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Development of Zoonotic Diseases at the Convergence of Wildlife-Livestock System: A Systematic Review

Dhananjay Kumar Yadav[1]*, Dr. Chhaya Agarwal[2], Bhuvana Jayabalan[3]
*[1]Assistant Professor, Maharishi School of Engineering & Technology, Maharishi University of Information Technology, Uttar Pradesh, India, Email Id- dhananjay.rishabh@gmail.com, Orcid Id- 0000-0002-8211-5252
[2]Assistant Professor, Department of Biotechnology, Noida Institute of Engineering and Technology, Greater Noida, Uttar Pradesh, India, Email Id- chhaya31jain@niet.co.in, Orcid Id-0000-0002-1227-619X
[3]Associate Professor, Department of Computer Sceince and Information Technology, Jain (Deemed to be University), Bangalore, India, Email Id- j.bhuvana@jainuniversity.ac.in, Orcid Id- 0000-0002-8372-6311

Abstract

Zoonotic diseases are a major danger in worldwide public health because they originate at the interface between animal and cattle systems. Effective disease control in cattle and poultry requires an understanding of the origins and hazards of infections. Since the human-animal interface is where the majority of illnesses originate, it is imperative to comprehend the unique processes and motivations at play to be ready for any future epidemics. The rise of zoonotic illnesses is attributed to interactions between livestock and wildlife systems, particularly about globalization, habitat degradation, fragmentation, as well as climate change. This comprehensive review investigates the complex mechanisms that contribute to the establishment and spread of zoonotic illnesses in the integration of wildlife-livestock systems. To monitor zoonotic illnesses, we want to determine the sources of infections in cattle and poultry to evaluate the risks of zoonotic transmission and implement One Health strategies. The research shows that a complex web of interrelated causes is causing zoonotic illnesses to emerge at the wildlife-livestock interface. There are many different sources of infections in livestock and poultry, from well-organized agricultural systems to wildlife reservoirs. The interdependence of these ecosystems presents zoonotic concerns that affect populations of animals and cattle alike. The relevance of bacterial and viral zoonoses in the context of wildlife-livestock systems is highlighted by the elucidation of disease transmission mechanisms. Here, we offer mitigation techniques for the danger of targeted diseases emerging or reemerging to stop epidemics in the future.

Keywords: Bacteria, Zoonoses, Infectious Diseases, Virus, Wildlife-Livestock System

INTRODUCTION

For thousands of years, humans, cattle and wildlife have coexisted. Due to factors such as exponential human population growth, increased global mobility, expanding human encroachment on wildlife habitat and a significant increase in organic waste, interactions between these three groups have become more frequent and intense, which has given rise to a variety of pathogens that have evolved to adapt to their environment (1). There is a continuum of new illnesses that impact populations of domestic animals, wildlife and humans, some diseases affect one group exclusively (2). One Health approach (OHA) is the phrase used to recognize and conceptualize this interdependence. It incorporates an unambiguous awareness of the strong interplay of animal health, ecosystem health and total human health (3). According to (4), livestock illnesses pose a danger to the economy and public health. The whole economic cost of cattle illnesses is not officially estimated, although it is known to involve indirect and direct costs to household income, private and public health along with agricultural productivity (5). Without accounting for ancillary expenses related to revenue losses and disease prevention, over 7.7 billion dollar is estimated to be the annual direct economic impact of production losses due to foot-and-mouth disease (FMD) globally (6).

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Additionally, domestic animals act as bridge species or reservoirs for zoonotic illnesses (7). Examples of this include domestic pigs in the case of the Nipah virus and domestic camels in the case of the coronavirus connected to the Middle Eastern Respiratory Syndrome (8).

Sources and Risks of Pathogens in Livestock and Poultry

Pathogens can be found in a wide range of animals, including confined and laboratory animals as well as cattle, wildlife and companion animals. Mammals raised on farms, including both big and small ruminants, pigs are referred as livestock. Chickens, ducks and geese are examples of poultry (9). Even though the term "livestock" covers a wide range of animals, uncommon species including ostriches, guineafowl, bison, elk, camels and dromedaries should be taken into account as potential sources of infection. Human communities depend on livestock together with poultry for a variety of products and services, including milk, meat, eggs, skins, feathers, fibers along with excrement, all of which carry a risk of infection. The food and agricultural organization's (FAO) definition of livestock can be used for nonavian livestock and poultry in this assessment, which is defined as farm domestic animals raised for local sales or subsistence, allowing them to interact with other species or supplying large quantities of animals to international markets after long-distance transports (10).

Zoonotic Challenges: Implementing the Effects on Livestock and Wildlife

The COVID-19 pandemic has brought attention to the possibility of zoonotic disease outbreaks and prompted measures to prevent them in the future. Many solutions have been put forth, most notably total prohibitions on the trade in wildlife and the holding of wildlife markets. However, some people believe that these solutions are unworkable that their implementation would address the issue by creating significant socioeconomic shocks and food insecurity (11). One of the most crucial resources for the impoverished to satisfy their demands for a living is livestock (12). Zoonoses and other animal illnesses are major obstacles to improve livestock production systems (13). Foodborne, zoonotic and transboundary illnesses have a detrimental effect on underprivileged communities and the national economy (14). In India, illnesses such as cystic echinococcosis and brucellosis have been known to cause enormous losses in the cattle industry (15).

Zoonotic diseases and OHA

The fundamental principle of this theory is the close relationship and interdependence between the environment, human health and animal health. Zoonosis is the term for any naturally occurring illness that can spread from vertebrate animals to people. Foodborne infections are those spread from animal to human by consumption of animal products like milk, meat, or eggs, as well as through direct contact with vectors carrying the pathogen. The threat posed by zoonotic diseases to public health is increasing due to a number of reasons, particularly those associated with livestock and poultry (16). A major problem in OHA is zoonotic infections, which are infectious agents that humans and animals get affected by the disease (17). Zoonotic disease development and reemergence have been impacted by changing conditions at the interface among animals, environment and the human's environment as a result of variables such as land use change, increased travel, climate change as well as trade (18, 19 and 20). Through optimizing resource allocation as well as improving the standard along with efficiency of healthcare delivery, an OHA can optimize zoonotic illness obstacle, organize initiatives and save lives (21, 22 and 23). Table (1) shows the significant number of newly discovered, highly consequential diseases that affect agricultural and public health have their origins in animals, such as birds, cows and wild pigs. Additionally, certain infections may or may not be contagious to humans and can be carried by animals asymptomatically.

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Table (1). Both livestock and wildlife impacted by Zoonotic disease and transmitted

(Source: Author)

Animals	Disease	Zoonotic disease	Disease transmission to people
Cow	Brucella abortus	True	Dairy products made without pasteurization
	Food and mouth disease (FMDV)	False	Illness not found in humans
Horses	Hendra virus	True	Taking care of injured horses
Goat	Brucella melitensis	True	Dairy products made without pasteurization
Pig	Brucella suis	True	Handling of animals and animal products

EVALUATION OF EMERGENCE RISK

The goal of risk evaluation is to integrate existing information to determine the probability and implications of an outbreak in a community. For a particular risk assessment, figuring out the size and location of the population of interest is crucial. Emergences can indeed have localized or global effects. Additionally, connections between animal along with human populations, as well as those between domestic animals and nature, differ throughout different components of the world (24). To prevent the distribution of illnesses to farm animals and to improve output, for example, a big compact of effort has been done in Europe over the past 60 years to restrict the contact between wildlife and livestock. However, more outside access and a higher risk of disease transmission are features of modern farm management practices (25). To take action to reduce transmission not between animals but also to people, risk assessment aids in estimating if the circumstances are present in states or areas. These techniques for risk evaluations can be used by health authorities to reduce the danger (26). An approach that is acknowledged and utilized by several authors and organization is used for risk assessment. It entails estimating the likelihood of the several scenarios that combine to produce a risk, such as the chance that the source would release a hazard and the probability that the population at risk will be exposed to it in the first place.

SPREAD OF ZOONOTIC DISEASES

Given the close link that exists between people and animals, it's important to comprehend the usual routes by which those ailments might be acquired. They can consist of:

Waterborne: Ingesting or emerging into contact with water contaminated by an animal's waste.

Foodborne: Every year, eating contaminated food makes one in six individuals sick. Eating or drinking unhealthy food or drinks, such as undercooked meat raw or eggs, milk, or uncooked crops contaminated with animal waste from a diseased animal. Consuming toxic food can make both people and animals including pets' ill.

Vector-borne: Sustaining an itch or bug bite, such as one from a flea or mosquito.

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Indirect contact: Coming into touch with surfaces or things that have been contaminated with germs, or places where animals reside and wander, is known as indirect contact. Pet food and water bowls are examples as well as habitats for animals such as henhouses, barns, water tanks in aquariums and plants.

Direct contact: Making physical touch with an infected animal's urine, blood, mucus, saliva, excrement or other bodily fluids. Bites and scratches are two examples, as well as caressing or stroking animals. Figure (1) depicts the transmission mode of zoonotic disease.

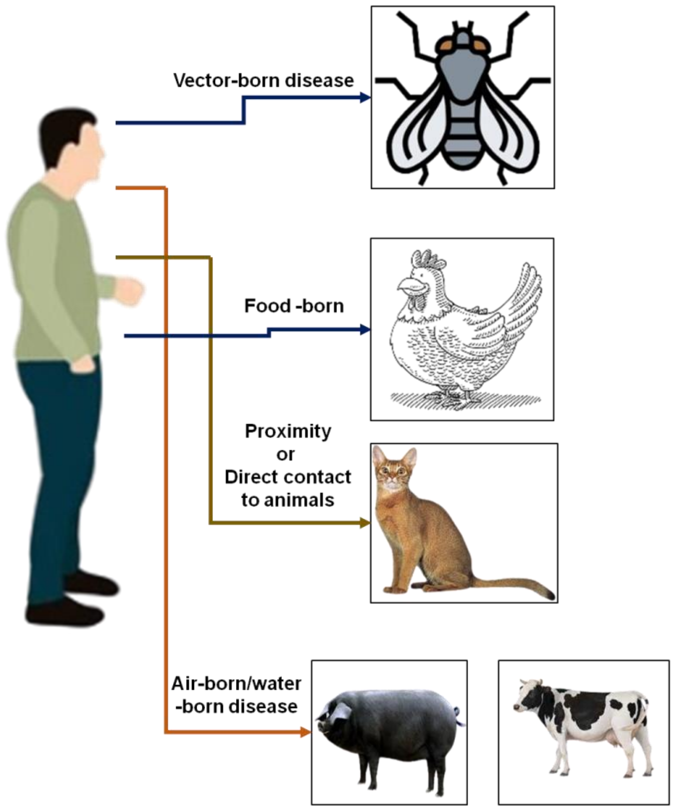

Figure (1). Transmission mode of zoonotic disease

(Source: Author)

Factors influencing zoonotic disease transmission in environments with animals

Equilibrium among the disease-causing agent, the vulnerable host and the environment that supports the host along with the agent is necessary for the effective development of illness in a host (27). Before establishing itself and initiating the illness, the agent needs to get past the host's physical, biochemical and immunological barriers. The host's genetic makeup, age, breed, species and sex are among the characteristics that determine whether they are resistant or vulnerable to an illness. An area's prevalent environmental characteristics, such as temperature, vegetation, rainfall, humidity, altitude and vector availability, can be the main cause of some zoonotic illnesses' geographic containment (28). The likelihood of disease transmission can rise if veterinarians and zoo employees neglect to use personal protective equipment during treatment, necropsy, cleaning the animal cages and practice poor hand hygiene (29). It was discovered that 16.8% of Indian wildlife veterinarians who participated in the study used for appropriate caution when working with wild animals, compared to almost 16.8% of respondents who took

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no safeguards at all (30). Out of the 54 veterinarians examined, 34 had received a preventive vaccination against rabies, according to the report. Given that wildlife veterinarians are more susceptible to contracting rabies, India leads the world in the number of human deaths from the disease. The survey results showing that 62.9% of respondents had received the vaccination that are concerning.

Types of zoonotic disease

An infectious illness called a zoonotic disease is one that can spread from animals to people. Contact with animals, their secretions or polluted settings can result in this transfer, either directly or indirectly. Health hazards to humans can arise from zoonotic illnesses that impact domestic and wild cattle. Figure (2) shows the types of Zoonotic disease. Below is a brief discussion of a few types of bacterial and viral zoonosis.

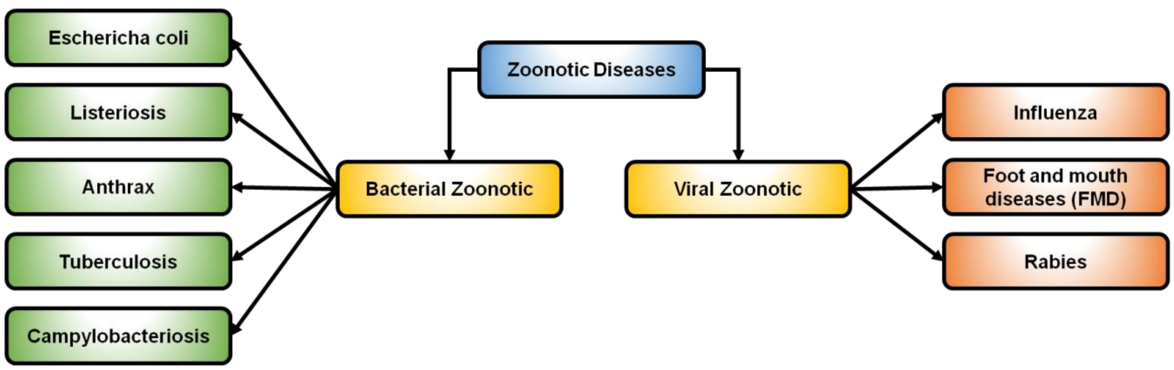

Figure (2). Categories of Zoonotic disease

(Source: author)

VIRAL ZOONOSIS

Foot and mouth disease (FMD)

According to (31), FMD is an extremely contagious sickness that can spread among vulnerable animals. In areas where FMD is not present, effective vaccinations can be used to control outbreaks. In studies, higher concentrations of nanobodies that are novel to a certain serotype have been combined with semiconductor nanocrystals and hydroxyl magnetic flux (32).

Rabies

The rabies virus is a kind of negative sense virus with RNA that belongs to the Rhabdoviridae family and causes the fatal neurological disease known as rabies in mammals (33). In the case of serious bleeding wounds, the WHO advises delivering the rabies vaccination in addition to local injection of human or horse rabies immunoglobulins to lessen the impact of the virus (34). The combination of vaccination and variable domain of Heavy chain of Heavy-chain antibody (VHH) has demonstrated a symbiotic response in protecting intralingual rabies infection models in rats. The virus is neurotropic, which means that once it penetrates the central nervous system, it is difficult to eliminate, which poses a major challenge to rabies management and treatment. Currently, the infection can be inhibited by chemicals that can penetrate nerve cells and the blood-brain barrier.

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BACTERIAL ZOONOSIS

Listeriosis

Listeria monocytogenes is the causative agent of listeriosis, an infectious bacterial illness (35). Food contamination is the main source of illnesses. Pregnant women, those with acquired immune deficiency syndrome (AIDS) as well as older persons are the main populations affected since miscarriages and preterm deliveries are the result.

Tuberculosis

A particular kind of bacterium is the cause of tuberculosis (TB), an infectious illness that affects the lungs (36). Mycobacterium tuberculosis is the bacteria that cause zoonotic disease. Although TB affects the lungs, it can also affect other bodily organs including the kidneys, brain and spine due to the bacterium. When an infected individual coughs, sneezes, or spits, the infection spreads via the air. Medication for tuberculosis includes isoniazid, pyrazinamide and rifampin (37).

Anthrax

Gram-positive, spore-forming Bacillus anthrax is the causative agent of anthrax and it is found in endemic areas of the soil (38). According to (39), anthrax is produced by poisons that contain virulence variables, edema factors and protection antigens. The effectiveness of llama-derived single-domain antibody (sdAb), genetic engineering and nanobodies in protecting mice against anthrax has been studied, promising results have been obtained.

Campylobacteriosis

The bacteria Campylobacter jejuni is the main cause of campylobacteriosis (40). This bacterium is present in birds without causing any symptoms. It is a significant cause of foodborne sickness, causing symptoms comparable to the stomach flu in people all around the world. The capability of VHH, a binding protein for Campylobacter jejuni, to enhance thermal and hydrolytic stability as well as to impede the bacteria's capacity to move through its flagella could have led to its isolation. This might prevent or reduce the bacteria's ability to colonize the stomach of birds. These VHHs might be useful as diagnostic and therapeutic tools.

Monitoring zoonotic diseases using the One Health approach (OHA)

Neglected tropical illnesses have contributed to the suffering of over 1 billion people living in impoverished and disadvantaged places worldwide. It is imperative to take prompt action to manage the zoonotic disease load via OHA (41). Currently, several international OHA have been utilized and implemented to support nations in achieving sustainable development goals (SDGs), adhering to international health regulations, managing common health threats and improving global health security. These initiatives help to facilitate and increase the capacity of the OHA. For instance, to anticipate, identify, address, prevent risks to global health as well as to advance sustainable development, the world health organization (WHO), world organization for animal health (WOAH) and FAO, United Nations Environmental Programme have worked combine to use the OHA. The WHO has released a historical OHA action accompaniment document to address neglected tropical diseases via a 2021–2030 roadmap to assist countries, stakeholders and non-state actors in accomplishing international organizations goals through a trans-disciplinary, cross-cutting strategy. The proposal called for each group to focus on achieving three key goals, or roadmap pillars. The first component increases systematic action by achieving targeted activities such as technical advancement, service and strategy delivery, financing integration, advocacy collaboration and multi-sectoral action using the OHA for neglected tropical sickness. The second objective is to improve cross-sectoral coordination mechanisms, prioritize neglected tropical illnesses in human-animal environmental medical systems and collaborate with other sectors to address neglected tropical diseases. These targeted actions are meant to intensify cross-cutting methods via coordination and integration actions in key sectors. The third pillar is cultivating and maintaining a nation-led OHA to promote culture along with operational models that support national mandates as shown in Figure (3). Targeted actions are taken to achieve this pillar, including defining stakeholder roles, establishing ownership at the national and subnational levels and coordinating organizational structure, operational models and thinking.

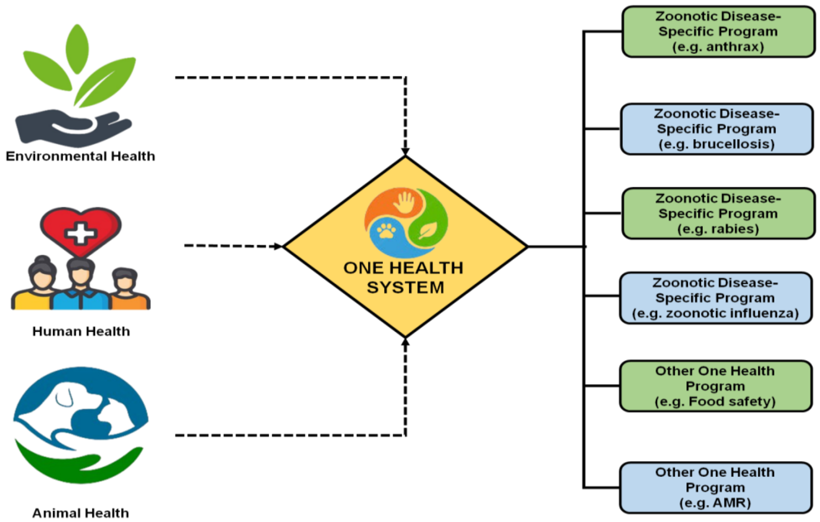

Figure (3). Visual representation of OHA

(Source: author)

CONCLUSION

Zoonotic illnesses emerge at the border between the animal and livestock systems; they pose a serious threat to population health across the world. Comprehending the sources and risks of infections is essential for managing diseases in cattle and poultry. This extensive review looks at the intricate processes that, in the integration of livestock systems, lead to the emergence and spread of zoonotic infections. Assessing the hazards of zoonotic transmission, implementing OHA and identifying the origins of infections in cattle as well as poultry are important steps in the monitoring of zoonotic diseases. The study reveals that zoonotic infections are emerging at the wildlife-livestock interface due to a complicated web of interconnected factors. Understanding the processes of illness transmission emphasizes the importance of viral and bacterial zoonoses in the circumstance of livestock systems. To prevent epidemics in the future, we provide mitigation strategies for the risk of specific illnesses resurfacing or developing.

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