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ZOONOTIC DISEASES

Can the transmission of pathogens between animals and humans be controlled?

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After being associated with more than six million deaths so far, the Covid-19 pandemic is one of the worst diseases of animal origin known to date. Other zoonotic diseases such as severe acute respiratory syndrome (2002–2004, which mainly affected China), Middle East respiratory syndrome (2012, mainly affecting the Middle East), Ebola (2013–2016 in West Africa), and Rift Valley fever (from 2016 to the present) have also caused major disease outbreaks in recent decades. In addition, and especially in low-income countries, some zoonotic diseases such as tuberculosis and rabies are endemic and cause thousands of deaths. Of note, up to 60% of known infectious diseases and 75% of emerging infectious diseases have an animal origin and are responsible for public health problems and economic losses.

Keywords: **pandemic**, **global health**, **One Health**, **animal health surveillance**, **zoonoses**.

■ WHAT ARE ZOONOTIC DISEASES?

A zoonotic disease, or zoonosis, is a disease transmitted from wild or domestic animals (usually vertebrates) to people. There are also reverse zoonoses, diseases transmitted from people to animals such as certain pets (mostly dogs and cats). These pathogenic leaps between species are known as spill overs and are much more common than we think. The most recent example is Covid-19, a disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Although this virus is mainly transmitted from person to person, viruses very similar to SARS-CoV-2 have been found in certain bat populations, suggesting that they might be the natural reservoir for this disease. Consequently, the predecessor of SARS-CoV-2 may have leaped from bats to a different species before reaching humans, as was the case with other coronaviruses (Temmam et al., 2022; Zhou et al., 2021).

«The emergence of new zoonotic diseases reminds us that people, animals, and the environment are interconnected»

To date, several animal species susceptible to infection by this coronavirus have been identified, including non-human primates, domestic and wild cats, canids, and mustelids, among others (Mastutik et al., 2022), but none of them has been shown to act as an intermediary host. This is neither new nor strange, and we already knew that coronaviruses have a high pandemic risk. In fact, SARS-CoV-2 is the ninth known coronavirus that infects people and the seventh to have been identified in the last 20 years.

Pathogen transmission requires three main elements: a source of transmission (animals or an environment contaminated by animals), a host susceptible to infection (symptomatic or not, acting

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as a carrier or vector of the pathogen), and a means of transmission (direct or indirect contact, aerosols, or via a vector). In order to fight a zoonosis, it is important to know and understand these elements well. Most zoonoses originate in wildlife (bats, rodents, wild birds, etc.), although others associated with domestic animals and livestock (cows, goats, pigs, birds, etc.) tend to occur in heavily populated areas and can have a significant impact on public health. In addition, there are many pathogen transmission routes between animals such as inhalation, ingestion, and through fluids, bites, and aerosols, etc.

Although we have used Covid-19, a viral zoonosis, as an example in this section, it is important to note that zoonoses can also be caused by other types of pathogens such as bacteria (e.g., *Salmonella*, *Escherichia coli*, or bovine tuberculosis), fungi (e.g., dermatophytosis, also known as ringworm), and parasites (e.g., cysticersis or malaria) (Walker et al., 1996; Walsh & Groll, 1999). The emergence of new zoonotic diseases and the presence of endemic zoonoses in certain areas of the planet remind us that people, animals, and the environment are interconnected and that the health of any of these elements cannot be understood separately. This triad is the central element of the One Health framework, which we will discuss later as the key to being able to prevent or be better prepared for a future pandemic.

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Viruses very similar to SARS-CoV-2 have been found in certain bat populations, suggesting that they might be the natural reservoir for this disease and that, consequently, its predecessor virus may have leaped from bats to a different species before reaching humans, as was the case with other coronaviruses.

■ WHAT FACTORS INFLUENCE THE EMERGENCE OF ZOONOSES?

History tells us that most emerging infectious diseases are zoonoses. But what factors influence their emergence? Covid-19 joins a long list of pandemics that reveal the risks of our continuous invasion of nature and the human exploitation of wildlife, both of which have had devastating effects on local and global communities. In recent decades, several diseases have posed a threat to public health: acquired immunodeficiency syndrome (AIDS), severe acute respiratory syndrome (SARS), avian and swine influenza, Middle East respiratory syndrome (MERS), Ebola haemorrhagic fever (EVD) and, more recently, Covid-19. But what do all these diseases have in common? All of them are zoonotic in origin or in their transmission mode. In fact, it is estimated that 60 % of infectious diseases in humans are zoonotically transmitted and 75 % of all emerging infectious diseases come from animals (Taylor et al., 2001).

«75 % of emerging infectious diseases come from animals»

These diseases, known as *zoonoses*, are not new; rather, they have been known for many years. Indeed, the plague or rabies are examples of other zoonotic diseases. However, we will have to go far back in time to understand the transmission of pathogens between different species. With the introduction of agriculture and the domestication of animals, humans began to live in larger communities and in closer contact with other animal species (Pearce-Duvet, 2006). This is one of the key factors favouring the transmission of pathogens between species. However, if outbreaks caused by pathogens jumping from one animal species to another (including humans) have been known for so long, why has their frequency increased only in recent years? Environmental experts attribute this to human action and our interaction with the environment (Jones et al., 2008). Some of the main factors currently influencing the appearance and spread of new diseases are deforestation, increased international travel, globalisation, mass urbanisation, changes in food habits, wildlife trafficking, and even religious beliefs (Church, 2004).

Hayden - Wikipedia

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«Recent history has shown that outbreaks will happen again»

Despite this, we would do well to also consider the more scientific aspects of this problem, not just its social components. The factors that can explain the emergence of a zoonosis or a potentially zoonotic disease are complex. Indeed, this process involves many different components, including molecular mechanisms (for example, the genetic drift and changes in the avian influenza virus) or the different immune statuses of individuals or populations. In addition, viruses, especially RNA viruses, can adapt to changing environmental conditions (for example, via genomic mutations, as was the case with SARS-CoV-2 variants). In fact, this is actually one of the reasons they represent potential emerging pathogens.

AVOIDING THE NEXT ZOONOTIC PANDEMIC: MISSION IMPOSSIBLE?

The Covid-19 pandemic has raised many questions regarding the role of animal–human interactions in the emergence of new infectious diseases. Will there be new epidemics or pandemics in the near future? Can we prepare better to deal with a situation like the one we have experienced in recent years?

Recent history has shown that outbreaks will happen again; the risk of new human pathogens emerging has increased in recent decades and the trend is continuing to rise (Baker et al., 2021). Nonetheless, it is hard to predict when this might happen, which makes preparation and surveillance a tremendous challenge. When the time comes, every sector related to the surveillance of infectious diseases must be prepared to detect them and make fast and prudent decisions. In addition, understanding the diseases that affect animals or their environment is essential to prevent future pandemics. This idea and its application have been around for many years, albeit with limited success, under the banner of what we know as One Health. But what does this model framework really mean, and more importantly, is it feasible?

The concept of One Health is easy to explain, but perhaps more difficult to implement. We cannot consider human diseases independently from animal health and from the environment in which we live. Thus, we must keep this triangle constantly in mind; this is why it is important to continue studying public health connected to that of animal and environmental health (World Bank Group, 2018). The pandemic caused by the SARS-CoV-2 coronavirus has highlighted many shortcomings in our society but has also led many professionals from different fields (healthcare, epidemiology, biology, veterinary sciences, and bioinformatics, among others) to work together. This has provided a wealth of knowledge and led to rapid progress in understanding this virus and, therefore, also in the development of measures to control it and prevent its spread. However, we are still far from an ideal model of cooperation between sectors, which is why we must persist in our work in this regard.

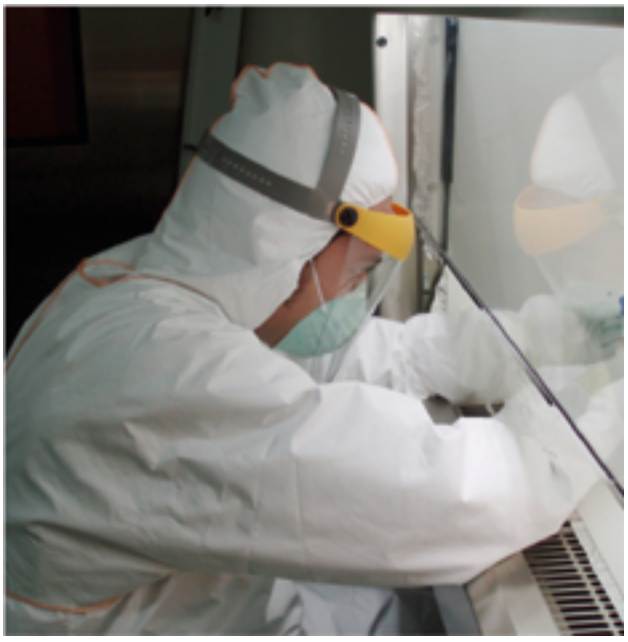
The Covid-19 pandemic has emphasised the need for preparation so we can detect and respond quickly to emerging diseases that may arise in the future. Planning in advance is important to be able to act swiftly. As already mentioned, three out of four emerging infectious diseases are of animal origin and therefore, the key to preventing a future epidemic or pandemic is the adoption of broader and more comprehensive epidemiological surveillance of wildlife, both domestic and wild. It is impossible to know for sure when, where, and what pathogen will next cause a pandemic, but we do know that they will be more likely occur in places where wildlife comes into close contact with domestic fauna and where animals of different species, including humans, coexist. Some examples of these places are live animal markets, both for the trade of exotic animals and livestock, and places with increasing environmental pressure that will bring animals and humans into closer and more permanent contact. Therefore, it is important to find a balance in our relationship with

nature and stop our harmful actions if we want to reduce the risk of new zoonoses.

To answer our initial question, we may not be able to avoid a future pandemic, but we do have tools that can help mitigate the spread of outbreaks with pandemic potential. However, this requires a holistic approach involving experts from all fields (animal, human, and environmental health) together with policy makers, and we must pay closer attention to the reality of communities living in high-risk environments. No single answer, let alone a simple solution, to this problem exists. Nevertheless, we clearly need to invest in surveillance systems and networks, in better management of animal health, and in the conservation of species. While it is true that these programmes and their implementation require considerable economic resources, the risks and economic losses of not doing so are much higher.

In this sense, international organisations such as the World Health Organization (WHO), International Organization for Epizootics (OIE), and United Nations Food and Agriculture Organization (FAO), together with national and international authorities, have joined forces and pooled resources for more than a decade now. But as the recent Covid-19 pandemic has shown, animal surveillance systems must be strengthened for better and more rapid detection, notification, and management of such diseases. Improving responsibility and commitment at the global level is absolutely essential to control future outbreaks and document diseases and the appearance of new animal pathogens. As already noted, to achieve these objectives, every country must increase its investment in the national veterinary services responsible for ensuring animal health and welfare and which are often at the forefront of zoonotic disease management. However, it is also important for national veterinary services to increase their collaboration with wildlife monitoring authorities.

Regarding the origin of SARS-CoV-2, the virus that caused the pandemic during the second decade of the 21st century and which quarantined the entire world, we have already mentioned that bats were the most plausible origin (Zhou et al., 2021). But how and when did the virus evolve to infect the human population? How long has the virus been mutating to better adapt to a particular species or to make a leap between species? There is still a long way to go in this field, but it is important that we continue its exploration. Understanding these mechanisms will help us to predict and avoid future situations like these recent ones, and to be better prepared for what may come. It is also important to note that the work and research being generated around Covid-19 will be useful far beyond this particular virus. It is highly likely that present and future knowledge regarding SARS-CoV-2 can be quickly applied to other fields in the future.



CReSa and the City Blog

Understanding the diseases that affect animals or their environment is essential to prevent future pandemics.

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Finally, let us imagine an illegal wildlife market with a large number of very diverse species all under the same «roof» and all in close contact with each other and with humans. Add poor sanitary conditions to that mix and you have the ideal place for pathogen transmissions, both within and between-species. These are arguably the optimal conditions for microorganisms to easily jump from one individual to another, for small mutations in their genome to occur that will translate into better adaptability to a particular host, a different one, or even a new species. However, we must now lay all the cards down on the table: unfortunately, wildlife trade is an important source of protein for many rural communities. That is precisely why we need to look for alternatives and to avoid illegal trading that has both negative effects on biodiversity and on the conservation of species and natural resources.

Pexels - Frank Barring

It is impossible to know for sure when, where, and what pathogen will be the next one to cause a pandemic, but we do know that they are more likely to originate in places where wildlife comes into close contact with domestic fauna, and where animals of different species, including humans, coexist. Some examples of these places include live animal markets, both for the trade of exotic animals and livestock.

Many of the questions posed here may never be answered or, should they find one, it will take a while. Nonetheless, to avoid future pandemics, we do need to be prepared and it is important to protect and understand wildlife and the environment.

■ SUMMARY AND KEY RECOMMENDATIONS

What have we learned? First of all, we know that zoonoses are natural infections that are transmitted between animals and humans and that, far from disappearing, they have not stopped increasing in recent decades. In addition, and to summarise the content discussed in this review in relation to the causes of zoonoses, we know that they depend mainly on three factors: the aetiological agent causing the disease (a virus, bacterium, fungus, or parasite), the reservoir host or intermediary; and animal–human–environment interactions.

Therefore, in order to prevent, control, and eradicate a zoonosis and reduce the risk of a future pandemic, we must control the reservoirs (epidemiological surveillance), limit potential contact with them, and boost host resistance to zoonotic agents (by applying prophylactic measures). Thus, it is absolutely necessary to establish a network and dialogue between professionals from many fields – mainly public, human, animal, and environmental health – but also with staff from public and private research laboratories, politicians, and sociologists, among others.

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