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CHAPTER

# 27

# Emergence and Reemergence of Viral Zoonotic Diseases: Concepts and Factors of Emerging and Reemerging Globalization of Health Threats

*Hamid El Amri*[1], *Mohamed Boukharta*[1], *Fathiah Zakham*[2] *and Moulay Mustapha Ennaji*[2]

[1]**Genetic Laboratory of Royal Gendarmerie, Rabat, Morocco** [2]**Laboratory of Virology, Microbiology, Quality, Biotechnologies/Eco-Toxicology and Biodiversity, Faculty of Sciences and Techniques, Mohammedia, University Hassan II of Casablanca, Casablanca, Morocco**

## ABBREVIATIONS

**WHO** World Health Organization
**MERS** Middle East respiratory syndrome

## INTRODUCTION

Zoonotic diseases have been serious threats to health with variable expressions, some have relatively benign and tolerable human clinical forms, and others constitute a major danger, source of fear, and global panic (Bourgeade et al., 1992). Moreover, the acceleration of the

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emergence rate of new zoonosis, particularly of viral etiology, has prioritized the question of emergence and reemergence on a global scale in both scientific and sociopolitical contexts (Chastel, 1998; Pappaioanou et al., 2009). These health events are only the tip of the iceberg, while the hidden one corresponded to a multitude of complexity related to health, societal, and environmental factors (Webster, 2002; Black and Nunn, 2009).

In a globalized world characterized by high mobility, economic interdependence, and an extraordinary flow of digital information, the advent of health threats is becoming a reality and the factors determining their emergence and reemergence have strengthened during time and space (Figuié and Peyre, 2013).

According to the World Health Organization (WHO), 60% of the agents recognized as human pathogens come from the animal kingdom and 75% of the pathogens responsible for emerging and reemerging animal diseases have a potential to cross animal−human interface. This interspecies passage facilitates the genetic exchange of virulent species and generates emergence and reemergence conditions for new highly pathogenic variants (Bidaisee and Macpherson, 2014; Webby et al., 2004; Rivailler et al., 2013). The diversity of host species in regard to emerging and reemerging viral zoonotic diseases means that all preventive actions must be based on updated and concerted approaches with all actors in the health system at global, regional, and local zoonoses.

With acute respiratory signs [highly pathogenic avian influenza (H5N1, H7N9, H7N7, and H9N2)], Middle East respiratory syndrome (MERS) has periodically led to international panic and has forced WHO to take the health measures to control outbreaks (Wu et al., 2017; Alraddadi et al., 2016).

Vector-borne viral diseases (West Nile, Chikungunya, Zika, Dengue fever, Rift Valley fever, etc.) generate approximately 1 million deaths annually; their distribution depends on environmental and social factors. The phenomenon of climate change, the diversity of mosquito vector species, the precariousness of lifestyle, the international movement, and transport are undoubtedly determining factors for the emergence of these diseases, or even their expansion to newly recognized geographical free areas (Kuno and Chang, 2005).

Bat-borne zoonotic diseases add a supplementary challenge to the global health community and their role has been demonstrated in the emergence and reemergence of many serious and highly publicized viral infectious diseases [Ebola and Marburg virus (reemergence in 2014), Hendra virus (emergence since 1994), Nipah virus (emergence since 1997)] (Allocati et al., 2016; Bidaisee and Macpherson, 2014; Cipolla et al., 2015).

In the hospital, the emergence and reemergence of nosocomial viral diseases (HIV, hepatitis A, B, C, etc.) and the emergence of new resistant forms of bacteria (tuberculosis, legionella, salmonella, *Escherichia coli*, etc.) are also reported. This phenomenon is attributed to the anarchic and disproportionate use of antibiotics, which is one of the major challenges in which control strategies are taken place. The typical example is that of multidrug-resistant tuberculosis, which represents a real problem in public health and requires a concerted response from health professionals (Aitken and Jeffries, 2001; Cipolla et al., 2015; Jacob, 1995).

Food zoonosis can be viral, bacterial or parasitic diseases is of particular interest. Indeed, waterborne viruses (Rotavirus, norovirus, coronavirus, enterovirus (poliovirus), Norwalk (Calicivirus), Coxsackievirus A and B, hepatitis A and E viruses), and pathogenic waterborne bacteria (endogenous or exogenous) (e.g., Salmonella, Listeria, Brucella, etc.), parasitic infestations [Echinococcus (hydatidosis)], Trichinella are examples of the lack of the application of hygiene and sanitary rules. Adoption of health insurance system at all stages of food production can help in the production of healthy and harmless food and prevent food and waterborne illness (Koopmans, 2012).

Zoonoses that are caused by livestock, living with animals, and domestic poultry also occupy a preponderant place in terms of health threat. Rabies, influenza, diarrheal diseases, MERS, Leptospirosis, Leishmaniasis, and Piroplasmosis are the best known examples. Defective prophylactic measures at the human–animal interface can defuse the contagion (Day et al., 2012; Zhou, 2012; Cipolla et al., 2015).

It appears that the three elements of the human–animal–environment triad are always present and any efficient prophylactic strategy must always take into account the interactions established between these three components. Most recently, important measures have been agreed and implemented globally, and their proper application is conditional on the full participation of national authorities. These measures were enacted as a globalized approach, concretized and institutionalized by the international community through the "One Health, One World" standard (Xie et al., 2017; Carlton, 2016).

This chapter is an update of a number of concepts that arise following the emergence and reemergence of new zoonotic diseases. We will list some emergence factors that bring together a number of conditions conducive to the emergence or qualitative and quantitative exacerbation of preexisting zoonotic diseases.

We considered the three components of the triad: human–animal–environment that share the same biosphere and only balanced relationships between each of them that perpetuate the state of good health of living beings (human and animal) and the ecosystem.

## HISTORICAL OVERVIEW

From antiquity, the humanity had undergone a multitude of epidemic or pandemic outbreaks of variable fatalities. The epidemic context related to biological causative agents, and the essential element of diseases the notion of interspecies transmission (human–animal) were unknown. Nevertheless, some authors noticed that shortly before the outbreak of epidemics, domestic animals, such as horses, dogs, and chickens, experienced clinical signs at least similar to those found in humans (Ozanam, 1835; Gubian, 1837). The correlation between the pathogenic effect (clinical sign) and the specific causative agent (virus, bacteria, fungi, etc.) was ignored. In 1848, the German researcher Rudolf Virchow, in his efforts to fight against the typhus epidemic, has studied the interaction between human and his environment (Taylor and Rieger, 1985; Cipolla et al., 2015).

Many authors agreed that the words "emergence and reemergence" correspond to the birth of modern microbiology in the 19th century following the studies carried out by the German researchers R. Koch and F. Loeffler.

Loeffler, a German bacteriologist (1852–1915), defined and founded the scientific approach of infectious diseases, as we know it today. The researchers demonstrated the causality between the pathogenic effect and the presence of an infectious agent that meets the four criteria of microbial theory (filterability, transmissibility, reproducibility, and specificity) (Flint et al., 2018; Mainil, 2005). This theory has made it possible to orient the reflection toward important innovations, such as the good practices of the hygiene rules and the invention of antibiotics and vaccines. At this time, it was described as a transition in which primitive scientific concepts quickly became obsolete in favor of nascent scientific ideas that gained more importance (Jacob, 1995).

The relationship established between pathogens and the human–animal–environment puzzles elements would gradually be revealed through the development of promising new biological techniques (serological techniques, isolation of pathogens in the first place on laboratory animals and then on cell culture, crystallization, development of photonic and electronic microscopy, etc.) and also the acquisition of new scientific knowledge in genetic molecular biology, microbiology, epidemiology, entomology, ecology, and phylogeny.

## UNIVERSAL CONCEPTS

### Environment

The environmental issue and its relationship with the emergence and reemergence of zoonotic diseases have a universal and institutional

dimension and its preservation was one of the three pillars of sustainable development and the seventh of the eight Millennium Development Goals during the UNESCO Congress in 1977 [Tbilisi (Georgia, former USSR)] (Unesco-PNUE, 1977).

The meaning of the word environment has evolved over time. In the old literature, the word "environémenz" designates circle, circuit, or contour, then it expressed an action of surrounding "environment" (Bontoux, 2011). Nowadays, the word environment has become a polysemy, meaning "action of surrounding" and it can make sense of context, of the neighborhood, notably in linguistics. The most recent definition considers the environment as the set of physical, chemical, or biological elements, natural and artificial, that surrounds a human being, an animal or a plant, or simply a species. This definition is often criticized by the fact that human occupies the epicenter and that all development policies are moving toward this goal.

The basic element of the environment is the ecosystem, which is the entire system of biotic (species richness, composition, and interactions) and abiotic (temperature, rainfall, soil) components that interact in some place (Loreau, 2010). All ecosystems are associated with the atmosphere from the biosphere. Macrosystems spread over vast geographical areas under a particular climate and include a natural diversity, plant formations (equatorial forests, savannahs, etc.), and wildlife. The environment is a mosaic of interlocking, interdependent, and fragile equilibrium ecosystems (Norris, 2012) and is delighted by a dynamic equilibrium, evolving over time in self-regulating oscillations without exogenous intervention (e.g., predator relationship). This multiparametric dynamic equilibrium determines the state of good health of the ecosystems (Lerner and Berg, 2015).

Currently, most of the planet's natural ecosystems, to variable degrees, are the footprint of human activities. Artificially modified ecosystems are maintained by humans to satisfy their food needs or feed the various food production chains. These agro-systems are recognized as fragile because they are devoid of species diversity, which is an essential element for maintaining dynamic equilibrium and is often characterized by natural ecosystems (Norris, 2012). In 1989, Croatian researcher Mirko D. Gmerk introduced the term "pathocenosis" to refer to the imbalance in the relationship between infectious diseases and the environment (Grmek, 1995).

## Human–Animal Interface

In prehistoric times, animals played multiple and determining roles for human, nutritional by maintaining physical and bodily well-being,

clothing (wool, cooking, fur, etc.), and a means of transport for the movements and the conquest of new inhospitable spaces.

The survival of human and the strength he had to move or work on the land were mainly through animal feed. More than 200 million animals are used in developing countries, generating economic incomes and reducing the state of poverty for rural populations. According to the Food and Agriculture Organization (FAO), the use of animals is a crucial step in getting out of poverty.

The animal is accused of certain nuisances: metabolic, infectious, and environmental. Nevertheless, the health threats associated with new emerging and reemerging zoonoses are much greater in a globalized world. So the recent epidemics (Ebola virus diseases, Rift Valley fever, H5N1/H7N9 avian flu, etc.) are examples of this. Moreover, the rabies health control programs are still strongly present in the world and rife in two-thirds of the world's countries. Also, hydatid disease is a significant problem medically, socially, and economically (Sarkar et al., 2017). Globally, the socioeconomic impact of these diseases has convinced the most skeptical about the need for collaboration between the human, animal, and environmental health sectors to provide more effective synergistic responses to the threats of zoonotic epidemics.

## One Health, One World

The existence of historically zoonotic diseases (influenza, plague, tuberculosis, HIV, etc.), and the periodic appearance of new animal origin transmissible diseases to humans with or without a vector, undeniably recalls the place that occupies animals in the dissemination and spread of pathogens (Calistri et al., 2013).

In addition, the improvement of public health is a concern of several awareness and fight programs and is continually implementing various means (financial and technical) that add to the state budgets, while this improvement depends imperatively on animals and the surrounding environment. Therefore it is logical that both veterinary and human medicines federate their actions and work together to ensure a safer and more secure health balance for both humans and animals (Papadopoulosa and Wilmer, 2011; Carlton, 2016).

The One Medicine approach was first proposed in 1984 by Calvin Schwabe in his book titled *Veterinary Medicine and Human Health*, in which the author advocates a concerted and complementary response to zoonoses by determining the roles and responsibilities of the different actors in human and veterinary medicine (Lerner and Berg, 2015).

Current threats from outbreaks of emerging and reemerging diseases have led to the return of the principles of the "One Medicine" concept


**FIGURE 27.1** The One Health triad. Source: *Based on http://sds.uanl.mx/en/one-health-one-medicine-in-a-globalized-world/ (accessed April 2018).*

and their evolution to the "One Health" approach, with the integration of ecosystem health into the equation: animal health + human health + ecosystem health = one health (Craddock and Hinchliffe, 2015) (Fig. 27.1).

In the 2004 Manhattan Congress, the Wildlife Conservation Society deliberated on the advancement of the "One Health" approach to integrate the health of human and animal/domestic and wild populations and the creation of the concept "One World, One Health" (OWOH), or "One World, One Health" (UMUS) (Calistri et al., 2013; Cipolla et al., 2015).

This concept outlines guidelines that promote cross-organizational and cross-organizational collaboration between the human health, animal health, and ecosystem health compartments and the cross-fertilization of ecological and health information on a global scale (Helden et al., 2013). The ultimate goals were unification of purpose, synergy of action, smoother dissemination of information, and formalization of surveillance and response measures for new emerging diseases.

Climate change and the globalization of flows of goods and people are opening new opportunities for the spread of pathogens, particularly through vectors such as insects that are colonizing new territories. The response requires institutional adaptation of health governance arrangements in a harmonized and coordinated manner at the global, regional, and national levels (Guiot and Cramer, 2015). With this in mind, the international organizations, traditionally in charge of the emergence issue, comply with the new approach by prioritizing the development of tools for anticipation and rapid intervention. The latter claims regulatory prerogatives toward the international health authorities.

The OIE (World Organization for Animal Health) has modernized its global animal disease information system by creating World Animal Health Information. WHO has a legal framework to detect and respond

to all health threats, through the International Health Regulations (2005) that provides new obligations to its members: update of legal instrument obligations notification and information of epidemiological events occurring in the territory of the member countries.

The tripartite alliance (OIE, WHO, and FAO) is launching the Global Early Warning System, a common platform for the three organizations to interconnect data and improve global early warning. The focus of their action was the prevention of the phenomenon of emergence and the gradual reduction of notifiable diseases. Subsequently, a consensus document to better coordinate medical and veterinary health policies was developed with the support of the United Nations International Children's Emergency Fund, the United Nations System Influenza Coordinator, and the World Bank (Craddock and Hinchliffe, 2015; FAO, OIE and WHO, 2010).

## FACTORS OF PATHOGENS EMERGENCE AND REEMERGENCE

Emergence and reemergence factors are all the elements or conditions that often act synergistically and contribute to situations that favor the emergence of emerging and reemerging diseases.

The acceleration of the emergence rhythm has been substantially concretized in recent years. Indeed, in a globalized world, the close contact between the human−animal and human−environment interfaces, the exacerbation of the virulence of infectious agents, and the globalization of human activities (movements of people and goods) are often incriminated. It not worthy to mention that the unprecedented use of digital technology favors the more fluid dissemination of information that sometimes leads to sanitary fears (false emergence) and excessive, exaggerated, and unjustified alerts (Choffnes et al., 2012; Zinsstag et al., 2011) (Fig. 27.2). The emergence factors are classified into factors related to the infectious agent, human and animal activities, and environmental changes.

### Mutations of Infectious Agents

The genetic variability (minor or major mutations) causes an exacerbation of the virulence and imposes difficulties of therapeutic and prophylactic order. Universal vulnerability to the irrational and anarchic use of antivirals and antibiotics contributes to the emergence and reemergence of multiresistant pathogenic forms.

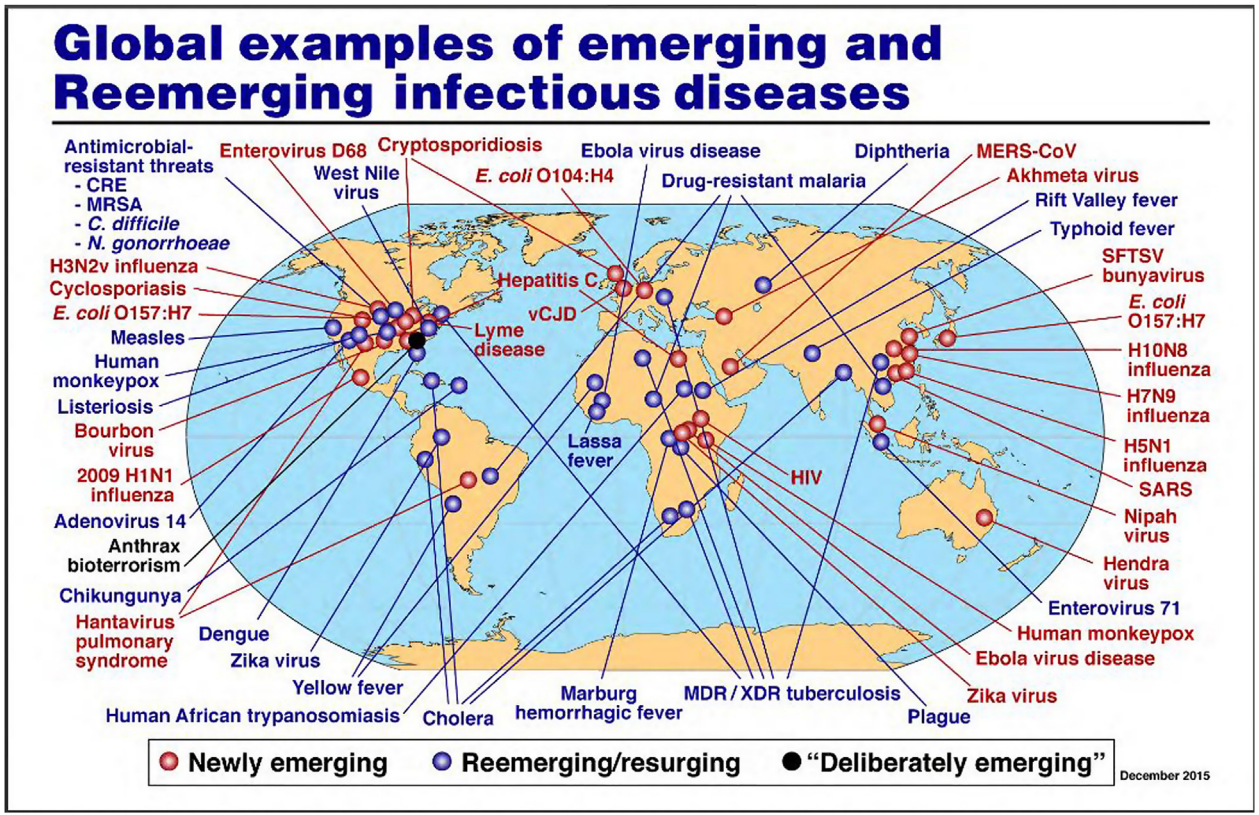


FIGURE 27.2 Mapping of emerging and reemerging infectious diseases through the world (Thompson, 2013, license code 4343590027308).

The pathogens' ability to transgress the interspecies barrier, with the possibility of changing hosts, broadens the range of contamination and complicates the epidemiological picture of diseases.

The genetic dynamism of pathogens, particularly viruses, is materialized by the accumulation of genetic and antigenic mutations, which maintains the virulence of pathogenic agents. Two distinct types of antigenic variation are known: "antigenic drift" and "antigenic shift" (Donatelli et al., 2013). Variations of the "antigenic drift" type constantly bring minor and progressive changes in the structure of the viral proteins. Variations such as "antigenic shift" or reassortment or antigenic breakage cause sudden and complete changes in the genome and result in emerging of new agents that have different antigens in nonimmunized population (Khanna et al., 2009).

## Human Activities

The modern lifestyle, intentional human behaviors, and common habitat between humans and animals with a dilapidated and unsuitable sanitary system are factors associated with the threats of emergence and reemergence of diseases.

The unprecedented globalization of movement, tourism, trade, and transport adds an additional burden and makes the management of public and animal health extremely complex. It is illusory to say that only continental or community efforts are enough to ensure the expected protection.

The intensification of industrial farms and the centralization of food production chains using technological and industrial processes are selecting new and optimal conditions for the emergence of diseases.

In the industrialized countries, the factors of emergence linked to human activity are different [leisure activities, the possession of pet animals (dog and cat), and of wildlife (reptiles, birds, etc.)].

An outdated health legislative framework hampers the effective application of animal health measures and generates underreported states of underreporting and biased epidemiological situations that do not reflect reality and impact the quality of prophylactic decisions. The low rate of literacy among the population was behind the failure of health programs due to difficulty to assimilate the good hygienic practices (Zinsstag et al., 2011).

## Environmental Changes

The aggression of the environment by the human is not a recent issue, it goes back further in the history of the humanity. However, the

aggression became complex and globalized, following the emergence and reemergence of industrial civilization, the main consumers of natural capital and generators of the devastating and polluting industries of the environment. This leads to an imbalance whose gap widens more over time, the term "pathocenosis" is used to describe the disease state of the ecosystems of the environment.

*Deforestation* is a result of the development of intensive monocultures and the extension of urbanization, which leads to a decreased vegetation cover across the planet. The reduction of wild areas is a factor often cited by experts as a leading factor for the emergence of diseases, the fragmentation of forests directly affects the natural biodiversity; likewise, the destruction of predators unbalances the food chain in favor of certain vectors carrying certain transmissible agents (Walsh et al., 1993; Gottwalt, 2013).

*The demographic explosion* induces multiple domestic effluents (domestic waste, water waste, etc.), and the lack of management will encourage the proliferation of rodents and insect vectors (mosquitoes, flies, etc.). Even more, the lack of general hygiene and precarious facilities or overflow aggravated the situation (Howard and Fletcher, 2012).

*Industrial pollution* is impacting the state of environmental health: the increase of greenhouse gas production incriminated in global warming, the destruction of the ozone layer, the release of harmful chemical substances of various origins into the nature (nitrates, phosphors, heavy metals, etc.), nonbiodegradable materials anarchically released in nature, and industrial petroleum waste from the pressure of exploitation of energy resources (oil, natural gas, coal, etc.) are few aspects of industrial pollution that provoked an international controversy and many cooperation agreements between the industrialized countries and the specialized international organizations were done.

The marine and freshwater environments (rivers and lakes) constitute the destination of all kinds of pollutants and affect the natural resources.

*Rapid urbanization* offers conditions conducive to the emergence of new diseases: Overcrowding promotes easy human-to-human transmission of disease. The modification of traditional mapping and contact between humans and ecosystems has greatly facilitated the cross-species passage of pathogens (Neiderud, 2015).

Construction of dams to meet the increased need for drinking water and global warming is fueling the proliferation of vectors including mosquitoes that are gaining new territories and recently has become vulnerable to infection after being declared free (Morse, 1995; Ahmed Hassan et al., 2011).

*Climate change* increases in the severity of extreme weather events, declining air quality, and destabilizing natural systems due to the

increase of greenhouse gas emissions. The direct and indirect health results of such a global imbalance include excessive heat-related illnesses, increased vector- and waterborne diseases, increased exposure to environmental toxins, exacerbation of cardiovascular and respiratory diseases due to declining air quality, and mental health stress among others (Luber and Prudent, 2009).

## PREVENTION STRATEGY AND CONSTRAINTS

The diversity of infectious agents both in the environment and in the animal kingdom, intentional human activities, and the globalization of trade and tourism make the formulation of relevant and multidimensional solutions indispensable. The scientific experts, who meet regularly, insist on the adoption of action plans for interorganizational and intergovernmental transversal coordination, complemented downstream in the field, by collaboration between professionals of the human health and veterinary health, actors of associations, educators, and social, economic, and environmental stakeholders.

Moreover, following the exceptional passage of highly pathogenic avian influenza H5N1 virus to the human in 2003, the scientific community has not stopped alerting the world population to the imminent threat of an influenza pandemic of bird origin. Unlike its expectations, the latter did not see the arrival of the pandemic H1N1 influenza virus responsible for the 2009 Mexican pandemic, where the responsible virus was emerging following the triple reassortment of three influenza A viruses from three different lineages (human, swine, and avian). This highlights the fact that the forecasting progress made to date remains insufficient and that humanity would have a long way to unveil the mechanisms of emergence of new highly pathogenic viral agents. The determinism of emergence and reemergence is an evolutionary process, the success of emergence and reemergence is acquired only after having exceeded the threshold of fitness compensation. Only a holistic and concerted approach will make it possible to better understand these mechanisms by establishing monitoring of specific parameters of emergence factors. It is noteworthy to point out the divergence between policies with economic aims and the need to preserve environmental capital imposes a burden and additional overload hindering development. The dichotomous zone between economic growth strategies and the protection of the environment is currently the basis of all sustainable development. The development of scientific and technical capacities for problems related to the modernization and efficient integration of environmental education into the academia can sustain the balance of global health.

## CONCLUSION

The complexity of issues related to the emergence and the reemergence of diseases mandates the health sector leaders in each country to prioritize the following points:

- Modernize the epidemiological surveillance system for emerging and reemerging diseases based on universal monitoring and to rectify and adapt health policy to data from the field.
- Interconnect the efforts between human and veterinary health professionals and their openness to other actors in society.
- Have an effective national regulatory health arsenal compatible with its global counterpart.

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## Further Reading

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