Zoonotic Diseases: Challenges, Stages, and Emerging

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Abstract - This study discovered compelling evidence connecting modern farming methods and intensified systems to the emergence and spread of diseases. To determine whether the net effect of intensified agricultural production is more or less favourable to disease emergence and amplification than if it were not used, however, would need knowledge beyond what is now accessible. Agriculture expansion encourages the encroachment of wildlife habitats, altering the ecosystem and bringing people and livestock closer to wild animals, their vectors, and the sylvatic cycles of potential zoonotic pathogens.

Keywords - Zoonotic diseases, Challenges, Stages, Emerging

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INTRODUCTION

Rudolf Virchow used the term "Zoonosis" (Plural: Zoonoses) in 1880 to describe the collection of illnesses that may be transmitted between humans and other animals in the wild. In 1959, the World Health Organization changed the way it defined zoonoses to include "those diseases and infections that are naturally transmitted between vertebrate animals and man." Only infections that can be shown to have spread from animals to people or that have strong circumstantial evidence to support this are considered zoonoses.

The Hendra virus, Nipah virus (NiV) (Chua K.B., et al., 2005), and many other emerging zoonotic viruses are exceedingly dangerous yet have minimal transmissibility in humans and non-reservoir animals, in contrast to many other agents residing and circulating in the human society. Numerous undiscovered agents have the potential to leave their wildlife reservoir and infect or kill other creatures, including people, without being noticed because they do not develop in their new host species. HeV would still be one of the undiscovered illnesses and parasites today if it weren't for the mechanical transmission of HeV among such a vast number of horses and people after the first epidemic.

ZOONOSES - AN INTERNATIONAL PROBLEM

In the past, zoonotic diseases have significantly hampered human advancement, particularly in cultures that placed a high priority on agriculture and the domestication of animals. Zoonoses, or animal diseases, are among the most pervasive and dangerous threats to humans. Worldwide zoonotic diseases exist and have no regard for national boundaries. The global economy and wellbeing are significantly impacted by disease importation, animal product import bans, foreign trade restrictions, and foreign animal migration. As a result, zoonoses are no longer a localised problem on a national scale. Effective zoonoses surveillance requires global observation. The globalisation of control activities has become more prevalent in academic, commercial, and societal contexts as the interconnections between nations have been mapped out. Zoonoses regulation is a priority for international organisations given the health and economic challenges that each nation faces.

- **Zoonoses- An emerging problem**

The significance of many zoonotic diseases has changed significantly over the past 20 years in some regions of the world due to ecological processes like urbanization, industrialization, and a decline in the number of people living in the so-called primary sector.

We can never predict what kind of challenge nature may present us with in an infinitely ecological cosmos. In the past two decades, a number of viruses that were previously believed to be human-only zoonoses have been revealed to be zoonoses, and numerous other human infections have been discovered in lower species as well.

- **Emerging zoonoses on the rise**

The advent of zoonotic diseases is beginning to get more attention. This growth is the result of both the broad dissemination of new zoonotic infections and our improved capacity to detect and identify agents. Technology improvements have improved our ability to detect and diagnose with better accuracy and scope. If a pathogen doesn't spread illness in large numbers, it could go undetected. For instance, if the initial 1994 epidemic hadn't been so pervasive and timely, the Hendra virus (HeV) that causes a fatal disease in Australia would never have been discovered. In only two weeks, twenty horses and two people were sick, leading government authorities and experts to conduct a thorough inquiry.

The majority of zoonoses do not spread from person to person directly, and it is rare for zoonotic agents to be transferred between species from the hosts of their natural reservoirs. But if spillover episodes grow, the chance of a highly transmissible, adapted virus arising would increase.

PREVENTION AND CONTROL

Depending on the particular pathogen involved, the best ways to stop the transmission of zoonotic illnesses may vary, however there are a number of basic practises that have been shown to work. Requirements for safe and sufficient animal care in the agricultural sector aim to lower the frequency of zoonotic disease outbreaks spread via consumables including dairy, milk, meat, and even certain vegetables. Standards for the safe distribution of drinking water and the disposal of waste, as well as environmental criteria for surface water, are essential for preserving a healthy ecosystem and guaranteeing public health. When zoonotic infections first appear, education programmes that encourage handwashing after contact with animals and other behavioural modifications may help to stop their spread in the community.

Antimicrobial resistance issues make zoonoses more difficult to prevent and manage. Antibiotics are often given to livestock raised for human consumption, which raises the risk that drug-resistant zoonotic illnesses may quickly spread throughout animal and human populations.

CHALLENGES OF MANAGING ZOONOTIC INFECTIONS

Globalization has led to a sharp rise in the flow of people, animals, and goods across international boundaries, which has aided in the spread of zoonotic diseases around the world. Given the prevalence of zoonotic virus epidemics in rural regions in the area, it is difficult to reach these isolated populations with public health services. Inadequate national capacity to plan, mobilise, and implement appropriate control measures in such settings, difficulties in dispatching teams for field investigation, inadequate sample shipment mechanisms, a lack of appropriate laboratory diagnostic facilities on-site or in-country, and inadequate laboratory diagnostic facilities are just a few of the reasons why the disease's detection and diagnosis were delayed. Nations that often encounter these diseases must engage in enhancing their subnational epidemic surveillance and response capabilities in order to properly detect these disease threats.

Many of the viruses that infect animals (most often wild animals) or animal products and then transfer to humans are known as zoonotic infections. Understanding these diseases' extra-human reservoirs is necessary to grasp the epidemiology of these zoonotic illnesses and to develop future prevention strategies.

Accountability problems still exist when it comes to the prompt reporting of newly discovered zoonotic diseases to the WHO or any other international organisation in charge of looking into and taking action in response to potential threats to the stability of the global health system. Health departments in a number of nations refuse to acknowledge human outbreaks, which prevents them from learning about epidemiology, disease transmission, and efficient treatments for specific diseases in various settings.

Under the "One Health" concept, which unites the human and animal health sectors by integrating the animal and human disease surveillance and response system, the absence of collaboration between the animal and human health sectors is one of the major challenges to effectively controlling zoonotic infections in the area.

Other obstacles to zoonotic disease prevention and control in Member States include inadequate monitoring and reporting procedures and a lack of laboratory capacity to diagnose emerging zoonotic diseases like SARS, Ebola, Marburg, and new influenza strains. Most countries' ability to respond locally is restricted by a lack of information, a scarcity of supplies, and ineffective and insufficient labour. Within the main economic sectors, there aren't many formalised methods for cooperation across sectors. Cooperation across Ministries of Health is lacking, and comprehensive data collection has been neglected. It may be challenging to get data and information about zoonotic disease outbreaks in agriculture (Veterinary Services). Effective community outreach and education on zoonotic illnesses are still lacking in the Area. Furthermore, there is a lack of consistency among the various public health regulatory frameworks. Either recent or no research has been done to treat diseases.

STAGE FOR ZOONOTIC DISEASES

In their most basic form, disease transmission networks are assemblages of interacting organisms. The simplest feasible system consists of a disease-causing pathogen and a single host species, such as humans; more complex systems may have a number of pathogens, many hosts, and/or arthropod vectors. The mechanism of zoonotic circulation allows infections to circulate among a variety of wild hosts; in rare instances, these diseases may "jump the species barrier" and infect humans, possibly leading to infectious outcomes. Environmental changes, such as those in temperature, topography, and zoonotic host and vector populations, have been proposed as potential catalysts for such shifts.

Environmental changes may affect zoonotic illnesses in a number of ways. To begin with, a change in the weather may have an immediate effect on the pathogen loads in hosts, for example, by altering immunocompetence. Second, changes in climatic or landscape characteristics may have an impact on the densities or species composition of host or vector populations. Third, changes in the environment or climate may have an impact on the frequency of interaction between zoonotic hosts, people, and vectors. For instance, Dearing and Dizney discovered that habitat alterations that decrease mammalian diversity enhance the frequency of hantavirus infection in deer mice (Peromyscus maniculatus) by raising intraspecific contact rates while lowering interspecific contact rates. In reaction to environmental changes, contact rates within and across groups may fluctuate. Fourthly, environmental pressures that alter the lifetime or movement patterns of environmental stages of vectors or hosts may have an influence on how often pathogen life cycles and hosts come into contact (zoonotic or human). There isn't enough concrete information to conclusively correlate certain environmental factors to modifications in diseases, vectors, or hosts. Numerous studies have examined the impact of climate on the geographical distributions, life cycles, or host populations of arthropod vectors. There is still a lot we don't know about how certain abiotic conditions, either directly or indirectly, effect zoonotic agents, despite the fact that others have described the host range (or biotic distribution restrictions) of zoonotic viruses.

Nearly every zoonotic disease is disseminated either directly from zoonotic hosts or indirectly via vectors that get infections from the reservoir animal and then distribute them to humans. For instance, several zoonotic helminths, protozoans, fungi, bacteria, and viruses may persist in soils and water bodies without zoonotic hosts or vectors and spread to humans years or even decades later. Environmental factors are only likely to have an influence on these illnesses' persistence (mortality) and transmission since, in the majority of instances, population formation and reproduction of these diseases only occur within hosts (movement). Beyond the little information available on the lengths of time some of these illnesses spend in their environments, nothing is known about the abiotic factors influencing persistence. Since abiotic factors may affect the development, growth, and demise of pathogens, hosts, and vectors, it is necessary to describe the specific activities of abiotic factors across all species involved in a disease transmission system.

- **An Outline of Distributional Ecology**

Ecologists utilise scenopoetic ecological niches to define the environmental tolerances that limit the geographic ranges of certain species. For the purpose of simplicity, these niches are also frequently referred to as climatic envelopes or abiotic niches. In disease systems, which are characterised by non-interacting, primarily abiotic variables including temperature, precipitation, and vapour pressure, pathogens, vectors, and hosts each inhabit different niches (Figure 1). Species richness may vary within these climatic ranges along environmental gradients that correspond to ideal and unfavourable conditions. The use of correlative ecological niche modelling at coarse spatial resolutions, which cannot discriminate between individual population dynamics and biotic interactions, has been a traditional approach for assessing the effects of climate change on species distributions. According to the Eltonian Noise Hypothesis, species interactions including competition, predation, and parasitism may occur at smaller spatial scales than the basic features of a species' geographic range. It is presumed that species' responses to climate change are "individualistic" since this option is not taken into account. Even at enormous geographical scales, however, species interactions may shape biotic ecosystems, and this is probably particularly true in disease transmission networks. As a consequence, the 'individualistic reaction' assumption fails to recognise important interdependencies across species. Recent studies on the subject have focused on finding techniques to quantify relationships between interdependent species using spatially explicit data, showing how biotic interactions affect species distributions beyond local limits.

The three factors that interact to produce a species' ranges are shown in Figure 1: I the abiotic conditions that allow persistence, such as temperature or moisture, the 'A' portion of the niche; (ii) the effects of other species, such as predators and competitors or mutualists, that either hinder or facilitate the focal species, the 'B' portion of the niche; and (iii) the capacity of the species to colonise new areas. The intersection of these three variables, known as the BAM diagram—a Venn diagram showing the interaction between biome, assemblage, and landscape—can be seen as the distribution of species over the planet. There are many different ways to arrange a BAM diagram, and each one has significant implications for the investigation of geographic and ecological distributions as well as the ability to recreate these characteristics. Species never fill the whole ecological niche's spatial footprint (A or AB), leaving suitable areas empty. This is due to the fact that species are always confined by an effect (M) that prohibits them from occupying the whole geographical range of an ecological niche.

A BAM diagram that shows the probable distribution of each interacting species of vectors, reservoir hosts, diseases, and humans may be used to see how each species involved in the transmission of a disease responds to its environment, other species, and dispersion obstacles (Figure 1). Abiotic variables in such systems influence the distributions of pathogen, vector, and hosts, triggering a web of interrelated processes that eventually emerge as the observable spread of diseases. The BAM diagrams may differ across species, regions, and environmental factors owing to scale effects, which increases uncertainty regarding the vector-host-pathogen system. The disease should only spread in circumstances when all of the species' BAM needs are satisfied, for instance if each species in the transmission chain has a distinctive sensitivity to its environment.

For this reason, for instance, the spread of the West Nile virus (WNV) is only possible in regions where all three of the following criteria are met: I a sufficient number of competent vectors are available; (ii) the pathogen is circulating; and (iii) a large population of susceptible hosts. If any of the abiotic requirements or biotic interaction requirements for the vector, host (in this example, birds), or pathogen are not satisfied, or if the site is inaccessible to any agent in the system, no transmission of WNV will take place (Figures 2 and 3 for the concept). For instance, despite the fact that North America has a population, sizable avian reservoirs, and vectors, mostly Culex mosquitoes, sustained WNV transmission has not occurred there since 1999. This occurs as a result of the disease's failure to cross the Atlantic Ocean. The same logic holds true regardless of the particular species that make up the disease transmission mechanism.

As a result, it is essential to analyse a species' BAM structure in order to understand its distributional ecology. Climate is the most common example, and recent study has shown that niches are best restricted to traits not influenced by populations of the species in issue. Joseph Grinnell initially proposed the concept of an abiotic niche over a century ago. These fundamental abiotic niches provide a starting point for the kinds of situations where the species might potentially support populations. The presence or absence of certain illnesses, prey, competitors, vectors, or hosts may be important interactions, but the abiotic niche does not take these effects into consideration (Figure 3). On the other hand, dispersal restrictions unquestionably determine the primary (coarsest) aspects of species' geographic distributions; seas, mountain ranges, and other significant geographic features restrict the widest aspects of distributions. At lesser sizes, dispersion or dispersal agents do not largely control range extension. For example, since ticks cannot fly, their long-distance dispersal depends on host movement. However, some tick species are transported from one location to another by animals with high mobility, such as birds or ungulates, and this could lead to the introduction of numerous ticks and the diseases they carry.

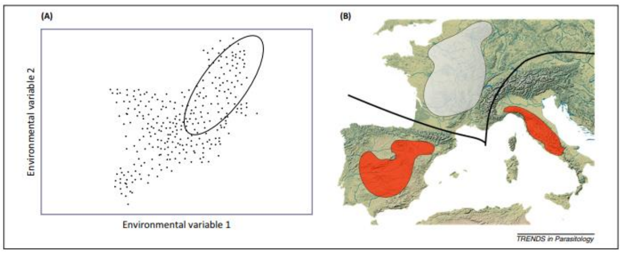

Figure 1: The relationships between abiotic niche and spatial distribution. Consider a large area in which two environmental variables (e.g., average temperature and total rainfall) are measured. The scatterplot (A) represents values of two variables at every site across the region of interest. The ellipse shows the abiotic niche of a hypothetical organism; this ellipse encloses the environmental conditions under which the organism can maintain populations. This ecological niche can be translated into the hypothetical spatial domain (B). These conditions may be found in scattered areas. Although in theory different areas are suitable, the organism may be found only in a subset of these (white) because geographic barriers to movement (black lines) prevent spread to other suitable areas (red)

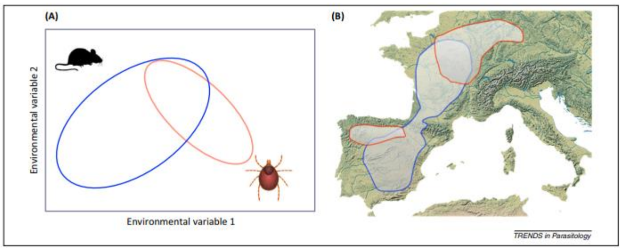

Figure 2: The species relationships in environmental and spatial domains. The space delimited by two environmental variables allows the description of the abiotic niche (A), and ellipses show the positions of both host and vector in the space delimited by these environmental variables. The two niches occupy distinct combinations of the two environmental variables, and their preferences overlap in some portions of the abiotic niche (points representing collection sites have been removed for clarity). When the abiotic niche is translated into a hypothetical spatial domain (B), the host and the vector may have contrasting distributions, resulting in spatial overlap only in some areas. The transmission of the pathogen to humans would be possible only at sites where both the host and the vector co-occur.

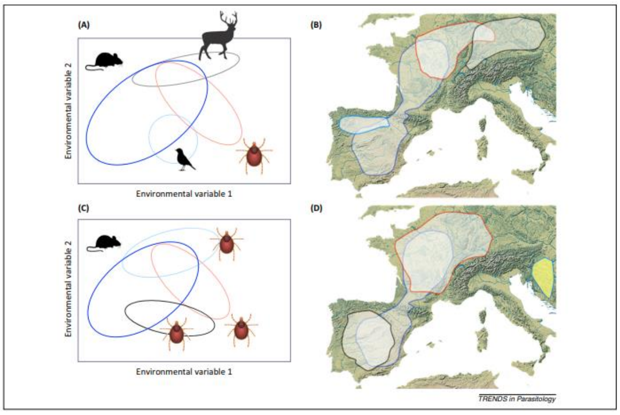

Figure 3: The disease systems with several interacting species. The figure represents a further complication of ideas explained in Figures 1 and 2, when several hosts (A, B) or several vectors (C, D) are involved in the zoonotic circulation of a pathogen transmitted to humans. In nature, disease systems may be associated with complex sets of host and vector species, and with distinct ecological niches. Several host species overlap in some portions of the environmental space (A). These host species may have a partially overlapping spatial distribution (B) where the potential for transmission of pathogens may be enhanced or diluted. In the same way, several vector species may partially overlap in the environmental niche (C) and hence occupy different areas. This may enhance the transmission of the pathogen at sites where several vector and host species exist (D). However, the translation of the abiotic space into geographic space may reveal the existence of species of vectors that do not overlap with other partners of the system (yellow ellipse in D).

EMERGING AND NEGLECTED ZOONOTIC DISEASES

Over the course of the 20th century, human and animal populations skyrocketed while natural ecosystems and biodiversity saw significant decreases. More than ever, the biophysical environment creates favourable circumstances for the transmission of diseases between domestic and wild animals to people, a situation known as zoonosis or zoonotic disease. As a result, there is a concerning continuation of untreated zoonotic infections in low-income areas of the world and a rise in food-borne zoonotic diseases globally.

75% of newly emerging infectious diseases and 60% of all infectious diseases that affect humans are thought to be zoonotic.

Human populations are affected by new infectious diseases every four months on average. Cattle often serve as a link in the cycle of transmission from animals to people, despite the fact that many infectious illnesses begin in animals. Intensively bred cattle may have a high degree of genetic similarity within a herd or flock because they are cultivated for production attributes rather than disease resistance, which reduces the genetic variability that supports resilience. Consider the transfer of the bird flu or avian influenza infections from wild birds to farmed chickens and, ultimately, to humans to highlight the significance of animals as "disease bridges." Zoonotic diseases are often attributed to human settlement, agricultural intensification, and invasions of forests and other habitats. To make matters worse, zoonotic illnesses often attack when their hosts are already under stress from the environment, culture, or economy around them.

In addition to endangering human and animal health, the development of zoonotic diseases also threatens environmental stability and the health of the economy. Recent media attention has focused on a few novel zoonotic diseases that have caused or threatened to create pandemics throughout the world. This list includes illnesses brought on by the avian flu, Ebola, MERS, Rift Valley fever, SARS, West Nile virus, and Zika virus. All members of the animal world may serve as long-term hosts for the infections that give rise to these diseases. Emerging diseases have cost the global economy more than $100 billion in direct costs over the last 20 years; if these outbreaks had turned into human pandemics, the losses would have reached several trillion dollars.

Another important group of zoonotic diseases that can be passed from animals to humans is caused by foodborne pathogens like Salmonella and Listeria bacteria. In the first-ever global evaluation of the issue in 2015, it was determined that the burden of foodborne illness was comparable to that of TB and malaria on a global scale.

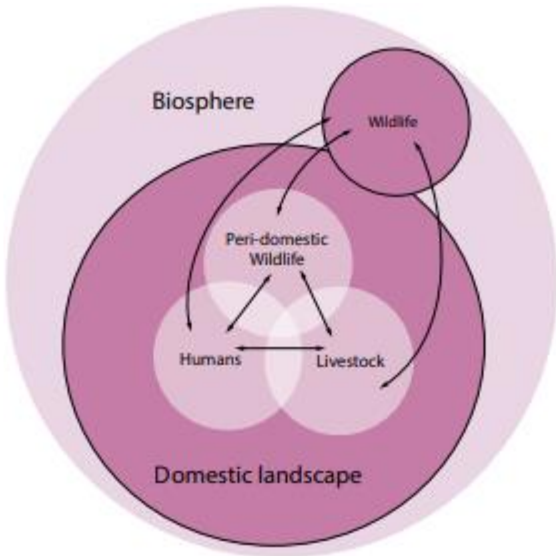

Figure 4: Pathogen flow at the wildlife–livestock–human interface

CONCLUSION

The study discovered compelling evidence connecting current agricultural methods and intensive systems to the establishment and spread of diseases. To determine whether the net impact of enhanced agricultural output is more or less favourable to disease onset and amplification than if it were not employed, however, would need more information than is now available. Agriculture expansion encourages the invasion of wildlife habitats, altering the ecology and putting people and cattle closer to wild animals, their vectors, and the sylvatic cycles of possible zoonotic infections.

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