organizations) can integrate and analyze data, ensure that the health challenges at the human-animal-environment interface are addressed effectively. At the international level, platforms that would allow for the sharing of data demonstrating the benefits of One Health and the most effective actions to adopt could help convince actors around the world that this is a viable and impactful approach.

Another recurring point during our interviews was the need to establish multisectoral coordination mechanisms, as the lack of cooperation between sectors at the national level is one of the major obstacles to the effective implementation of the One Health approach. Communication between different sectors (such as human

and animal health) is crucial but can often be problematic due to differences in "culture" and priorities. For example, we were told that some actors in the human health sector may perceive their work as more important than that of veterinarians, which makes collaboration difficult. A key recommendation in this regard is to create national One Health platforms, which are institutionalized spaces for dialogue between ministries and sectors. This would facilitate better coordination and break the long-standing institutional silos and sectoral divisions. According to the experts we interviewed, it is also important that such platforms be placed at a high level of government, for example within the Prime Minister's office, so that the senior official has the authority to coordinate across sectors. These platforms must also be adequately funded. Many examples of such platforms have failed because they did not meet these conditions. One interviewee explained us that one of Africa CDC's roles is precisely to help countries set up their multisectoral coordination mechanisms. One of Africa CDC's objectives — and more broadly, one of the key conditions for effective cross-sectoral collaboration — is to create a shared vision. Each sector must understand the value of its role within the One Health approach and see how it contributes to the broader goals. This again links back to the question of data and data sharing: with strong enough evidence, different sectors would better understand that collaborating with each other can help prevent major issues, notably the spillover of zoonotic diseases. With a multisectoral coordination mechanism, each sector would be aware of its responsibilities, the actions it needs to undertake, and its level of commitment toward the others. It's also essential to ensure that no sector lags behind the others, and that all sectors have the financial and technical capacity to meet their responsibilities. The Zoonotic Disease Unit (ZDU) in Kenya is a good example of cross-sector collaboration, despite its limitations. Education also plays a role in facilitating cross-sectoral collaboration. Introducing new educational approaches can help open young people's minds to interact with diverse groups outside of their own sector. Finally, environmental issues and actors must not be left aside, as has long been the case. Climate change, as well as biodiversity loss, play a crucial role in both human and animal health.

Another major challenge in implementing One Health Strategies is the difficulty in engaging the community in a meaningful manner and adapting the interventions to meet the local contexts. All the experts we interviewed mentioned that co-designing interventions with local communities and civil societies is crucial for building trust and ownership. At present, there are efforts being made to train journalists, engage with youth groups and leverage on trusted local figures like women, villagers, and religious leaders to amplify One Health messaging. Whereas if the messages come from large institutions or foreign experts, they will not be well received by local communities. One interviewee mentioned how the African CDC uses *Event-Based-Surveillance* method to gather information through media scanning and local reports which can enable crowd sourcing of health-related data. Lack of community engagement can make the interventions fail or even backfire, thus limiting their effectiveness in addressing public health risks. There is no 'one size fits all' approach in One Health, it has to be adopted to regional contexts. Poorly adapted interventions such as the closure of live animal markets in China, show that without understanding local systems, policies might fall short of expectation. Policies need to consider the local context, economically and socially, and provide alternatives.

Otherwise, it backfires. Experts had shared some of the practices currently in use like developing simplified and culturally relevant educational tools, such as education in local languages, visual aids, and practical demonstrations such as coloring books, safe food preparation methods like boiling of the fruit sap to prevent the spread of Nippah etc. However, making them a sustainable and continuous part of the community life is more difficult. Education is an important tool for spreading prevention awareness. One interviewee emphasized that risk communication should be contextualized, using local languages and through clear and action-oriented dissemination of information. Experts highlighted the need to engage youth and shared successful strategies where children were utilized to pass on knowledge regarding prevention to their families. Other key players who are often overlooked but are very relevant to this discourse are the Social scientists and Anthropologists, they help in understanding the local dynamics and can assist in tailoring communication in a more inclusive and culturally sensitive manner for diverse audiences. They also help create behavioral changes within the community for long term adoption of these strategies.

One challenge that came back several times during our interviews is the funding gaps for One Health units or specific sectors (often linked to the environment) as seen in many countries like Kenya, which depend on external donors. This can limit autonomy and lead to misaligned priorities. Experts believe that governments should take ownership of their priorities, reduce dependency, and develop self-sustaining health strategies. Governments often focus on immediate results which makes it difficult to finance primary prevention activities that can reduce zoonotic spillovers. However, collaborations with international bodies can be useful for gathering more funds. For the environmental sectors, one interviewee recommended collaborations with organizations such as UNEP and GCF which can partially help channel resources directly to environmental surveillance initiatives.

Finally, we also discussed about how to convince the private sector to adopt the right behaviors. One interviewee emphasizes that businesses are enthusiastic about data sharing, particularly in hospitals and diagnostics; the private sector prioritizes profits, so if the governments can create a market demand and demonstrate potential financial gains it can encourage private participation in pandemic prevention areas. Public-private partnership can be important in areas where profitability is low, like in the case of antibiotics development, farming and diagnostics. In Bangladesh, collaboration with Farmers Associations supports economic development and biosecurity on farms. Partnerships with private health providers, especially in AMR diagnostics helped facilitate data sharing on effective antibiotics, this further addressed resource challenges. Recognizing their importance, efforts were made on engaging stakeholders from farmers to pharmaceutical and health service providers, thus ensuring stronger collaboration and impact. Moreover, even without regulation, companies can change due to public pressure : consumer demand is a powerful tool.

Policy recommendations

Thanks to the knowledge gained through this research project, we have formulated 10 recommendations based on successful strategies identified in the literature review, our two case studies (Kenya and Bangladesh), and expert's interviews. These 10 recommendations are addressed to governments and other stakeholders involved in the development of effective One Health national action plans.

1. Adopt Practical Primary Prevention Policies

It is important to tackle key risk factors for future pandemics like land use change, intensive farming, wildlife trade, deforestation, and antimicrobial resistance (AMR).

There should be an increased commitment to promoting sustainable agricultural practices, such as agroecology and crop diversification etc. which can build better resilience and reduce disease emergence risks.

Improving animal husbandry practices, ranging from routine veterinary services to physically separating animals will further help to prevent interspecies transmission.

Regulating antimicrobial use in veterinary medicines and aquaculture, by educating farmers and other stakeholders to prevent misuse, as seen in the case of the antibiotic-resistant Pabda fish in Bangladesh.

It is essential to ensure that wildlife trade reduction measures are implemented in ways that respect the rights of dependent communities; as seen in cases like Bangladesh's CITES suspension, punitive actions without local engagement might risk eroding trust, cooperation, and conservation outcomes.

2. Strengthen intersectional governance :

It is important to establish in each country a One Health multisectoral coordination mechanism, at a high level of authority to ensure it has sufficient weight within the country, for example, under the authority of the Prime Minister, who can arbitrate and ensure collaboration between different ministries.

It is also essential to ensure the participation of all key stakeholders in a One Health strategy, whether from human health, animal health, the environment, but also agriculture, education, or finance (for budgeting issues). Some experts are sometimes reluctant to work with other sectors, but it is important to break down these silos, notably through education and data sharing, to create a common vision.

This structure should be formalized through clear legal frameworks and collaboration protocols, which define the mandates of each stakeholder and the way they should operate to ensure optimal collaboration (for example, how data sharing should be carried out).

A widely recognized example comes from Kenya, with its Zoonotic Disease Unit (ZDU) (even though it is not without flaws). The ZDU is an official and permanent structure in Kenya, with a clear mandate (notably the identification of priority zoonoses and the development of One Health policies and plans), and it has a firmly

rooted multisectoral approach, bringing together actors from the human, animal, and environmental health sectors to work collaboratively.

3. Strengthen Integrated Surveillance Capacities :

At the national level, governments should develop a unified national system that monitors wildlife, livestock, humans, and the environment to detect emerging health threats early.

Existing digital early warning tools and intersectoral data-sharing platforms, such as DHIS2, EMPRES-i (FAO), or ProMED, should be adapted to national contexts to enable real-time information flow and coordinated responses. For instance, Bangladesh has been successful in deploying DHIS2 as a national-scale disease surveillance platform.

Engaging with local communities, Indigenous groups, rangers, and livestock keepers through Event-Based Surveillance (EBS) to enhance early detection at the grassroots level. In Bangladesh, the Institute of Epidemiology, Disease Control and Research (IEDCR) has implemented One Health EBS, successfully integrating community-level reporting to capture multisectoral health data more effectively.

Integrating antimicrobial resistance (AMR) and food safety monitoring under a One Health framework by aligning efforts with global standards such as GLASS and Codex Alimentarius to enhance food safety and antimicrobial stewardship and ensure comprehensive risk assessment and management across sectors to ultimately improve both national and global health security.

4. Fully Integrate the Environmental Sector :

It is essential to include the environmental sector and its experts within One Health multisectoral coordination mechanisms, which is all too often neglected. It hardly needs repeating that ecological health is just as important and interconnected with animal and human health. As highlighted throughout this work, climate change, but also biodiversity loss, deforestation, and certain agricultural practices are all drivers that can increase the risk of zoonotic spillovers. It is therefore crucial to collaborate with experts from these fields to prevent harmful practices and establish effective strategies.

It is also important, by extension, to integrate environmental policies (such as biodiversity conservation, pollution control, climate adaptation…) into One Health action plans.

Moreover, the environmental sector is often underfunded at both national and global levels, as it is frequently overlooked in favor of other sectors considered more important. It is thus essential to provide it with the necessary funding. Organizations such as UNEP and the GCF can help channel resources directly to environmental surveillance initiatives.

The ZDU in Kenya can again serve as an example here, but this time as a negative one : at the time of its creation, this unit initially left out the environmental sectors,

focusing instead on the human and animal health sectors. Since then, these sectors have been integrated into the ZDU.

5. Anchor Action at the Local and Community Level

Recognize the vital role of communities in One Health implementation and pandemic prevention, as they are often the first to detect health threats.

Strengthening local One Health Units, such as Community One Health Units (COHUs) in Kenya, by providing adequate human and financial resources to support cross-sectoral coordination.

Train and equip community health workers, animal health officers, and other local actors to carry out prevention, biosafety, and surveillance activities, with fair compensation to sustain engagement.

It is important to adapt and develop educational tools in collaboration with sociologists, anthropologists, and local leaders to ensure relevance and acceptance within communities.

It is crucial to provide Community Health Workers (CHWs) with training tailored to local contexts. This should include cultural practices and language, to ensure that health messages are easily accessible and culturally sensitive, as seen in the case of Bangladesh where majority of the CHWs are trained local women called Shasthya Shebikas (SS). This has been successful in building trust within communities.

Co-designing interventions with communities through programs like the Bangladesh Rural Advancement Committee (BRAC) and by employing participatory approaches such as community mapping and focus groups to promote co-ownership, trust, and long-term sustainability.

6. Ensure Sustainable and Equitable Financing :

It is essential that all sectors relevant to a One Health strategy are financed equitably, thereby avoiding fragmented, sector-specific funding. This can be achieved by establishing a multisectoral common fund supported by the state, international partners, and private actors.

However, states should not rely exclusively on external aid to finance these strategies, to avoid becoming overly dependent on it. The state must therefore take responsibility for financing the various sectors and components of its One Health approach.

It is also important that states cost their action plans from the outset and adopt an investment strategy with short-, medium-, and long-term budgeting. This will allow them to understand the financial burden from the beginning and prepare accordingly. Otherwise, the plan risks becoming just another document left on the shelf.

To ensure that investments are made in prevention and the One Health approach, data demonstrating the effectiveness of these investments is essential. We will discuss this in more detail in another recommendation, but it can already be mentioned here that one effective strategy to justify certain investments is to

highlight economic co-benefits (e.g., halting deforestation provides both health and climate benefits), which could further motivate governments and other stakeholders to allocate funding.

7. Make Education and Training a Central Pillar

It is essential to integrate the One Health approach into school curricula, university programs, and ongoing professional development to build cross-sector understanding from an early age.

Establishing intersectoral training centers such as the VOHUN model in Vietnam and the AFROHUN model in Kenya and other African countries to offer joint modules in human, animal, and environmental health.

Promoting field-based training programs for veterinarians, epidemiologists, biologists, foresters, and health professionals is crucial for developing practical skills in real-world settings.

Developing public information campaigns, especially those targeting children and youth is important to raise awareness and promote behavioral change.

8. Structure Research and Data Collection :

Data demonstrating the importance of the One Health approach are essential to convince governments and other stakeholders (such as the private sector) to invest in preventive measures.

It is therefore important to fund interdisciplinary research on spillover mechanisms, policy impacts, cost-benefit analyses, and pathogen behavior to provide evidence that adopting One Health measures is not only crucial for human, animal, and environmental health, but is also financially advantageous and can generate long-term savings.

As mentioned in a previous recommendation, an effective strategy is to highlight the co-benefits of interventions to prevent spillovers, because broadening the scope of anticipated benefits also broadens the base of support for addressing the underlying drivers.

The sharing of data at both national and international levels across health sectors is also crucial to anticipate and prevent spillover events. Such exchanges help create a common language among professionals from different sectors and align their vision around shared objectives, which is essential for effective policy development.

Establishing a national One Health research platform that brings together researchers, practitioners, and policymakers could be a valuable initiative, ensuring that data sharing occurs rapidly and regularly at the national level.

At the international level, it is important to foster international partnerships and to publish successful case studies.

9. Encourage Private Sector Engagement

At the national level, governments should create economic incentives for companies

to invest in prevention measures such as diagnostics, veterinary vaccines, and biosecurity.

It is important to establish clear health standards, robust traceability regulations and control mechanisms to ensure effective oversight and industry compliance by the private sector.

Supporting and replicating global initiatives like GALVmed, which demonstrate how partnerships with the private sector can expand access to affordable veterinary vaccines in low-income countries. This can further empower the communities economically by safeguarding their primary assets like livestocks.

Encouraging transparency and data sharing between public institutions and the private sector and by leveraging consumer pressure to influence safer and more sustainable practices in sectors such as livestock and food distribution.

10. Ensure that Equity and Equality are Cross-Cutting Principles

At the national level, it is critical to ensure the inclusion of all marginalized groups, including (among others) Indigenous peoples, women, and youth, in the co-design of One Health policies, legislation, and practices. In that regard, interventions must be adapted to local socio-economic contexts, as this is the only way to ensure that they are well received by the population and effective on the ground for each group, based on their need. If the messages come solely from large institutions or foreign experts, they will not be well received by local communities. It is therefore essential to include these groups from the very beginning of the process and that the strategies are tailored for each.

At the international level, it is necessary to ensure equity between countries, particularly through better access to funding, technology, and training in low-resource settings, as low- and middle-income countries are the most affected by infectious zoonotic diseases. This requires international legal frameworks and platforms for information sharing.

At the international level, an equitable approach is essential to avoid paternalistic or colonial attitudes that dictate what low- and middle-income countries should do. For example, while shutting down wet markets might be technically justified to prevent zoonotic outbreaks, ignoring the livelihoods of those who rely on them could result in One Health initiatives ultimately harming the very populations they aim to protect. The One Health approach requires listening to these countries and understanding their needs.

Conclusion and Discussion

Through this research, we have been able to answer our initial research question: "Which drivers of zoonotic spillover should governments evaluate to identify the necessary actions in their national One Health action plans to prevent pathogen transmission from animals to humans."

This research has advanced our understanding of the main drivers of zoonotic spillovers, through a comprehensive literature review, case studies, and expert interviews. We have seen that "super drivers" such as land use change, climate change, and globalization (and all the other activities that stem from them) can be responsible for zoonotic spillovers, in addition to having negative repercussions on animal and environmental health. While these drivers are now well documented, certain uncertainties persist, particularly regarding their interactions and underlying mechanisms.

Following this improved understanding of the drivers, we were then able to determine the best actions and strategies to adopt within an effective national One Health action plan, in order to protect human, animal, and environmental health. This was made possible through our literature review, as well as our two case studies on Kenya and Bangladesh, two countries that are very advanced in implementing the One Health approach, and our interviews with experts in the field, who provided a different and more practical perspective. Our recommendations reflect what we have learned throughout our work and would be useful within a One Health action plan, not only to save as many lives as possible, but also to reduce the economic costs of a potential future epidemic or pandemic.

Undeniably, considerable challenges remain to ensure that countries worldwide adopt these best practices and thereby lower the risk of epidemics and pandemics arising from zoonotic diseases. There is, among other things, a pressing need for further research, improved data collection, stronger collaboration among stakeholders, and increased funding for prevention measures among other things.

We remain hopeful that, through international agreements, ongoing academic progress, the advocacy's work of NGOs, and the exemplary leadership of certain states, the international community will come to fully recognize the importance of primary prevention and the One Health approach, for the well-being of humanity and all living beings on our planet.

Bibliography :

-Agarwal K, Srivastava S, Singh V, et al. One health concept and its applications in clinical practice: a comprehensive review. One Health Cases. 2024;2024:ohcs20240031. doi:10.1079/onehealthcases.2024.0031

-Ahmed S, Dávila JD, Allen A, Haklay MM, Tacoli C, Fèvre EM. Does urbanization make emergence of zoonosis more likely? Evidence, myths and gaps. *Environ Urban*. 2019;31(2):443-460. doi:10.1177/0956247819866124

-Ahmed, Mohamed Mustaf, et al. "Holistic Approaches to Zoonoses: Integrating Public Health, Policy, and One Health in a Dynamic Global Context." *Zoonotic Diseases*, vol. 5, no. 1, 2025, p. 5, doi:10.3390/zoonoticdis5010005.

-Akhtar F, Lodhi SA, Khan SS, Sarwar F. Incorporating permaculture and strategic management for sustainable ecological resource management. J Environ Manage. 2016;179:31-37. doi:10.1016/j.jenvman.2016.04.047

-Alimi Y, Bernstein A, Epstein J, et al. Report of the Scientific Task Force on Preventing Pandemics. *Harvard T.H. Chan School of Public Health*; August 2021. Available at: https://www.hsph.harvard.edu/wp-content/uploads/sites/2343/2021/08/PreventingPandemicsAug2021.pdf

-Banoo S, Bell D, Bossuyt P, et al. Evaluation of diagnostic tests for infectious diseases: general principles. Nat Rev Microbiol. 2006;4:S21-S31. doi:10.1038/nrmicro1523

-Bedford J, Farrar J, Ihekweazu C, et al. A new twenty-first century science for effective epidemic response. Nature. 2019;575:130-136. doi:10.1038/s41586-019-1717-y.

-Bianchini J, Humblet M, Cargnel M, et al. Prioritization of livestock transboundary diseases in Belgium using a multicriteria decision analysis tool based on drivers of emergence. Transbound Emerg Dis. 2020;67:344-376. doi:10.1111/tbed.13496

-Bukachi SA, Onono J, Onyango-Ouma W, et al. Opportunities, gaps, and challenges in the implementation of the One Health approach in Kenya. *One Health Cases.* 2024;ohcs20240019. doi:10.1079/onehealthcases.2024.0019

-Buttke DE. Toxicology, environmental health, and the “One Health” concept. J Med Toxicol. 2011;7:329-332. doi:10.1007/s13181-011-0172-4

-Cediel-Becerra N, Rodriguez-Moreno M, Vasquez N, Collins R. Public, private and public-private partnerships (PPP) to implement a One Health approach to combat antimicrobial resistance in Colombia. One Health Cases. 2024;2024:ohcs20240031. doi:10.1079/onehealthcases.2024.0031

-Daszak P, Zambrana-Torrelio C, Bogich TL, et al. Interdisciplinary approaches to understanding disease emergence: The past, present, and future drivers of Nipah virus emergence. Proc Natl Acad Sci U S A. 2013;110(suppl 1):3681-3688. doi:10.1073/pnas.1201243109

-Drewe JA, George J, Häsler B. Reshaping surveillance for infectious diseases: less chasing of pathogens and more monitoring of drivers. *World Organisation for Animal Health*. 2023.

-Ellwanger JH, Kulmann-Leal B, Kaminski VL, et al. Beyond diversity loss and climate change: Impacts of Amazon deforestation on infectious diseases and public health. *An Acad Bras Cienc*. 2020;92(1):e20191375. Published 2020 Apr 17. doi:10.1590/0001-3765202020191375

-ELLWANGER JH, FEARNSIDE PM, ZILIOTTO M, et al.. Synthesizing the connections between environmental disturbances and zoonotic spillover. An Acad Bras Ciênc. 2022;94:e20211530. doi:10.1590/0001-3765202220211530

-FAO, UNEP, WHO, WOAH. *One Health Joint Plan of Action (2022-2026): Working Together for the Health of Humans, Animals, Plants and the Environment*. Rome: FAO; 2022. doi:10.4060/cc2289en.

-Friant S, Ayambem WA, Alobi AO, et al. Eating bushmeat improves food security in a biodiversity and infectious disease "hotspot." Ecohealth. 2020;17:125-138. doi:10.1007/s10393-019-01473-3

-Friant S. Human behaviors driving disease emergence. *Evolutionary Anthropology*. 2024; 33:e22015. doi:10.1002/evan.22015

- Grima N, Singh SJ, Smetschka B, Ringhofer L. Payment for Ecosystem Services (PES) in Latin America: analyzing the performance of 40 case studies. *Ecosyst Serv*. 2016;17(1):24-32. doi:10.1016/j.ecoser.2015.11.010.

-Haq Z, Nazir J, Manzoor T, et al. Zoonotic spillover and viral mutations from low and middle-income countries: improving prevention strategies and bridging policy gaps. *PeerJ*. 2024;12:e17394. Published 2024 May 30. doi:10.7717/peerj.17394

-Henley P, Igihozo G, Wotton L. One Health approaches require community engagement, education, and international collaborations—a lesson from Rwanda. *Nat Med.* 2021;27(6):947-948. doi:10.1038/s41591-021-01350-5

-Hopkins, S. R., Lafferty, K. D., Wood, C. L., Olson, S. H., Buck, J. C., De Leo, G. A., Fiorella, K. J., Fornberg, J. L., Garchitorena, A., Jones, I. J., Kuris, A. M., Kwong, L. H., LeBoa, C., Leon, A. E., Lund, A. J., MacDonald, A. J., Metz, D. C. G., Nova, N., Peel, A. J., Remais, J. V., Stewart Merrill, T. E., Wilson, M., Bonds, M. H., Dobson, A. P., Lopez Carr, D., Howard, M. E., Mandle, L., & Sokolow, S. H. (2022). Evidence gaps and diversity among potential win–win solutions for conservation and human

infectious disease control. The Lancet Planetary Health, 6(8), e694-e705. https://doi.org/10.1016/S2542-5196(22)00148-6

-IDRC. Community first: One Health projects collaborate with communities to respond to epidemics. 2024. https://idrc-crdi.ca/en/research-in-action/community-first-one-health-projects-collaborate-communities-respond-epidemics

-Institute of Epidemiology, Disease Control and Research (IEDCR). *Bangladesh One Health Strategic Framework 2025-2030.* Government of Bangladesh, 19 Jan. 2025,https://iedcr.portal.gov.bd/sites/default/files/files/iedcr.portal.gov.bd/page/4d2edfa9_7dbf_45bd_8425_f3a404fc6ab1/2025-01-19-16-18-1439f76d504ffdc65537cc7e7bd277f6.pdf.

-IPBES. (2020). *Workshop Report on Biodiversity and Pandemics of the Intergovernmental Platform on Biodiversity and Ecosystem Services*. Das Neves, Carlos G., ed. UNEP.

-Jones BA, Grace D, Kock R, et al. Zoonosis emergence linked to agricultural intensification and environmental change. *Proc Natl Acad Sci U S A*. 2013;110(21):8399-8404. doi:10.1073/pnas.1208059110

-Keesing F, Holt RD, Ostfeld RS. Effects of species diversity on disease risk. *Ecol Lett*. 2006;9(4):485-498. doi:10.1111/j.1461-0248.2006.00885.x

-Keesing F, Ostfeld RS. Impacts of biodiversity and biodiversity loss on zoonotic diseases. *Proc Natl Acad Sci U S A*. 2021;118(17). doi:10.1073/pnas.2023540118.

-Liao, H., Lyon, C. J., Ying, B., & Hu, T. (2024). Climate change, its impact on emerging infectious diseases and new technologies to combat the challenge. *Emerging Microbes & Infections*, *13*(1). https://doi.org/10.1080/22221751.2024.2356143

-Loh EH, Zambrana-Torrelio C, Olival KJ, et al. Targeting Transmission Pathways for Emerging Zoonotic Disease Surveillance and Control. *Vector Borne Zoonotic Dis*. 2015;15(7):432-437. doi:10.1089/vbz.2013.1563

-Mahon MB, Sack A, Aleuy OA, et al. A meta-analysis on global change drivers and the risk of infectious disease. *Nature.* 2024;629:830-836. doi:10.1038/s41586-024-07380-6

-Markotter W, Mettenleiter TC, Adisasmito WB, Almuhairi S, et al. Prevention of zoonotic spillover: From relying on response to reducing the risk at source. PLOS Pathog. 2023;19(10):e1011504. doi:10.1371/journal.ppat.1011504.-

-McMichael C. Climate change-related migration and infectious disease. *Virulence*. 2015;6(6):548-553. doi:10.1080/21505594.2015.1021539

-Milbank C, Vira B. Wildmeat consumption and zoonotic spillover: contextualising disease emergence and policy responses. *Lancet Planet Health*. 2022;6(5):e439-e448. doi:10.1016/S2542-5196(22)00064-X

-Mora C, McKenzie T, Gaw IM, et al. Over half of known human pathogenic diseases can be aggravated by climate change. *Nat Clim Chang.*2022;12(10):869-875. doi:10.1038/s41558-022-01426-1

-Munyua PM, Njenga MK, Osoro EM, et al. Successes and challenges of the One Health approach in Kenya over the last decade. *BMC Public Health*. 2019;19(Suppl 3):465. Published 2019 May 10. doi:10.1186/s12889-019-6772-7

-Mwatondo A, Rahman-Shepherd A, Hollmann L, et al. A global analysis of One Health Networks and the proliferation of One Health collaborations. Lancet. 2023;401(10376):605-616. doi:10.1016/S0140-6736(22)01596-3

-Olaru ID, Walther B, Schaumburg F. Zoonotic sources and the spread of antimicrobial resistance from the perspective of low- and middle-income countries. *Infect Dis Poverty.* 2023;12(59). doi:10.1186/s40249-023-01113-z

-Olivero, J., Fa, J.E., Real, R. *et al.* Recent loss of closed forests is associated with Ebola virus disease outbreaks. *Sci Rep* **7**, 14291 (2017). https://doi.org/10.1038/s41598-017-14727-9

-One Health Poultry Hub. *Bangladesh One Health Brief*. Jan. 2024, https://www.onehealthpoultry.org/wp-content/uploads/2024/01/Bd-One-Health-brief_final_Jan2024.pdf.

-Patz JA, Daszak P, Tabor GM, et al. Unhealthy landscapes: Policy recommendations on land use change and infectious disease emergence. Environ Health Perspect. 2004;112(10):1092-1098. doi:10.1289/ehp.6877

-Plowright RK, Reaser JK, Locke H, et al. Land use-induced spillover: a call to action to safeguard environmental, animal, and human health. *Lancet Planet Health.* 2021;5(4). doi:10.1016/S2542-5196(21)00031-0

-Rohr JR, Barrett CB, Civitello DJ, et al. Emerging human infectious diseases and the links to global food production. *Nat Sustain*. 2019;2(6):445-456. doi:10.1038/s41893-019-0293-3

-Rogalski MA, Gowler CD, Shaw CL, Hufbauer RA, Duffy MA. Human drivers of ecological and evolutionary dynamics in emerging and disappearing infectious disease systems. *Philos Trans R Soc B.* 2017;372(1712):20160043. doi:10.1098/rstb.2016.0043

-Ruckert A, das Neves CG, Amuasi J, et al. One Health as a Pillar for a Transformative Pandemic Treaty. Global Health Centre Policy Brief. 2021. https://www.graduateinstitute.ch/sites/internet/files/2021-11/policybrief-onehealth-v3.pdf

-Sangong S, Saah FI, Bain LE. Effective community engagement in One Health research in Sub-Saharan Africa: a systematic review. *One Health Outlook.* 2025;7:4. doi:10.1186/s42522-024-00126-4

-Scotch M, Brownstein JS, Vegso S, et al. Human vs. animal outbreaks of the 2009 swine-origin H1N1 influenza A epidemic. EcoHealth. 2011;8:376-380. doi:10.1007/s10393-011-0706-x
-Sharp PM, Hahn BH. Origins of HIV and the AIDS pandemic. *Cold Spring Harb Perspect Med*. 2011;1(1):a006841. doi:10.1101/cshperspect.a006841
-Shivaprakash KN, Sen S, Paul S, Kiesecker JM, Bawa KS. Mammals, wildlife trade, and the next global pandemic. *Curr Biol*. 2021;31(16):3671-3677.e3. doi:10.1016/j.cub.2021.06.006

-Institute of Medicine (US) Committee on Emerging Microbial Threats to Health in the 21st Century; Smolinski MS, Hamburg MA, Lederberg J, eds. *Microbial Threats to Health: Emergence, Detection, and Response.* Washington, DC: National Academies Press (US); 2003:53-147.

-Stel M, Eggers J, Alonso WJ. Mitigating Zoonotic Risks in Intensive Farming: Solutions for a Sustainable Change. *Ecohealth*. 2022;19(3):324-328. doi:10.1007/s10393-022-01605-8

-Stern NJ, Hiett KL, Alfredsson GA, et al. Campylobacter spp. in Icelandic poultry operations and human disease. Epidemiol Infect. 2003;130:23-32. doi:10.1017/S0950268802007914

-The Lancet. One Health: a call for ecological equity. *Lancet.* 2023;401(10372):169. doi:10.1016/S0140-6736(23)00090-9

-U.S. Global Change Research Program;National Oceanic and Atmospheric Administration. Climate Change Impacts in the United States: The Third National Climate Assessment. 2014. Available at: https://nca2014.globalchange.gov/report/sectors/human-health.

-Vora NM, Hannah L, Lieberman S, Vale MM, Plowright RK, Bernstein AS. Want to prevent pandemics? Stop spillovers. *Nature.* 2022.https://www.nature.com/articles/d41586-022-01312-y#ref-CR1

-Vora NM, Hannah L, Walzer C, et al. Interventions to Reduce Risk for Pathogen Spillover and Early Disease Spread to Prevent Outbreaks, Epidemics, and Pandemics. *Emerging Infectious Diseases*. 2023;29(3):1-9. doi:10.3201/eid2903.221079.

-Wang LD, Chen HG, Guo JG, et al. A strategy to control transmission of Schistosoma japonicum in China. N Engl J Med. 2009;360:121-128. doi:10.1056/NEJMoa0800135

-World Health Organization. *Bangladesh Completes Its Second Joint External Evaluation of the International Health Regulations Core Capacities.* WHO South-East Asia, 11 July 2024, WHO

-WHO. Reducing public health risks associated with the sale of live wild animals of mammalian species in traditional food markets. 2021. https://iris.who.int/bitstream/handle/10665/340719/WHO-2019-nCoV-Food_safety-traditional_markets-2021.1-eng.pdf?sequence=1

-WHO. No date. https://www.who.int/health-topics/foodborne-diseases#tab=tab_1
-World Health Organization. International Health Regulations (2005) – Third edition. Geneva: World Health Organization; 2016. add this as well

-WHO. Community engagement: a health promotion guide for universal health coverage in the hands of the people. 2020. https://iris.who.int/bitstream/handle/10665/334379/9789240010529-eng.pdf?sequence=1

-WHO. *"Quadripartite welcomes OHHLEP's new white paper on zoonotic spillover prevention".* May 2023. Available at: https://www.who.int/news/item/03-05-2023-quadripartite-welcomes-ohhlep-s-new-white-paper-on--zoonotic-spillover-prevention

-World Health Organization, Food and Agriculture Organization of the United Nations, United Nations Environment Programme and World Organisation for Animal Health. *"A guide to implementing the One Health Joint Plan of Action at national level"*. 2023. https://iris.who.int/bitstream/handle/10665/374825/9789240082069-eng.pdf?sequence=1

-World Organisation for Animal Health & IUCN. General guidelines for surveillance of diseases, pathogens and toxic agents in free-ranging wildlife: An overview for wildlife authorities and others working with wildlife. Paris, Gland: World Organisation for Animal Health & IUCN; 2024. 56 pp. https://doi.org/10.20506/woah.3509.Licence: CC BY-SA 3.0 IGO.

-WHO. « Pandemic prevention, preparedness and response accord». 2025. https://apps.who.int/gb/ebwha/pdf_files/WHA78/A78_10-en.pdf

-Wu T, Perrings C, Shang C, et al. Protection of wetlands as a strategy for reducing the spread of avian influenza from migratory waterfowl. Ambio. 2019;49(4):939-949. doi:10.1007/s13280-019-01182-0

-Zhang G, Qiu Y, Boireau P, et al. Modern agriculture and One Health. Infect Dis Poverty. 2024;13:74. doi:10.1186/s40249-024-01240-1

-Zhang L, Liu S, Guo W, et al. Addressing biodiversity conservation, disease surveillance, and public health interventions through One Health approach in Hainan's tropical rainforest. *One Health Adv.* 2024;2:8. doi:10.1186/s44280-023-00035-7

-Zhang T, Nickerson R, Zhang W, Peng X, Shang Y, Zhou Y, Luo Q, Wen G, Cheng Z. The impacts of animal agriculture on One Health—Bacterial zoonosis, antimicrobial resistance, and beyond. *One Health.* 2024;18:100748. doi:10.1016/j.onehlt.2024.100748.

-Zoonotic Disease Unit. *One Health Strategic Plan for the Prevention and Control of Zoonotic Diseases in Kenya (2021-2025).* Nairobi : Ministry of Agriculture, Livestock, Fisheries and Cooperatives; Ministry of Health; 2021. https://www.onehealthcommission.org/documents/filelibrary/resources/one_health_strategic_action_plans/OneHealthStrategicPlan_Kenya_202120_8756689A2C54E.pdf

Nivitha Leena Naveen
Nicola Gabriele Nicastro

Annex

Interviews transcripts

Dr. Elsa Léger and Dr. Manon Lounnas : One Health experts working for the PREZODE initiative

Interviewer : So yeah, she'll join us in 15 minutes, but we can start.

Elsa : Okay, that works for me. I actually have another meeting at four, so if we're not done, or if she wants additional information, we can still work on a document or schedule another meeting next week. What's your deadline?

Interviewer : We have time, but ideally, this meeting would last less than an hour.

Elsa : Perfect, let's keep it straightforward then.

Interviewer : Great. Maybe you can start by introducing yourself briefly – your background and your work with One Health.

Elsa : Sure. I'm the Science Officer for PREZODE. I coordinate the scientific activities along with Manon, the other Science Officer. Together we oversee the pillar working groups composed of experts on different topics, and we also manage various scientific activities. Before joining PREZODE, I worked with the WHO and FAO as a consultant, focusing on developing roadmaps and guidelines for zoonotic diseases. Earlier, I was a researcher at the Royal Veterinary College in London, working on interdisciplinary projects using a One Health approach for prevention and control.

Interviewer : That's great. Your experience will be very useful for our project. We've been identifying gaps in the literature, and you might help us fill some of them. You've seen our questions – we've done a literature review and a few interviews so far.

Elsa : That's interesting. One of our pillar working groups is actually focused on identifying the drivers and mechanisms of zoonotic disease emergence. We aim to review the drivers and identify knowledge and research gaps. I'm not sure we'll be able to fill all the gaps ourselves—everyone in this field is trying—but we can certainly discuss them.

Interviewer : That's already very helpful. The first question we wanted to ask was about urbanization. Do you think urbanization increases the risk of zoonotic spillovers? Literature seems divided on this.

Elsa : Yes, in my opinion, urbanization is a driver of zoonotic spillovers. It increases contact between humans and animals, especially when urban areas expand into natural habitats. That contact is a key factor in spillover events. Some argue urbanization reduces contact with animals due to less biodiversity in cities, but it really depends on the context. Often, urban expansion means encroachment into ecosystems, bringing humans and wildlife closer together.

Interviewer : Do you think it's the urbanization itself or the interaction between urbanization and other drivers, like intensive livestock farming?

Elsa : I think urbanization alone can be a driver. The argument that cities reduce animal contact might hold in very urbanized environments, but in many contexts, urban expansion pushes into natural or agricultural areas. That creates interfaces where humans and animals interact more frequently. We see animals in urban spaces in many parts of the world. For instance, in Rio de Janeiro, city expansion into forest areas has led to more human-animal contact and higher risk of spillover.

Interviewer : That makes sense. Some authors argue urbanization brings better healthcare, potentially reducing spillover risk, but your explanation clarifies that spillover and healthcare access are two separate things.

Elsa : I am not sure that there is a correlation everywhere between urbanization and better access to healthcare. And where this is the case, access to healthcare might reduce disease impact after infection, but it doesn't prevent spillover. If humans and animals are brought into contact, spillover risk increases, regardless of healthcare systems.

Interviewer : Great. We also wanted to ask about interactions between drivers. Are there specific interactions the literature underestimates?

Elsa : Yes. I think many drivers are interconnected. For example, land use change includes deforestation, urbanization, agricultural expansion, and natural resource extraction. These are often treated separately, but they're part of a broader pattern. I would consider land use change a "super driver" that encompasses several more specific drivers. Similarly, global trade and climate change can also be seen as "super drivers". Global trade involves infrastructure development, population movement, and international exchange. Climate change affects ecosystems, water, and vectors, influencing disease dynamics. These broader categories help understand how multiple drivers interact.

Interviewer : That concept of super drivers is interesting. So, land use change, climate change, and global trade would be the main super drivers?

Elsa : Yes. And within them, you can place more specific drivers. For example, deforestation and intensive agriculture can fall under land use change. Trade in animals and people's mobility can fall under global trade.

Interviewer : Thank you. Manon has just joined us—thank you for being here.

Manon : Thank you for having me.

Interviewer : We were discussing super drivers and how natural resource extraction is considered part of land use change. Elsa, could you elaborate?

Elsa : Yes. Natural resource extraction changes ecosystems and brings humans into closer contact with wildlife. This increases the risk of both spillover and pathogen emergence. It falls under land use change and can disrupt ecological balances, making new infections more likely.

Interviewer : Thank you. Now a broader question: how can we convince governments to scale back certain activities to prevent future spillovers, given that they often prioritize short-term gains?

Manon : It's a big challenge. One way is to demonstrate win-win strategies—actions that bring co-benefits for health, climate, and development. We need more evidence showing that primary prevention works and that it can be cost-effective. We also need better communication between science, public policy, and society, because we don't speak the same language.

Elsa : And we need to improve how we communicate science. Funders should ask researchers to include plans for communicating with governments and stakeholders.

Manon : Communication across sectors is also key. That's one of the main challenges in implementing a One Health approach. Different actors have different cultures and priorities.

Elsa : Human health actors often feel their work is the most important—"we are saving lives"—which makes it harder to bring in other sectors.

Manon : That's why we need to demonstrate co-benefits and the economics of prevention. Cost-effectiveness data is lacking.

Elsa : I completely agree. Economic data is crucial. We lack cost-effectiveness studies showing that prevention saves money. Without evidence, it's hard to convince governments or even the private sector to invest in prevention.

Interviewer : So, how do we improve that? Why haven't we developed a proper economic framework?

Manon : It's hard to measure prevention because, by definition, you're measuring something that didn't happen. But we're working on developing indicators and methodologies to assess cost-effectiveness.

Elsa : Yes. We need clear metrics for success. But the private sector is not interested in prevention—it's not profitable. Prevention doesn't bring in money the way treatments or vaccines do. Governments need to create the demand. If governments prioritize prevention, the market will follow.

Interviewer : What is the other major challenge to implementation?

Manon : Working with communities is key. Interventions need to be adapted to local contexts. That takes time, and funders don't always allow that.

Elsa : For example, in China, they closed live animal markets, but the problem just moved to surrounding areas. If you don't understand the system, your intervention can fail.

Manon : That's why co-designing interventions with communities is essential.

Elsa : We also need to involve social scientists and ensure participatory approaches, especially when working with communities. Understanding local dynamics is essential. Funders didn't used to see the value of including social sciences in projects. Now it's improving.

Manon : And we need more time and flexibility from funders. Often, there's not enough time to properly co-design interventions with communities. And without community buy-in, interventions might fail or even backfire.

Elsa : Absolutely. And working with communities should be done jointly with governments and NGOs. As researchers, we bring data and insights, but implementation requires broader cooperation.

Interviewer : Do you ever face conflicts of interest with governments or NGOs when working directly with communities?

Elsa : It depends on the context. Ideally, we ensure that local authorities and community leaders are on board. But yes, in some cases, especially on sensitive topics like gender or land use, there can be tension. That's why sustainability and alignment with local priorities are key.

Manon : And misinformation is another challenge. That's why education is crucial. We've seen successful examples using schools, coloring books, and other tools to engage children, who then pass on knowledge to their families.

Interviewer : That's very helpful. What about at the institutional level? What frameworks should governments establish to implement One Health effectively?

Manon : One key recommendation is to create a national One Health platform—an institutionalized space for dialogue between ministries and sectors. This kind of coordination is essential.

Elsa : And this platform should be placed at a high level—like in the Prime Minister's office—so that it has the authority to coordinate across sectors. Some countries have tried this, but often the platforms lack funding or political support to become truly operational.

Interviewer : Do you think One Health is sometimes overshadowed by broader climate or development frameworks?

Elsa : One Health should be the umbrella. It includes climate, environment, and health. The problem is that it's often siloed under one ministry, like agriculture or health, which limits its scope. Governments don't always see One Health as a priority. There's a lack of data and will. If governments spend money on it, their populations might not understand the benefit either.

Manon : Exactly. Education is key. Children, communities—everyone must understand that prevention pays off in the long term. That's why we need to elevate One Health to a higher political level and communicate its importance more clearly. Lack of data and clear economic evidence remains a major barrier.

Interviewer : Finally, what mechanisms should be established at the international level to reduce the prevention capability gap between high- and low-income countries?

Elsa : It's a very complex issue. But initiatives like PREZODE aim to share knowledge, build research capacity, and connect governments and scientists. We need more investment in data sharing, capacity building, and joint platforms to ensure everyone has access to the tools and information they need.

Dr. Sophie Masika : accomplished Veterinarian and Epidemiologist, currently working at the World Federation for Animals as Global Health Policy Manager

Dr. Masika :
I currently work for the Wild Federation for Animals, based in the US, but I'm based in Nairobi and work in a hybrid capacity. I lead the work on antimicrobial resistance as the Global Health Policy Manager. I also work on pandemics—the Pandemic Treaty, pandemic prevention, preparedness and response—and serve as the liaison to the United Nations Environmental Program on the triple planetary crisis in health.

Previously, I worked for the Kenyan national government as a veterinary epidemiologist, contributing to national policy development and implementation at the subnational level. I've also done wildlife research, particularly in pangolin conservation, looking at zoonotic viruses in wild populations in Kenya. During COVID-19, I supported the government at hospital levels in epidemiology. That's a bit of my background.

Interviewer :
Thank you very much for your explanation. Let's start with a general question. How can governments be convinced to scale back certain activities to prevent future zoonotic spillovers and pandemics? For example, agricultural activities that drive spillovers, or deforestation. How can we convince them that the long-term benefits outweigh the short-term economic gains?

Dr. Masika :
The first thing that comes to mind is that most governments look for evidence. It's helpful to present successful examples from similar countries. Additionally, governments prioritize issues financially. If you bring a cost-benefit analysis showing that prevention is cheaper than response and recovery, they'll be more inclined to listen.

Also, align your recommendations with their existing priorities. They may not be focused on pandemic prevention specifically, but if they already work on surveillance or general disease control, you can build on that rather than introducing something entirely new.

Interviewer :
But even though governments know pandemics are costly—as we've seen with COVID-19—not much has changed in many places.

Dr. Masika :
I wouldn't say they've done nothing. For instance, Kenya developed its first One Health strategic plan for zoonotic disease prevention after COVID-19. That's a good step. Even if implementation is slow, recognizing and building on these small wins is key. Governments—especially in low- and middle-income countries—face many competing priorities: hunger, drought, climate change. So, pandemic preparedness often comes after more immediate concerns.

Interviewer :
How do we make governments realize that primary prevention can also help them achieve other goals, like addressing hunger or climate change, rather than treating it as a separate burden?

Dr. Masika :
That's a difficult message to deliver at high levels. For example, the Pandemic Treaty negotiations are not the right place to convince governments—it's a legally binding process with 198 member states and a lot of political pressure. Instead, targeting ministries directly can be more effective. They often have more autonomy and are more open to technical input. When I worked in the Kenyan government, if a partner came to the ministry with a clear proposal, we could act on it more easily than if it came through a global process.

Interviewer :
So ministries are more open to input because it's within their mandate?

Dr. Masika :
Exactly. They can act on their own within a certain scope. But a treaty, or a policy at the national level, involves many layers of government. That's why implementation should start at the local level.

Interviewer :
Thank you. That's very clear. Let's talk about the private sector. What role do industries like agrifood or pharmaceuticals play in prevention? And how could they be more involved?

Dr. Masika :
They care about profit, but it's important to involve them early. For example, in antimicrobial resistance, we've included industry in a coalition from the beginning. That way, we're not just instructing them after policies are developed and they are also able to see the benefits of a certain policy, for instance reducing the use of antimicrobials. During COVID-19, pharmaceutical companies produced the vaccines. So their involvement is essential.

Interviewer :
But aren't they even more financially driven than governments? Can they really be convinced to change their practices?

Dr. Masika :
That's where governments come in. Governments can offer compromises—like tax subsidies in exchange for reduced antimicrobial production or monitoring use. But NGOs and civil society have limited power to influence industry. Policy incentives must come from governments.

Interviewer :
Got it. And what could the UN or other international organizations do better to incentivize countries to adopt One Health measures?

Dr. Masika :
The UN produces guidance documents and supports independent expert panels, but in negotiations like the Pandemic Treaty, they are neutral conveners. They don't have a direct voice. What they can do is promote equity in leadership—ensuring both Global South and Global North countries have strong roles. That affects how other countries perceive and follow leaders. For instance, if we had a strong country from the global south who is championing One Health as one of the core facilitators of the pandemic treaty, there's a very high likelihood that the member states who are negotiating from the global South would listen to the leadership. So it is about creating balance equity and ensuring that the voices from all angles of the world are listened to equally and equitably, at any given point. This balance that we keep was not there from the beginning.

Interviewer :
Why has the Global South performed better in One Health and primary prevention?

Dr. Masika :
Because Africa lived through outbreaks. Ebola, Rift Valley fever—these originated here. We've developed preparedness out of necessity. We had to put in, for instance, community disease reporters or community health workers who are familiar with diseases from both human health and animal health. Our proximity to animals is higher, and ministries collaborate out of experience. During COVID-19, I worked in a hospital even though I'm a vet—that's part of our training (my training was tailored around being able to support epidemiology from the entire health spectrum environment, animal and human health. You, get that broad knowledge from school). Our ministries coordinate on zoonotic diseases, even if we didn't call it "One Health" at the time.

Interviewer :
How does advocacy for One Health policies implementation differ between the Global North and South?

Dr. Masika :
In global forums like the Pandemic Treaty, the Global North pushes for One Health. But in the South, especially at community level, One Health is already happening. There is very little advocacy that you have to do for one health implementation at the community level in the global South. Advocacy is needed more for formalization of the One Health approach and resourcing. In the North, resistance sometimes comes from fear of having to provide additional support to the South. And that is where advocacy for the global North would need to focus on : for them to also understand the benefit of supporting the global south to prevent, diseases because it could very well originate from the global South and end up in the global North. Otherwise, the Global North is now receptive to One Health.

Interviewer :
Some Global North countries could still do more—like regulating wildlife trade or environmental measures.

Dr. Masika :
Absolutely. They've been receptive, but there's still room for improvement. For example, wildlife trade regulations could be stronger.

Interviewer :
How can we ensure One Health measures are implemented at the national level?

Dr. Masika :
Advocacy at the national level is crucial, because advocacy at the global level is never enough. Non-

state actors must push for adoption. Global documents should be adaptable to national contexts. Costed action plans help governments see what resources are needed—this has worked well for AMR.

Interviewer :
Now we'd like to ask a few questions about Kenya. Why is Kenya a champion in One Health?

Dr. Masika :
Kenya is progressive in many elements and has taken leadership roles in the region. It's a hub for medical care in East Africa. There's strong technical expertise, a large population of animals, and experience with outbreaks. Our systems are developed out of need. A lot of Kenyans are well educated, well trained, and they are able to permeate different areas of health.

Interviewer :
Is Kenya ahead because of what the government put in place in term of One Health approach?

Dr. Masika :
the one health approach came 10 or 15 years ago. This is not necessarily a deliberate system that the government put previously. Okay. But when the need to have a one health approach was brought to the attention, the government was very quick to form a zoonotic disease unit, that coordinates the different One Health programs.
I would like to add that, because of the progressive nature of the country, we have a lot of NGOs in the country on different areas. So that advocacy has been very strong from this perspective.
Kenya also hosts the United Nations grounds, the biggest one in Africa. That also has played a significant role in the progressiveness of the country.

Interviewer :
Has the government created an enabling environment for NGOs?

Dr. Masika :
Yes. Kenya hosts the largest UN grounds in Africa, and the government has allowed NGOs to advocate effectively. That has helped push One Health forward.

Interviewer :
What are the biggest challenges Kenya still faces?

Dr. Masika :
Funding. The government doesn't allocate enough resources to One Health, so we rely on external donors. That limits autonomy. There's also room to improve inter-agency coordination and data sharing between ministries.

Interviewer :
Does the government have the means to support One Health, or does it still need external help?

Dr. Masika :
Governments should fund their priorities first before seeking external help. Kenya could do better here. Relying too much on donors leads to misaligned priorities.

Interviewer
You've also worked on the gender dimension of One Health. Could you explain how gender fits into this?

Dr. Masika :
Gender is central. In many African communities, women raise livestock. They are often first affected by zoonotic outbreaks. Women also fetch water and manage food, so they're on the front lines of

waterborne and foodborne diseases. Any policy that ignores gender won't reach the right populations.

Interviewer
Can gender-sensitive policies help with primary prevention?

Dr. Masika :
Absolutely. If you target the right groups—like women in rural areas—you increase the effectiveness of your interventions.

Interviewer :
Thank you very much. We'll share our final output with you once it's ready.

Dr. Masika :
I'd appreciate that. One last point: governments should cost their action plans from the start. That way, they know the financial burden. If a plan isn't costed, it risks becoming just another shelved document.

Interviewer :
That's very helpful. Thank you again for everything.

Dr. Yewande Alimi : AMR and One Health unit Lead at Africa CDC :

Dr. Alimi : Five heads of states of the African Union created Africa CDC as a public health agency that can really cater to the needs of the African population. I think this was quite important in terms of changing the narrative of how global health should look like for LMICs, and we are quite proud that the heads of states of the African Union were able to identify this need and really give the leadership to Africa CDC.

So I've been with Africa CDC since 2017, and my role primarily was to come into a new organization and try to figure out what the One Health priorities should look like and what the organization can do to support that.

What we are focused on right now is on antimicrobial resistance, zoonotic diseases, climate change and health, as well as food safety on the continent. Of course, we are cognizant there are several other One Health areas, but this has been addressed by different technical divisions of Africa CDC.

I think lastly, One Health has been a buzzword (a lot of conversations) but when it comes to real-life implementation, such as shared financing, domestic mobilization of resources, having governance structures in place, this is often very missing. So a lot of the bulk of the work we do is really around building a sustainable approach to One Health implementation — things like helping countries to set up their governance structure, their multisectoral coordination mechanisms, helping them with resource mobilization, legal frameworks, depending on what the conversation is.

Interviewer :
Thank you very much for this really complete introduction. We know that climate change is recognized as a major driver for zoonotic diseases, but the transmission pathways remain poorly understood. Is Africa CDC working to strengthen research on these mechanisms?

Dr. Alimi :
Yes, indeed. The pathways of zoonotic disease spillover are quite multifaceted and very complex. It's not just climate change that drives it. Africa CDC is very keen to improve what the research agenda looks like, particularly on zoonotic disease spillover.

We have a focus area on climate change in trying to understand, for example, what the disease pattern is looking like across our member states, and trying to also use climate or meteorological data to guide our countries to prepare for outbreaks. Those are the areas that we are primarily focused on.

But in addition to that, we are taking on a broader lens. For example, zoonotic disease spillover — one of the ways we are working on this is not just looking at it from the climate change lens, but also to better understand sociocultural nuances using an anthropological lens. Those are the areas where our research agenda is going to focus on.

We are going to be launching the climate change strategic framework that really goes in-depth to identify some of the burden or hot topic research priorities for the African continent.

Interviewer : And we know that despite international recommendations, the environmental pillar is often neglected in the implementation of the One Health approach. Do you know what concrete measures can be taken to strengthen this component, particularly in Africa?

Dr Alimi :
I think as a start, the reason why the environmental health sector has been left behind is because each sector has its own sector-specific agenda. If you think about it, human health will always be heavily funded versus other sectors. Now, when we talk about a One Health approach, the environmental lens takes on different perspectives.

For example, environmental surveillance is different from climate data surveillance. One of the key challenges that I've seen on the African continent is that when we bring all stakeholders to the table, we often forget to then describe what the shared vision or the shared goal is.

For example, I've been working in the AMR space for the longest time, and even globally, UNEP just came on board in the Quad about two or three years ago. So yes, we've been saying environmental health brings a different dynamic and is important, but we haven't been able to define exactly what is important or what is the most urgent thing for the environmental health sector.

When we are doing some of this engagement, it's not that the environmental sector is not interested or unwilling to work. But when we share our vision and our goals, more often than not, they don't see themselves in that shared vision.

One of the things that we are trying to do at Africa CDC is to co-create a shared vision, a shared One Health vision for all sectors, in every country and in every setting, so that everyone can see the value. When you look at it from the fact that they don't have enough resources, whether financial or technical, it makes the environmental sector lag behind. But there's also the fact that their contribution or commitment is not often defined from the beginning. They're brought in last minute as an afterthought, so it's not clearly defined to them. They don't feel committed to continuing the work.

And I think the last point is that we need to create that value. For example, when we say environmental surveillance, what does this really do? We need to be able to describe it in such a way that it contributes to the bigger picture.

For example, if we improve AMR surveillance in the environmental sector, it can tell us how to improve regulatory frameworks for industry. Is the contamination in our river a result of pharmaceuticals? Then you can give the environmental health sector clear actions to be able to mitigate such a shared threat.

Another example: when you think about zoonotic diseases, we often talk about how the environment is important — but in what exact way? What is the ask? What are we asking the environmental health sector to contribute to the shared vision?

Interviewer :
Thank you very much. You were talking about stakeholder engagement, and I was wondering: how can we make sure that all these stakeholders have equal participation in the One Health effort, so that environment, animal health, and all these external stakeholders can equally contribute and feel equally involved?

Dr. Alimi :
That's a very good question. I think one of the ways to understand the One Health approach — and I love the definition from the OHHLEP (— is that it's deeper than just human, environment, and animal sectors. It really takes a whole-of-society, whole-of-government approach to addressing shared threats.

The first way to do that is to understand that One Health is nuanced and context-specific. For example, the way we support One Health in Kenya may be different from Chad, because of different governance structures, different cultural and social norms. All of this is very important.

So at Africa CDC, one of the first things we do to demonstrate stronger coordination mechanisms is to conduct a situational analysis — understand the setting and context — then co-create solutions using the One Health Joint Plan of Action and operational tools like the MCM (Multisectoral Coordination Mechanism) to help them form governance structures.

When we're working with countries to establish their MCMs — and I use MCMs or One Health platforms interchangeably; they both mean coordination mechanisms in-country — one thing we insist on is having shared terms of reference. Some countries may not use ToRs; they might use MOUs — Memoranda of Understanding — but this defines each sector's responsibilities, contributions, leadership, and commitment. It holds them accountable. We've seen this really works.

Whether you call them ToRs, MOUs, CWG guiding documents — the name varies — something needs to be put on paper to define how the mechanism operates.

In addition to that, how do we build capacity? More often than not, the human health sector is at the forefront, and you can't blame the other sectors if they lag behind. So, we try to improve capacity across all sectors. The environment sector, for example, has been top on our list. We're working with partners like UNEP, the GCF, and others to make sure investments and resources go directly to the environmental health sector.

It's really about helping those sectors that are left behind catch up — either through capacity building or advocacy to help them raise resources.

Interviewer :
Do you also think that one of the main challenges right now for the implementation of One Health is the lack of available spillover data?

Dr. Alimi : Data — for example, in AMR — can be very different from data in zoonotic diseases or climate. If you try to look at it at a granular level, you'll see variation.

For AMR, people can argue there's good data from agriculture, environment, and human health.

Data is very broad. With different topics, data exchange differs. So is the question about data for One Health generally, or something else?

Interviewer :
I was specifically talking about spillover data. For example, data that proves that climate change or urbanization can lead to zoonotic spillovers.

Dr. Alimi :
Those would be attributing or contributing factors. It's not going to be direct.

For example, we can argue that increased rainfall can drive Rift Valley Fever outbreaks, but we can also argue that if we put the right interventions — such as animal vaccines and biosafety on farms — we may not have a spillover. So yes, climate change contributes, but there are other factors that amplify outbreaks, like bushmeat hunting.

Climate change will always be there, but if we reduce those interactions, like eating bats, we could potentially prevent Ebola outbreaks. Climate change contributes, but it's not a direct effect on spillover.

It's clinically nuanced.

Interviewer :
Let's talk about the local and the communities as well. How does Africa CDC support the implementation of One Health strategies not only at the national level but also at the local or community level, where the risk of spillovers is often the highest?

Dr. Alimi
Just before we move on, let me finish with this broader point: data exchange or information exchange is essential to anticipate spillovers. We need improved One Health data exchange across sectors — that's a clear recommendation. But also, there is the need to perceive the value. One reason One Health works in some places but not in others is that people don't always see the value of working together.

During COVID-19, we saw veterinary labs in LMICs supporting human testing. That's a practical example of why One Health works. It's not necessarily about data but about generating knowledge on the benefits of collaboration.

Now, on communities — this is where our One Health work focuses on risk communication. This is where the social and anthropological aspects come in. We believe communities are the most important building block of a One Health approach. Everything we do across sectors should benefit people.

At Africa CDC, we have what we call Event-Based Surveillance (EBS). It's one of our surveillance mechanisms to get quick data — using media scanning and information from countries. It's unlike indicator-based surveillance where you wait for test confirmation. For example, an EBS signal could be someone in a Malawian village reporting hemorrhagic signs after eating a dead cow — that could indicate anthrax. That's the community feeding us information, not the other way around.

We also have a large community health workforce. In every outbreak, especially zoonotic ones, we use a One Health approach to build their capacity. When they go back to communities, they can educate them on safety measures and how to prevent outbreaks.

This approach works well because community health workers are closer to the people than doctors or pharmacists. Mothers, villagers, and religious leaders trust them. So we use them to amplify risk communication around zoonotic diseases and potential outbreaks.

We also work with non-state actors like civil society groups doing great work on consumer information — for example, how to handle milk or meat to avoid outbreaks. We try to collaborate closely with them.

Another key group is the media. Journalists are very important. We do regular training for them — annually, we train journalists on One Health issues, especially how to communicate with communities about preventive practices.

Lastly, youth groups. Africa has the highest youth population, and we want them to be ambassadors to support these activities.

Interviewer :
Most of these are very local or grassroots-level campaigns. Is there anything done at an international or regional level that you think is effective?

Dr. Alimi
That's actually where I started. We bring in political advocacy. If you want to elevate One Health to the highest level of leadership, this is where Africa CDC plays a key role.

Last year, we took AMR to the UN General Assembly, where we launched an African Union landmark report on AMR with clear One Health recommendations.

We have the first political declaration from the African continent on AMR, made by a president. We also have strategic documents that go beyond policymakers — they reach ministers of health, agriculture, environment, and when needed, heads of state.

We're also working with the G20 — South Africa currently holds the presidency — to support One Health discussions. We engage in AU–EU dialogues and work closely with global partners like the US, UK, EU, China, and others to push for a One Health agenda.

Interviewer :
Coming back to the local level — two questions: How can governments ensure that local communities are truly involved in the co-construction of One Health strategies? And second, what education strategies have you found effective in risk areas?

Dr. Alimi
Let me start with the second one — education. In simple terms: you need to contextualize risk communication. Risk is only meaningful based on how it's understood. We try to communicate in local languages — Africa has over 2,000 languages. Local communication matters the most.

For example, how do I explain to a grandmother in a remote part of Togo what she needs to do to prevent an influenza outbreak, even if she raises chickens and eats eggs? The best educational material is what can be understood: local languages, simple concepts.

Often we overcomplicate things with science . We try to make it as simple as possible. Effective communication is simple communication.

Finally, we use action-oriented education. We can say, "AMR will kill millions." But what does that mean to someone who isn't a doctor? What can they do? What's their responsibility?

We want people to see the risk and immediately understand the action they can take. What should a farmer do to reduce climate impact? So, education must be action-based.

Now for the first question — how can governments ensure local communities are truly involved?

The OHHLEP One Health definition includes all sectors of society. When governments use this lens, they realize it's not just about inviting ministries to a workshop. It's about including religious leaders, community health workers, youth, farmers, market women — real community representation.

If the interventions are co-created with the community, they're more likely to be implemented successfully. The community understands the value, feels ownership, and becomes committed to supporting the interventions.

Interviewer :
Thank you very much. I have a more broad-based question. How do farming, food security, and AMR go together in the African context, particularly at the community level?

Dr. Alimi
That's an important but very broad question. AMR and food security are two different subject matters.

Africa CDC doesn't work directly on food security — the AU has another agency that supports food security, nutrition, and agriculture. So we don't take on everything One Health-related.

However, on AMR, we follow the Global Action Plan, and countries have their own national action plans. All of them include awareness and education as a key area. You'll see that reflected from the very first page of any national AMR action plan.

And even within AMR, the messaging to a farmer is different from what you'd give to a doctor or someone in the pharmaceutical industry. It's not one-size-fits-all.

But the summary is: we need a One Health approach. A doctor may do everything right — prescribing antibiotics correctly — but if the farmer misuses antibiotics, or if industries dump them into rivers, everyone is affected. It's a holistic, collaborative approach.

Interviewer :
You also mentioned financing. How do we bring the financial/private sector into this conversation? How do we convince them that primary prevention is more economical than waiting for outbreaks?

Dr. Alimi
This is where knowledge generation is critical. We say One Health works — but if you look online, there's little economic evidence. We need to show the benefits using numbers: cost savings, DALYs, QALYs — anything that shows the real value of One Health.

At Africa CDC, we're working on economic analyses. For example, if a farmer runs a poultry farm of 10,000 chickens and spends $500 on vaccines and biosafety, they protect future profits of $10,000. But if they don't invest, they risk losing the full $15,000 value in case of an outbreak.

We need more data like this — cost-benefit analyses — to show why prevention is worth the investment.

Interviewer :
How do we balance economic development and zoonotic disease prevention in countries where high-risk practices are essential to livelihoods ?

Dr. Alimi
Again, it comes down to value. You don't need to choose between livelihoods and safety — you need to show people the value of doing things safely.

Back to the poultry example — show the farmer that for a $500 investment in biosafety, they protect $10,000 in profits. It's not about saying "don't raise chickens" — it's about helping them run a sustainable farm.

It's about explaining risks and solutions in a simple, logical framework. The same approach applies to a school child, a dentist, or a patient.

Interviewer :
What mechanisms should be established at the international level to mitigate the gaps in prevention capabilities between high-income and low- and middle-income countries?

Dr. Alimi
That's a very political question. One Health is not just a discipline, it's a way of life, an approach. Many global equity issues come up here: technology transfer, access to vaccines or diagnostics, pathogen sharing, etc.

In AMR, the big debate is technology transfer of new antibiotics. In zoonotic diseases, it's more about pathogen access and surveillance data.

But what's fundamentally missing is global evidence. We've had COVID-19, Ebola, Marburg, influenza — all zoonotic — and yet we don't have consolidated global evidence that One Health works. We don't have a platform or set of case studies that the world can point to and say: "this is why this model works."

So regardless of income level, we need global generation of that evidence. Something countries can reference — whether they're in Russia, Peru, Ghana, or Switzerland — to see the value of a One Health approach in pandemic prevention.

Research has positioned itself well on the global agenda. One Health has not — because we don't yet have that solid, visible evidence base.

Interviewer :
How do we sort that out? How do we finally get the data to prove that the One Health approach is effective?

Dr. Alimi
Generation of evidence. I led many COVID-19 responses. I have institutional memory. I can tell my children that One Health works — but where is the written proof?

Where do countries that weren't involved in the outbreak response go to see those models and replicate them?

We need publications, case studies, cost-benefit analyses, operational research — all showing that One Health works. Especially in LMICs. We need to document this better.

Interviewer :
During COVID-19, people adopted practices like handwashing, cooking food properly, and social distancing — but once the crisis ended, many reverted to old habits. How can we make preventive behaviors stick long-term?

Dr. Alimi
This brings us back to anthropology and social behavior. One Health isn't just about three sectors — it includes behavior change.

We as experts are good at giving people information. But information alone doesn't lead to action. We're often terrible at driving actual behavior change.

That's why we need anthropologists and social scientists. Why don't people keep washing their hands after a pandemic? Often, it's not because they don't want to — but because they can't. In LMICs, over 60% of people don't have access to clean water.

There are structural barriers. We need interventions to address those. We need to work with the community, understand their context, and design solutions that work. This is where social science is essential.

Interviewer :
Can you tell us why Kenya is often cited as a leader in One Health — particularly in cross-sector collaboration and institutionalization of the approach?

Dr. Alimi
Thank you. Just to clarify: I wouldn't say Kenya is "at the top" of One Health globally, because that would imply excellence across all thematic areas — AMR, zoonoses, food safety, climate, etc. That's rare.

But Kenya's Zoonotic Disease Unit (ZDU) is a very strong model. It was jointly established by the Ministries of Health and Agriculture, recognizing the importance of agriculture and frequent Rift Valley Fever outbreaks.

What makes it effective is that both ministries contribute leadership, resources, and decision-making. It's not just a unit inside one ministry — it's truly cross-sectoral.

This model works well under certain governance types. In Tanzania, for example, One Health leadership sits in the Prime Minister's Office — decisions are faster, and no ministry can opt out.

Nigeria's coordination platform sits at the Presidency and includes technical working groups for AMR, zoonoses, etc.

What all these models share is political buy-in. When leadership is at the top — presidency, prime minister, or ministerial level — operations become easier, and coordination happens more smoothly.

Interviewer :
That's interesting because I thought top-level leadership would make things more bureaucratic and slow. Why is the opposite often true?

Dr. Alimi
Why do you assume it creates more bureaucracy?

If I'm a technical officer in the agriculture sector and I want to collaborate with health, I have to report to my head of department, who reports to a director, who goes to the permanent secretary, and maybe then to the minister. That takes time.

But if a directive comes from the permanent secretary or a high-level office, coordination happens much faster. So top-down approaches can actually accelerate decision-making.

That said, this isn't one-size-fits-all. In some countries, bottom-up models work. It all depends on the context — governance structure, culture, administrative systems.

Bangladesh, for example, has a different model led by a coordinating agency. In some places, universities lead One Health networks. The UK, EU — they all have different models.

What matters is understanding your context and identifying what works best there. There's no perfect model — but many good practices we can learn from and adapt.

Dr. Nitish Debnath : Expert in tropical veterinary medicine, virology, and the One Health approach. President of One Health Bangladesh and member of the OHHLEP

Interviewer: Dr. Debnath, you've mentioned the Theory of Change in relation to One Health initiatives. Could you elaborate on what this entails, particularly in the context of Bangladesh?

Dr. Debnath: The Theory of Change for One Health in Bangladesh focuses on three key pathways: Policy and Legal Frameworks, addressing financial and legislative support; Governance Structures, fostering organizational collaboration and effective oversight; and Data Management, enhancing data sharing, utilization, and actionable insights. These interconnected pathways collectively strengthen One Health implementation.

Interviewer: Regarding urbanization, there's debate about its role in increasing zoonotic disease risks. What's your perspective?

Dr. Debnath: Urbanization indeed poses significant challenges. In densely populated cities like Dhaka, the close proximity of people facilitates easier transmission of diseases. The convergence of individuals from various backgrounds in limited spaces, coupled with the movement of goods and animals, creates a conducive environment for disease spillover.

For instance, live bird markets in urban areas act as sinks, bringing poultry from across the country into one location. This not only increases the risk of avian influenza but also serves as a surveillance point to understand disease behavior nationally.

Moreover, urban settings often grapple with inadequate infrastructure, such as poor drainage systems and water supply issues, further exacerbating health risks.

Interviewer: What specific steps has Bangladesh taken within its One Health Strategic Framework to address urbanization-related challenges?

Dr. Debnath: Recognizing the limitations of a solely national-level approach, we've expanded our governance structures to include local entities. This involves integrating city corporations, municipal bodies, and local governments into our One Health governance system.

We've proposed establishing One Health hubs at divisional levels, ensuring engagement from all relevant partners. This decentralized approach allows for tailored interventions that address specific urban challenges, such as vector control, sanitation, and public health education.

By involving stakeholders directly responsible for implementing health measures, we aim to create a more responsive and effective One Health system that reaches from national policymakers to community members.

Interviewer: In your opinion, which practices present the highest risk for zoonotic disease spillover at the human-animal-environment interface? Is globalization the primary driver, or are there other significant factors?

Dr. Debnath: It's challenging to prioritize one over the other, as both globalization and local practices contribute to spillover risks. Globalization facilitates rapid movement of people and goods, potentially spreading pathogens across borders swiftly. The COVID-19 pandemic exemplified how quickly a disease can become a global issue.

However, local factors, such as urbanization, deforestation, and wildlife encroachment, also play critical roles. These practices disrupt natural habitats and increase human-animal interactions, creating opportunities for disease transmission.

Therefore, while we must be cognizant of global dynamics, it's imperative to act locally. Implementing preventive measures at the source, enhancing surveillance, and promoting sustainable practices are essential components of our One Health strategy.

Interviewer: Dr. Debnath, could you explain how deforestation and habitat changes contribute to the transmission of zoonotic diseases like the Nipah virus in Bangladesh?

Dr. Debnath: Certainly. In Bangladesh, deforestation disrupts the natural habitats of fruit bats, the primary reservoirs of the Nipah virus. As their habitats shrink, these bats move closer to human

settlements in search of food, increasing the risk of virus transmission to humans. This is particularly concerning during the winter season when date palm sap is harvested—a delicacy in our culture. Bats often lick the sap collection sites, contaminating the sap with the virus. When people consume this raw sap without boiling, they risk infection. This situation underscores the direct link between environmental changes and zoonotic disease spillovers.

Interviewer: Given these challenges, how do prevention strategies in Bangladesh address such issues?

Dr. Debnath: Our prevention strategies are multifaceted. Public awareness campaigns educate communities about the risks of consuming raw date palm sap and the importance of boiling it before consumption. We've also promoted the use of physical barriers, like bamboo skirts, around sap collection areas to prevent bat access. Additionally, surveillance systems have been strengthened to detect early signs of outbreaks, and healthcare facilities are trained for prompt response. These measures are part of our broader One Health approach, which recognizes the interconnectedness of human, animal, and environmental health.

Interviewer: How receptive has the government been to implementing One Health strategies, especially when it involves scaling back certain economic activities for long-term health benefits?

Dr. Debnath: The government has shown increasing commitment to One Health principles. For instance, we've successfully advocated for mass dog vaccination programs to control rabies, leading to a significant reduction in cases. Regarding antimicrobial resistance, the government has banned the use of critical antibiotics like colistin in agriculture. These decisions often require presenting clear evidence of long-term benefits outweighing short-term economic gains. By demonstrating how preventive measures can save lives and reduce healthcare costs, we've been able to influence policy decisions positively.

Interviewer: Engaging local communities is crucial. How do you ensure their involvement and compliance with health recommendations, especially when it affects their traditional practices or livelihoods?

Dr. Debnath: Community engagement is at the heart of our strategies. We work closely with local leaders, healthcare workers, and educators to disseminate information in culturally appropriate ways. For example, in promoting safe sap consumption, we respect traditional practices while emphasizing health risks and preventive measures. When advocating for reduced antibiotic use in livestock, we provide farmers with alternative practices and support to maintain their livelihoods. Building trust through consistent communication and demonstrating tangible benefits encourages communities to adopt healthier practices.

Interviewer: Are there any economic frameworks or research initiatives in place to support these One Health strategies and convince policymakers of their efficacy?

Dr. Debnath: Yes, we've incorporated economic assessments into our One Health strategy documents. These assessments evaluate the cost-effectiveness of preventive measures versus the expenses incurred during outbreaks. By quantifying the economic impact, we provide policymakers with compelling arguments for investing in prevention. Additionally, ongoing research initiatives aim to generate data on disease patterns, risk factors, and the effectiveness of interventions, further informing policy and practice.

Interviewer: Finally, what are the key challenges and opportunities you foresee in advancing One Health initiatives in Bangladesh?

Dr. Debnath: One of the main challenges is ensuring sustained collaboration across sectors and maintaining political will. However, the increasing recognition of the interconnectedness of health issues presents an opportunity to strengthen these collaborations. By continuing to generate evidence, engage communities, and advocate for integrated approaches, we can build a resilient health system that protects both people and the environment.

Interviewer: Dr. Debnath, in your opinion, what are the most significant challenges right now for implementing strategies to prevent zoonotic diseases?

Dr. Debnath: There are several challenges I'd like to highlight. Firstly, cultural issues play a significant role. We're accustomed to a siloed approach, and while collaboration sounds appealing in theory, it's challenging in practice. There are cultural divides and resource divisions that make institutionalizing One Health across all levels, especially in the domains we're advocating for, quite difficult.

These silos have been built over a century, and now we're realizing that this isn't the right approach. Breaking these barriers isn't easy because financial systems and legal frameworks are already established in a certain way. We're advocating for change, emphasizing that without addressing these issues, progress is hindered.

To move forward, we need engagement at three levels: a whole-of-society approach, a whole-of-government approach, and a global approach. One Health must be a strong component of global health security. The current global situation, such as the challenges faced by the U.S. government, influences not only the U.S. but also affects funding and activities worldwide.

We're in a difficult time, but we can't give up. For our survival, we must adhere to these basic principles. Implementing a whole-of-government approach isn't easy. It's effective during emergencies but not always sustainable.

In the context of Bangladesh, there are positive examples, like our disaster management systems. Society has established mechanisms that work during crises, and people collaborate effectively during emergencies, pandemics, or epidemics. We need to expand such activities broadly.

At a micro level, we must adopt system thinking. We strongly advocate for influencing the government and educational systems to engage the younger generation in system thinking. It's essential to understand that issues aren't isolated; they encompass human, animal, and environmental health, including biotechnology and antibiotics.

Interviewer: Could you provide an example of a cultural issue that poses a challenge?

Dr. Debnath: Certainly. As a veterinarian, I have my professional culture, and veterinarians often feel comfortable interacting with fellow veterinarians. They might be reluctant to engage with professionals from other fields. However, to address complex problems, we must foster a culture that encourages thinking outside the box.

Identifying common grounds is crucial. We need to create environments where professionals from different sectors can come together, stepping out of their comfort zones. This involves introducing new educational approaches and opening the minds of young people to interact with diverse groups.

Technology can facilitate cross-sectoral and interdisciplinary approaches. Disciplinary research and education are gaining attention among academicians, and we must leverage this trend.

Interviewer: Do you believe education will play a significant role in prevention in the future, both at the academic level and lower levels?

Dr. Debnath: Absolutely. We need to approach education through three avenues: informal education across all platforms, formal education at tertiary, primary, and secondary levels. While we already engage in education traditionally, it's time to adopt a more holistic approach.

This requires developing educational curricula that encourage crossing boundaries and acquiring STEM competencies and skills at various levels. Transformational educational thinking is necessary to achieve this.

Interviewer: Do you think the private sector has a major role to play in this?

Dr. Debnath: Yes, the private sector is crucial. In Bangladesh, we're engaging the private sector at both the farming and diagnostic levels. For instance, we collaborate with Farmers Associations to promote economic development and biosecurity on farms.

We're also working with private health service providers, especially in diagnostics, to share data on antimicrobial resistance (AMR). By bringing this data to a common platform, we can inform people about effective antibiotics, thereby addressing resource challenges.

The private sector needs support from us, and we recognize that they are important stakeholders in this process, starting from the farming community to pharmaceutical diagnostics and health service providers.

Interviewer: How can we involve the private sector and convince them, considering they often prioritize their own benefits?

Dr. Debnath: The private sector often seeks funding and is enthusiastic about data sharing, especially in hospitals and diagnostics. They require regulatory support and strive for business excellence. By advocating for better services and attracting people, they can enhance their tertiary hospitals and service centers.

However, there are business challenges, such as the lack of profitability in developing new antibiotics. In such cases, public-private partnerships are essential. The government needs to support these initiatives, and the private sector must collaborate. We need to foster a culture that encourages such partnerships to address the new challenges we face.

Interviewer: What institutional frameworks should governments establish to effectively prevent future pandemics? What should be the priorities?

Dr. Debnath: Cross-sector coordination is vital for governance. During the COVID-19 pandemic, the government had positive experiences with such coordination. However, these efforts often fade post-emergency. We must advocate for permanent systems that facilitate dialogue and collaboration.

Governments already engage in such practices in other areas, recognizing the need for support from various actors to solve complex problems. Advocacy should target three levels: politicians, who can understand and support public benefits; professionals, who can provide evidence; and institutional frameworks that practice problem-solving.

During COVID-19, we observed human samples being sent to animal health labs, a practice previously uncommon. This experience highlights the potential for cross-sector collaboration, and we must continue to build on it through global, national, and community approaches.

Interviewer : Bangladesh has been implementing the One Health approach to address health challenges at the human-animal-environment interface. Could you elaborate on the goals the country aims to achieve in the next five years through this strategy?

Dr. Debnath: Over the next five years, our primary goal is to enhance community-level engagement in health prevention. We plan to decentralize our coordination mechanisms, ensuring that community members actively participate in health initiatives. This involves fostering cultural changes and increasing awareness about health practices. To support this, we are establishing platforms like "One Bangladesh," a civil society organization that unites professionals and activists across sectors. Additionally, the "One Health University Network" will promote multidisciplinary research, and the "One Health Young Voice" will involve students in advocacy efforts. We also aim to implement community-based organizations focusing on education, participation, and awareness to drive cultural and attitudinal changes toward preventive health practices.

Interviewer : Food security is listed as a component of the One Health Strategic Framework for Bangladesh. What steps are being planned to address this issue in the coming years?

Dr. Debnath: Food security is indeed a critical concern within the One Health framework. Bangladesh's unique geographical location, bordered by India and traversed by various water bodies, presents both opportunities and challenges for food security. Our approach involves a multidisciplinary strategy that addresses health, environmental, and security aspects. We are focusing on enhancing governance, improving surveillance systems, and strengthening laboratory capacities to monitor foodborne diseases. Collaboration across sectors is essential to ensure that our food systems are secure and that the population has access to safe and nutritious food.

Interviewer : Regarding data collection and evidence-based policy-making, do you believe the current data are sufficient to support public policies at global, national, and local levels? What are the main data gaps?

Dr. Debnath: There is a recognized scarcity of comprehensive data at all levels. To address this, we are emphasizing data management, analysis, and sharing. At the national level, we have developed publicly accessible platforms like the genetic disease data dashboard, promoting transparency and encouraging data sharing among professionals. However, challenges remain in data sharing due to negligence or bureaucratic barriers. We are actively working to overcome these obstacles by advocating for open data policies and fostering a culture that values data sharing. This approach is crucial for informed decision-making and effective policy development.

Interviewer : Can you provide more details about the initiatives aimed at collecting intelligence about animals in Bangladesh?

Dr. Debnath: We have established the "One Health Secretariat," which serves as a central hub for collecting and analyzing data related to animal health. This initiative involves collaboration with various stakeholders, including government agencies, non-governmental organizations, and community-based organizations. By integrating data from multiple sources, we aim to enhance our understanding of animal health trends, identify potential risks, and implement proactive measures to prevent zoonotic diseases. This comprehensive approach ensures that we address health challenges at the human-animal-environment interface effectively.

Interviewer : Reflecting on Bangladesh's journey with the One Health approach, what milestones can you highlight, and how have they contributed to the current health landscape?

Dr. Debnath: Since 2008, Bangladesh has made significant strides in institutionalizing the One Health approach. In 2012, we developed the National One Health Strategy and Action Plan, endorsed by key ministries. This led to the establishment of governance structures like the Inter-Ministerial Steering Committee and the One Health Secretariat in 2017, ensuring coordinated efforts across sectors. Our active participation in regional collaborations, such as the One Health Joint Plan of Action Workshop in 2024, has further strengthened our approach. These milestones have fostered a culture of collaboration, leading to improved surveillance, response mechanisms, and a more integrated health system.

Interviewer : Given the emphasis on evidence-based decision-making, how is Bangladesh leveraging data to inform health policies and interventions?

Dr. Debnath: Bangladesh is committed to enhancing data collection and analysis to inform health policies. We've established platforms like the genetic disease data dashboard to make data accessible to both professionals and the public. This transparency encourages informed discussions and policy formulations. However, challenges in data sharing persist due to various barriers. To address this, we are advocating for policies that promote open data sharing and are working to build trust among stakeholders. By improving data accessibility and collaboration, we aim to strengthen our health policies and interventions.

Interviewer : Looking ahead, what are the key priorities for Bangladesh in advancing the One Health agenda, and how can international partners support these efforts?

Dr. Debnath: Our key priorities include enhancing community engagement, strengthening data systems, and expanding the scope of the One Health approach to address emerging health challenges. We recognize the importance of involving communities in health initiatives and are working to empower local leaders and organizations. Improving data systems is crucial for informed decision-making, and we are investing in technologies and training to bolster data collection and analysis. We also aim to broaden the One Health approach to encompass new areas such as environmental health and non-communicable diseases. International partners can support these efforts by providing technical expertise, facilitating knowledge exchange, and supporting capacity-building initiatives. Collaborative efforts will be essential to address the complex health challenges of the future.

Mr. Neil Vora : senior advisor for One Health at Conservation International :

Interviewer: We already know a bit about you, but feel free to introduce yourself and tell us more about your background and current work.

Mr. Vora: Sure. I'm a medical doctor. I still see patients in a public tuberculosis clinic in New York City. Most of my work is as Executive Director of the Preventing Pandemics at the Source Coalition and as a Senior Advisor for One Health at Conservation International. I do a mix of research, policy, and public communication.

Interviewer: I came across something interesting during my research about you. In 2020, you were asked by the New York City mayor to lead the city's COVID-19 contact tracing program. Could you tell us more about that?

Mr. Vora: Of course. Before my current work, I spent almost a decade at the US Centers for Disease Control and Prevention (CDC), responding to outbreaks globally. I worked on Ebola in West and Central Africa and led a team investigating a newly discovered virus related to smallpox in Georgia. In 2020, New York City was hit hard by the first wave of COVID. After the wave passed, we shifted from mitigation to suppression strategies. One key strategy was contact tracing, and the mayor asked me to lead the program.

We hired over 3,000 people and traced more than 700,000 affected New Yorkers. We contacted every identified case through surveillance systems and asked them to voluntarily isolate. We provided food deliveries, walked dogs if needed, and sent care packages. We also contacted their close contacts and asked them to quarantine, offering the same support. It was a comprehensive response. It was challenging but necessary, and though it's hard to do contact tracing for a virus like COVID, we believe it was a useful strategy at the time.

Interviewer: Is this kind of contact tracing still being used in the US for other diseases?

Mr. Vora: Yes, for certain diseases. We're no longer doing contact tracing for COVID, but we still do it for diseases like gonorrhea, syphilis, HIV, tuberculosis, and measles. It really depends on the disease.

Interviewer: Thank you. Just so you know, you're our last interview for this project. We've prepared a few questions that we hope can help fill some gaps from earlier interviews. Let's start.

One major recommendation from previous experts was the urgent need for more data and research demonstrating that the One Health approach and prevention efforts are effective. Many studies rely on localized case studies, limiting broader applicability. What kind of studies or methodologies do you think are most urgently needed to strengthen the evidence linking human activities to spillovers?

Mr. Vora: It's difficult to study spillovers. They occur frequently, though most don't lead to pandemics. We understand several drivers—land use change (like deforestation), commercial wildlife

trade, and unsafe farming practices. But high-risk areas often lack robust surveillance systems. Even in wealthy countries like the US, where avian flu is spreading, it's still hard to monitor spillovers and transmission.

Because surveillance is limited, it's hard to measure the effectiveness of prevention interventions. Ideally, we'd use randomized trials, but that's complicated. So we rely on lower-quality evidence. Still, we already know enough to say it's possible to reduce spillover risk.

It's not an either/or approach—primary prevention or pandemic preparedness. We need to invest in multiple strategies, because none are perfect alone.

One useful strategy is to highlight co-benefits—interventions to prevent spillovers also help with climate change and biodiversity protection. Emphasizing these co-benefits increases the efficiency of investments, which is critical in a resource-constrained world.

Interviewer: Thank you. I have a follow-up. You've spoken about deforestation. Are there specific types of deforestation that contribute more to spillovers? Are some aspects of it more controllable?

Mr. Vora: Multiple pathogen systems show deforestation contributes to outbreaks: Ebola, malaria, Hendra virus, Nipah virus. There are at least four mechanisms linking deforestation to spillovers:

1. **Edge creation**: Deforestation creates edges where humans and wildlife interact—essential for spillover.
2. **Biodiversity loss**: Specialists die off; generalist species like rodents and bats survive and often carry zoonotic pathogens.
3. **Animal stress**: Like humans, stressed animals are more susceptible to illness and can shed more pathogens.
4. **Climate change**: Deforestation drives climate change, which itself increases spillover risk.

That's why forest protection is critical—not just to prevent pandemics but for biodiversity, climate, and cultural reasons (especially for Indigenous communities). Good research by Raina Plowright in Australia on Hendra virus shows that targeted tree restoration can help reduce spillovers. We need more such research, but we already have enough evidence to act.

Interviewer: So would you say that preventing deforestation for zoonotic spillover prevention alone isn't enough to convince governments or companies? Do we have to emphasize climate and biodiversity co-benefits?

Mr. Vora: Exactly. We've known for decades that forests matter for climate and biodiversity, yet deforestation continues. We've relied too much on a small group of forest guardians. To change that, we need to broaden support by showing the different reasons forests matter—for climate advocates, for health professionals, for biosecurity experts.

In public communication, the message must be tailored to each audience—but always grounded in science. This approach is especially important today, when governments are cutting budgets. Emphasizing multiple benefits can help justify the investments.

Interviewer: That makes sense. Speaking of climate change, our research showed that climate can interact with other drivers—like deforestation, urbanization, etc.—to increase disease risks. Over 1,000 pathways have been documented. Are there specific mechanisms of climate-related transmission that are underestimated?

Mr. Vora: Yes. Over 50% of known infectious diseases are exacerbated by climate change. Zoonotic spillovers increase because animals move toward more hospitable areas—often human-populated—creating interfaces for transmission.

But beyond zoonoses, climate change also increases foodborne illnesses (due to spoilage), waterborne diseases (due to floods disrupting sewage systems), and even fungal diseases.

I wrote a New York Times op-ed on fungal pathogens. The show *The Last of Us* is fictional, but based on a real fungal pathogen in insects. While that scenario is unlikely, climate change may select for fungi that survive at higher temperatures, possibly adapting to human body temperature.

There's a Candida species recently detected that may have emerged due to climate change. Fungal diseases can be devastating, as seen in amphibian extinctions and bat die-offs from chytridiomycosis and white-nose syndrome. These are hard to prevent, as many fungal pathogens spread environmentally.

Interviewer: Do you think fungal pathogens are underestimated by the scientific community?

Mr. Vora: Absolutely. Fungal threats are hugely underestimated. We tend to focus on viruses, but systemic fungal infections are serious. They're everywhere—you're breathing in spores right now. And antifungal medications are toxic because fungi are biologically closer to us than viruses. It's a big risk that doesn't get enough attention.

Interviewer: Are there any vaccines?

Mr. Vora: There's interest and ongoing research, but I'm not sure how far along we are.

Interviewer: A more general question: are there any examples where a single measure successfully addressed multiple interconnected drivers?

Mr. Vora: Let me share a few articles I co-authored that touch on this. Some interventions, like forest protection, can simultaneously address deforestation, biodiversity loss, and climate. You'll find more in the papers I just shared.

Interviewer: Which interactions between drivers or spillovers do you think are most underestimated?

Mr. Vora: Climate-health intersections are getting more attention, which is great. But I don't see enough on the link between nature and health—like biodiversity and health. We in the health sector are finally talking about climate, but not enough about nature.

Nature is essential. Climate change may kill millions, but we'll likely survive as a species. However, the ongoing mass extinction poses a much deeper existential threat. 96% of mammalian biomass is humans and our domestic animals. Only 4% is wildlife. We've lost 75% of wildlife populations in 50 years. Without nature, there's no future for humanity.

Interviewer: That's a good point. We've read a lot about biodiversity and spillovers, but you're saying the broader health sector still overlooks it?

Mr. Vora: Yes. People who work on spillovers already understand these links. But in mainstream public health, the conversation is still mostly human-centered. That's the problem.

Interviewer: We've also noticed that in governments, ministries of health are rarely connected to environmental ministries. How can we push governments to integrate planetary health and One Health?

Mr. Vora: Great point. The tripartite partnership (WHO, OIE—now WOAH—and FAO) existed for years without UNEP. Only in 2021 was UNEP added, forming the quadripartite.

That exclusion reflects the neglect of environmental dimensions. But good news: COP15 on biodiversity adopted a global action plan recognizing biodiversity as a determinant of human health. That's major. WHO is also drafting a pandemic agreement that includes One Health.

The key now is translating these global frameworks into national and local action—and that's where civil society and academic institutions like yours play a crucial role.

Interviewer: What's the main thing missing from the pandemic agreement in your view?

Mr. Vora: The language could be stronger on prevention and One Health. There are too many escape clauses—phrases like "if resources allow" or "if feasible" give countries room to avoid commitments.

But I'm glad the agreement is moving forward. It includes articles on One Health and prevention. If adopted at the World Health Assembly, it can evolve further through future protocols. It's a start.

Interviewer: There's also a big equity issue. Low- and middle-income countries face higher spillover risks but have fewer resources. What mechanisms should be established to bridge the gap?

Mr. Vora: Intellectual property and benefit-sharing are big issues. Many biological threats emerge in the tropics, but benefits (like vaccines or IP) go to the Global North. The treaty tries to address this by guaranteeing limited vaccine access.

But I'm not convinced it will fix the deep inequities. That's why primary prevention is key—it's equitable by nature. Preventing spillovers benefits everyone and has immediate local co-benefits like local cooling and biodiversity conservation.

Interviewer: But how do we convince governments—especially those in developing economies—to invest in primary prevention when their focus is on economic growth?

Mr. Vora: There are several reasons why primary prevention has been neglected. Public health professionals weren't traditionally trained to think ecologically. Funding cycles are short, aligned with elections. It's easier to show quick results from vaccines than from preserving forests.

That's why we emphasize co-benefits—climate, biodiversity, cultural—and build the evidence base. Our current economic model is extractive, but we're reaching tipping points. Some countries, like Guyana, are trying new models to generate income by conserving nature. We need mindset shifts. 20 years ago, few people talked about One Health. Now it's on the agenda—even in government. That's thanks to persistent advocacy.

Interviewer: How can governments incentivize the private sector to invest in spillover prevention?

Mr. Vora: The economic case is clear, but often overlooked due to short-termism. Carbon markets and biodiversity credits may help. Consumer demand is also powerful. Even without regulation, companies can change due to public pressure.

Interviewer: Do you think data is enough to convince people?

Mr. Vora: Data is essential, but not enough. We live in an age of misinformation. Even good vaccine data doesn't convince everyone. That's why we need storytelling, partnerships with artists, philosophers, and community leaders. Trust is built through stories, not just numbers.

Interviewer: Could you give a concrete example of that?

Mr. Vora: Storytelling doesn't come from policy—it comes from community leaders. Big institutions like WHO or CDC can't build trust alone. Community partnerships are essential. If the first interaction with public health is during a crisis, it's too late.

Take Ebola in West Africa: foreign experts told communities not to wash dead bodies, which conflicted with cultural practices. Only when community leaders were involved did the message resonate.

Interviewer: Are there examples of community-based zoonotic prevention that work? And common mistakes to avoid?

Mr. Vora: Wildlife trade is tricky. People have the right to access wildlife—hunting is common globally. The goal isn't to ban traditional practices but to ensure safety and offer alternatives.

Commercial trade is different. Selling live wild animals in urban markets—for fur or luxury—is unnecessary and risky. Policies to regulate this need to consider those economically affected and provide alternatives. Otherwise, it backfires.

Interviewer: Can the private sector play a bigger role?

Mr. Vora: Yes. Companies often respond to consumer demands. But some also take initiative without pressure. Both regulation and public advocacy matter.

Interviewer: What about civil society?

Mr. Vora: It plays a huge role—especially local community-based organizations. A strong, diverse civil society is crucial to ensuring all stakeholders are represented and engaged.

Interviewer: One last question: from your experience, what's the next big step in pandemic prevention?

Mr. Vora: I'm encouraged by the global momentum on primary prevention. But countries need tools to turn global agreements into national plans. That's where civil society comes in—translating frameworks into real action.

Interviewer: Do you see a big research gap?

Mr. Vora: Yes. Spillover prevention is underfunded and neglected. More research will help identify solutions. Most funding still goes to downstream measures like vaccines. We need more investment upstream.

Interviewer: Thank you so much. That was extremely informative.

Mr. Vora: Thank you. It was a pleasure.

List of abbreviations

-OH = One Health

-WHO = World Health Organization

-UN = United Nations

-WOAH = World Organization for Animal Health

-UNEP = United Nations Environment Programme

-AMR = Antimicrobial Resistance

-CAN = Community Action Network

-HPAI = highly pathogenic avian influenza

-ENM = Ecological niche modeling

-IPLCs = Indigenous Peoples and Local Communities

-IUCN = International Union for Conservation of Nature

-MCMs = multi-sectoral coordination mechanisms

-PPPs = Public-Private Partnerships

-OHNs = One Health Networks

-EU = European Union

-OHHLEP = One Health High-Level Expert Panel

-CITES = Convention on International Trade of Endangered Species

-FAO = Food and Agricultural Organization of the United Nations

-MEL = monitoring, evaluation and learning

-CDC = Centers for Disease Control and Prevention

-ZDU = Zoonotic Disease Unit

-MALF = Ministry of Agriculture and Livestock department

-MoH = Ministry of Health

-ZTWG = Zoonoses Technical Working Group

-COHUs = County One Health Units

-DVS = Directorate of Veterinary Services

-MOEF = Ministry of Environment and Forestry

-MOTW = Ministry of Tourism and Wildlife

-NZTC = National Zoonoses Technical Committee

-PESTLE = prevailing Political, Economic, Social, Technological, Legal and Environmental factors

-KABS = Kenya Animal Bio-Surveillance System

-MoHWF = Ministry of Health and Family Welfare

-MoOFL = Ministry of Fisheries and Livestock

-MoEFCC = Ministry of Environment, Forest, and Climate Change

-MOA = Ministry of Agriculture

-MoF = Ministry of Food

-LDC = Least Developed Countries

-OHSF = One Health Strategic Framework

-OHAT = One Health Assessment Tool

-GOB = Government of Bangladesh

-GMP = Good Manufacturing Practices

-HACCP = Hazard Analysis and Critical Control Points

-FETP = Field Epidemiology Training Program

-MOUs = memoranda of understanding

-JEE = Joint External Evaluation

-IHR = International Health Regulation