

# Emerging infectious diseases in a globalized world

*Enfermedades infecciosas emergentes en un mundo globalizado*

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## Summary

The impact that zoonoses have today worldwide on human populations is an unprecedented phenomenon. Three quarters of emerging infectious diseases that affect people have its origin in animals. This paper analyzes the conditions are necessary for an epidemic to occur: the species leap, the amplification, and the propagation.

Currently, the natural systems are changing at an unprecedented rate and can modify the interactions between humans and reservoirs and vectors of viruses. Most of these changes have an anthropic origin and can increase the probability of species leap. One of the most important environmental changes taking place is the deforestation in tropical regions, whether to create space for new human settlements, land for pasture, crops or farming, or for commercial logging.

The demographic increase plays an important role from an epidemiological point of view because does that the urban areas grow in inhabitant numbers and facilitates the amplification of the infection. For this reason, cities are exposed to epidemics and we must prepare them and protect them against future epidemics.

Current mobility is unprecedented in human history and represent a critical epidemiological factor that increases the risk of disease propagations.

Much of the emergence, amplification and propagation of the zoonosis are consequence of human activity. In this sense, one of the things we must learn as quickly as possible is that we need to change our relationship with the natural systems, because our actions can have consequences - such as pandemics.

**Key words:** Communicable diseases, zoonoses, viruses, epidemic, ecoepidemiology, biosphere.

## Resumen

El impacto que las zoonosis tienen hoy en día en todo el mundo sobre las poblaciones humanas es un fenómeno sin precedentes. Tres cuartas partes de las enfermedades infecciosas emergentes que afectan a las personas tienen su origen en los animales. Este artículo analiza las condiciones necesarias para que se produzca una epidemia: el salto de especie, la amplificación y la propagación.

Actualmente, los sistemas naturales están cambiando a un ritmo sin precedentes y pueden modificar las interacciones entre los seres humanos y los reservorios y vectores de los virus. La mayoría de estos cambios tienen un origen antrópico y pueden aumentar la probabilidad de que se produzca un salto de especie. Uno de los cambios ambientales más importantes que se están produciendo es la deforestación en las regiones tropicales, ya sea para crear espacio para nuevos asentamientos humanos, tierras para pastos, cultivos o agricultura, o para la tala comercial.

El aumento demográfico juega un papel importante desde el punto de vista epidemiológico porque hace que las zonas urbanas crezcan en número de habitantes y facilita la amplificación de la infección. Por ello, las ciudades están expuestas a las epidemias y hay que prepararlas y protegerlas contra futuras epidemias. La movilidad actual no tiene precedentes en la historia de la humanidad y representa un factor epidemiológico crítico que aumenta el riesgo de propagación de enfermedades.

Gran parte de la aparición, amplificación y propagación de las zoonosis son consecuencia de la actividad humana. En este sentido, una de las cosas que debemos aprender cuanto antes es que tenemos que cambiar nuestra relación con los sistemas naturales, porque nuestras acciones pueden tener consecuencias, como las pandemias.

**Palabras clave:** Enfermedades transmisibles, zoonosis, virus, epidemias, ecoepidemiología, biosfera.

## Introduction

Human populations have suffered epidemics since ancient times. The measles first appeared around 2,500 years ago and evolved from a virus of livestock<sup>1</sup>. Severe outbreaks of black death occurred in the years 541 and 542 and were caused by the *Yersinia pestis*, bacteria transmitted by the fleas carried by rats<sup>2</sup>. The 1918-1919 flu pandemic killed between 50 and 100 million people worldwide. It was caused by a strain of Influenzavirus A, subtype H<sub>1</sub>N<sub>1</sub>, probably caused by recombination between human viruses, pigs and birds that occurred during the years before the pandemic<sup>3-5</sup>. Taking into account the humanity suffers epidemics since old times what has changed now? Why have been produced these changes? Why has SARS-CoV-2 infected humans now, if coronaviruses have been circulating for many years in animal reservoirs in the Wuhan region? What are the factors that have caused the species leap? What are the factors that have enabled it to spread? The answers to these questions should help us to implement measures geared towards prevention and containment: not only to tackle the current pandemic, but also to prepare for the viral epidemics that will emerge in the future. This paper analyzes some of these changes that increase the probability that an epidemic occurs.

## Conditions for an epidemic to occur

Three conditions are necessary for an epidemic to occur: the species leap, the virus that infected an animal species must also be able to infect humans; the amplification, the infection must affect many people; and the propagation, the virus has to propagate over a large area<sup>6</sup>. We will begin by analysing the species leap.

### Species leap

On average, three to four new pathogen species are detected in the human population every year<sup>7</sup>. Since the beginning of the 21st century five human outbreaks of coronaviruses inducing respiratory diseases were reported including SARS-CoV, HCoV-NL63, HCoV-HKU1, MERS-CoV, and SARS-CoV-2. Three quarters of emerging infectious diseases that affect people have its origin in animals<sup>8</sup>. With more studies carried out and more information available, it is evident that the wildlife plays a key role in emerging infectious diseases. There are some good examples in SARS, HIV, Ebola, Chikungunya, MERS, rabies, West Nile virus, Zika and COVID-19. The interaction between human and animal health is not a new phenomenon, but the impact that zoonoses have today worldwide on human populations is an unprecedented phenomenon. But why do they have the zoonoses today a big impact on human populations?

One of the qualities that defines today's era is the speed at which change occurs and the magnitude

of such changes. We live in an increasingly globalized world, whether at a commercial, economic or pathogen distribution level. Most of these changes have an anthropic origin and may have an impact on viral zoonoses and consequently on human health. Much of these changes affect natural systems and has consequences not only in biodiversity loss but also in human health. Often, from our anthropocentric perspective we forget that we are also part of Nature. The humans are part of an extremely complex biosphere, with multitude relationships between living organisms and the environment. Currently, the structure and functionality of ecosystems are changing at an unprecedented rate and can modify the interactions between humans and reservoirs and vectors of viruses. In some cases, the narrow contact between infected animals and people can increase the probability of pathogens crossing the species barrier and adapt to humans. Land modification, changes in vegetation pattern, changes in dynamics of reservoirs or vector species can increase the contact between reservoirs or vectors species and humans, livestock or pets. To this must be added the effect of climate change, which, among other things, will lead to the spread of infectious diseases in new regions of the planet. The loss or diminish of one or more reservoir species in a concrete area, can modify the dynamic of pathogen and change the sanitary risk. Disease emergence frequently results from a change in hosts, or in vector, in pathogen ecology or in all of them.

One of the most important environmental changes currently taking place is the deforestation in tropical regions, whether to create space for new human settlements, land for pasture, crops or farming, or for commercial logging. The destruction of tropical forests is usually analysed in relation to the loss of biodiversity. In other words, the analysis focuses on the potential loss or reduction in numbers of the species that live in the area being deforested, and the destruction of their habitats. The consequences of deforestation can be far more unpredictable than they might appear at first glance. Some animals abandon the deforested area in search of a new habitat, while others remain. The animals that remain in deforested region continue to look for food and shelter and may entry into the farms and houses of the area's new human inhabitants. As a result, increase the contact with humans. This contact may cease to be trivial if any of these animals are reservoirs of zoonotic viruses, as they can then infect the area's inhabitants, their livestock or pets.

The rate of deforestation has been very high in Southeast Asia where the 30% of its forest cover has been lost in the last 40 years<sup>9</sup>. In the Amazon, thousands of square kilometres of forest are lost every year. We have observed in the Amazonian region where we work how deforestation can affect human health. Rainforests drain a great deal of water, which is then removed through evapotranspiration.

Deforestation reduces this drainage, causing water to accumulate on the surface in pools and wetlands. This creates more areas where mosquitoes can lay eggs, leading to an increase in the mosquito populations and of vector-borne diseases such as dengue, malaria, Zika, etc.

The construction of roads for transporting timber of rainforests also provides hunters with improved access to areas that were previously difficult to reach. Some authors argue that deforestation in Cameroon has led to increased trade in bushmeat, and thus to increased contact between hunters and wild animals<sup>10</sup>. Various cases of infection have been found in hunters who had handled simian species that were infected with the Ebola virus<sup>11</sup>. One of the key factors driving the bushmeat trade in Cameroon is the growing urban demand for meat, which is closely linked to the beginning of forest. However, environmental changes do not only occur in tropical countries: in the First World, changes also take place that can have an impact on human health. Although these impacts tend to be less severe, the modification of natural systems can affect reservoir populations, while at the same time causing changes in viral dynamics.

Another aspect to consider that can increase the probability that occur the species leap of pathogens is the poverty. The lack of resources can force people to expand their range of activities in order to survive, pushing them into the rainforests where they are more exposed to zoonoses<sup>11</sup>.

The legal and illegal trade in wild animals for food, medicine and other products is another major global threat to biodiversity and is also responsible for the appearance of pathogens that threaten the health of humans and livestock and the global economy. We have a good example in the SARS epidemic of 2002-2003. This epidemic began with an increase of consumption of mammal species called common palm civet (*Paradoxurus hermaphroditus*). This species is a lot appreciate in Chinese gastronomy was carrier of SARS-CoV.

### Amplification condition

For an epidemic occur, it is not enough for the species leap, the virus must infect a large number of individuals. If it only affected a few people, the disease would go away quick and it would be a local episode. For example, if the species leap occurs in a small isolated human community living in the jungle.

Humanity has tended to form large metropolitan areas where living thousands of people and this increase the amplification risk if an infectious outbreak occur. The demographic increase plays an important role from an epidemiological point of view because does that the urban areas grow in habitant numbers. For this reason, cities are exposed to epidemics and we must prepare them and protect them against future epidemics. We

have a good example of the role that the cities play in the pathogen amplification in the COVID-19 pandemic. The location of the first human infection of COVID-19 is difficult to know. It may have occurred by contamination through traditional medicine, pets, consumption of wild animals or any other contact between humans and the source of the virus<sup>6</sup>. After a latency phase the COVID-19 quick spread. In December 2019, Wuhan met all the conditions for amplification to occur. More than nine million people live in the metropolitan area of Wuhan. The city is also a major educational hub, and home a 1.2 million students whose mobility is extremely high during the holidays. On the other hand, in December 2019, when the first cases of COVID-19 were reported in China, many people had gathered in Wuhan to celebrate an important festivity that brought together thousands of people from around the country. Consequently, there were many more people in the city than normal, resulting in increased urban travel and a much higher attendance of traditional markets. Close contact between people combined with the humid weather conditions amplified COVID-19. According to our studies the species leap of COVID-19 appears to have originated some months earlier outside the Wuhan market<sup>6</sup>.

### Propagation over a large area

The propagation to other areas, countries or continents requires movement on the part of human populations. Although humans have always moved around, our current mobility are unprecedented in human history, and represent a critical epidemiological factor that increases the risk of disease propagations. For example, approximately 225,000 flights take place around the world every day before the pandemic. Moreover, these movements are not uniform: most of them coincide with the world's main economic hubs. Wuhan is one of the important economic, scientific and educational centers in China and is connected to other global economics hubs of the world. In this sense, it is no surprise that COVID-19 quickly spread to Milan, New York, London, Paris, Madrid, Barcelona, etc. Amplification also occurred in these cities, after which the virus was spread to other secondary population centers.

Southeast Asia is a region with a high pathogen diversity where a species leap is most likely to occur. On the other hand, it is an emerging region that is undergoing strong economic growth, increased interconnectivity, where occur major environmental impacts and it is densely populated. These characteristics make Southeast Asia one of the hotspots on the planet from emerging infectious diseases.

### What measures should be taken?

The impact of the COVID-19 pandemic is unprecedented in our modern civilization. One must go back to the Spanish flu or black plague in the Middle Ages to find similar societal impacts. Society today is globalized, driven by social networks, and connected with information flowing in real

time. This leads to over-reactions, with irreversible damage to society. COVID-19 is the first “4.0 pandemic”<sup>6</sup>. Nothing can be done to avoid the circulation of coronaviruses in the wild (sylvatic cycle). Much of the emergence and propagation of the zoonosis are consequence of human activity. In this sense, one of the things we must learn as quickly as possible is that we need to change our relationship with the environment, because our actions can have consequences - such as pandemics. The natural systems are quickly changing and in many cases this is having and will continue to have an impact on human health. To this we must add the effects of climate change, which –among other impacts–will facilitate the propagation of infectious diseases to new regions of the planet. It is also necessary to take greater precautions when trading goods that may be transporting vectors of disease (such as mosquitoes and ticks) or pest species.

On the other hand, the zoonotic research is essential to provides relevant information in terms of public health, because it allows assessing the epidemiological risk and take preventive measures. For the understanding of the zoonotic diseases is important to do an approach that considers the complex relationships between viruses, reservoirs or vectors, humans and environment. Some studies with this approach we have done in Balearic Islands about lyssavirus, flavivirus, coronavirus and phlebovirus<sup>12-16</sup>.

In summary, it is important to change our relationship with our environment and to devote greater efforts to research, biodiversity conservation, prevention, combined with rapid detection and intervention to tackle future epidemics.

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