THE 2030 AGENDA AS A BLUEPRINT

The Ecological and Socio-Economic Factors of Epidemics: Challenges to Planetary Health

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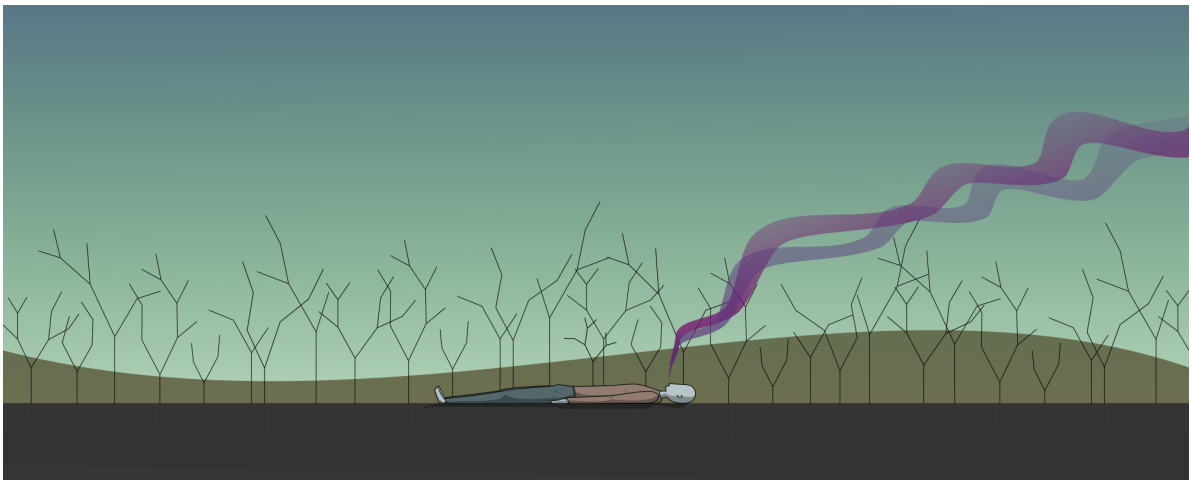

As said by the author, human action has a severe impact on the environment and can lead to the creation and propagation of pandemics. Illustration: "Dead man with dead tree", by Fernando Prado

The emergence of epidemics is closely related to the goals presented in the United Nations' 2030 Agenda. Achieving the Sustainable Development Goals (SDGs) is of utmost importance in preventing pandemics such as the one we are currently faced with. Ensuring healthy lives, promoting the well-being of the human population, ending poverty and hunger, reducing the impact of climate change, making cities sustainable and protecting natural systems are all examples of SDGs that would reduce the likelihood of epidemics occurring. The Covid-19 pandemic allows us to carry out a wide-ranging analysis of the factors that contribute to the emergence of epidemics while also enabling us to reflect on the importance of the 2030 Agenda.

Globalisation and the distribution of pathogens

One of the qualities that defines today's era is the speed at which change occurs and the magnitude of such changes. This has an impact not only on the globalisation of trade and the economy, but also on the distribution of pathogens. At present we are witnessing two different phenomena: first, the shift in the distribution limits of certain diseases, which were previously restricted to specific parts of the planet; and second, the emergence of

previously unknown diseases, such as Covid-19. The distribution of species that have the potential to transmit diseases (we call these species “vectors”) is also changing. A good example is the introduction into Europe of various Asian mosquito species of the Aedes genus, such as the tiger mosquito.

Three quarters of known emerging infectious diseases are zoonotic: in other words, they are transmitted by animals (*zoon* stands for animal, while *nosos* means disease). The term “emerging disease” generally refers to one of the following three scenarios:

1. A known pathogen appearing in a new geographical area .
2. A known pathogen appearing in a species that was previously not susceptible to it .
3. An unknown pathogen that has been detected for the first time .

Wild animals play a key role in the emergence of infectious diseases, as they provide a “zoonotic pool” from which pathogens can emerge. Although this has always been the case, nowadays zoonotic diseases can have an unprecedented impact on the global human population. The majority of human viruses, emerging or otherwise, originated from animals. Examples include HIV, dengue, measles, plague, smallpox, Zika, Middle East Respiratory Syndrome (Mers) and SARS-CoV-2. However, viruses should not be viewed in an entirely negative light, as they have played a key role in the evolution of life. Approximately half of the human genome is made up of genetic material of viral origin.

Human populations have suffered from epidemics since ancient times. Measles first appeared around 2,500 years ago, and may have been linked to the development of the first large cities. Although it is a human morbillivirus, it may have evolved from a type of virus that originated in livestock. Another example is smallpox, whose scientific name, variola, comes from the Latin word viriola, meaning “spotted”. It belongs to the poxvirus family and seems to have evolved from an ancestor that was present in African rodents. Taking all of the above into account, if epidemics have always existed, what has changed now? The answer is simple: it is the frequency with which they occur and the extent to which they spread.

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The Covid-19 pandemic has made humanity sit up and take notice of the potential scope of infectious diseases in today’s globalised world. Many people in the First World thought that viral epidemics were limited to the poorer parts of the planet: now, the Covid-19 pandemic has shown us that the First World is not exempt from the globalisation of diseases. Since the start of the twenty-first century, we have been warned that a phenomenon such as this

could occur. Severe Acute Respiratory Syndrome (Sars) appeared in 2002 and 2003, chiefly affecting Guangzhou, Hong Kong, Taiwan and Canada, with cases exported to many other locations around the world; Mers appeared in 2012, with outbreaks limited to countries in the Arabian Peninsula, although cases were exported to other continents; and the Ebola epidemic began in Central Africa in 2014. It is important to note that these last two epidemics continue to infect people and produce high mortality rates in the Arabian Peninsula and Central Africa, respectively, although we do not hear about it in the media.

How do epidemics occur?

The Covid-19 pandemic has given rise to a number of questions. 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. These questions include: why did the pandemic originate in Southeast Asia and not somewhere else in the world? Why has SARS-CoV-2 only 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?

To answer these questions, we must first understand the conditions that lead to an epidemic involving a virus of animal origin. In order for an epidemic to occur, three conditions must be met:

1. There must be a species leap, i.e. the virus that infected an animal species must also be able to infect humans.
2. The virus has to amplify and affect many people.
3. The virus has to propagate over a large area [1]

What has been happening in recent years? In short, we have been increasing the likelihood that each of these three conditions will be met.

> In recent years, we have been increesing the likelihood that the conditions that create a pandemic will be met

Analysing the causes of an epidemic requires a multidisciplinary approach that provides information on the dynamics of the pathogen in wild animals, the interaction between humans and wild animal species, the anthropogenic pressures on and changes to the environment and their impact on natural systems, the environmental characteristics of the region in question and the socio-economic changes that have taken place in the human societies in the area where the epidemic originated. All of the interdisciplinary information obtained must then be studied and summarised.

Species leap

Many of the emerging zoonotic viruses appear following increased contact between human populations and the animal reservoirs of potentially zoonotic pathogens. Environmental changes can increase the likelihood of this contact and facilitate the species leap or the propagation of the disease. A particularly significant environmental change is the deforestation that is taking place in tropical regions, whether to create space for new human settlements, clear 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. Although these impacts undoubtedly occur, the consequences of deforestation can be far more significant and unpredictable than they might appear at first glance. Some animals abandon the deforested area in search of a new habitat, while others remain. However, after the deforestation has taken place, the animals that remain are much more likely to come into contact with people. They continue to look for food and shelter, and may stray into the farms and houses of the area's new human inhabitants. As a result, certain animals may now enter into contact with humans, when previously it was very difficult for them to do so. 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. This facilitates contact between humans and certain pathogens that were previously more or less isolated in their animal reservoirs.

The rate of deforestation can be particularly high in certain regions: for example, Southeast Asia has lost 30% of its forest cover in the last 40 years, while Cameroon is losing an estimated 800-1,000 km2 of forest each year due to the construction of roads and the expansion of human settlements. In the Amazon, thousands of square kilometres of forest are lost every year: moreover, in this particular region we have observed how deforestation can affect human health. Tropical forests 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: in turn, this creates more areas where mosquitoes can lay eggs, leading to an increase in vector-borne diseases such as dengue, malaria, etc.

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Some authors argue that deforestation in Cameroon has led to increased trade in bushmeat, and thus to increased contact between hunters and wild animals. Various cases of infection have been found in hunters who had handled simian species that were infected with the

Ebola virus. One of the key factors driving the bushmeat trade in Cameroon is the significant (and growing) urban demand for meat, which is closely linked to the commencement of forest concessions. The construction of roads for transporting timber also provides hunters with improved access to areas that were previously difficult to reach [2]. Notwithstanding the above, we should also bear in mind that increased exposure to new pathogens is not always the result of the large-scale exploitation of forests. Poverty can also force people to expand their range of activities in order to survive, pushing them into the forests in search of fresh resources.

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.

There are a number of different ways to reduce the likelihood of potentially zoonotic viruses performing a species leap. First and foremost is improving our understanding of the viruses that exist in nature, learning about their dynamics and identifying their reservoirs [3]. It is very important that we identify the factors that limit the dynamics of these viruses, in order to be able to implement effective prevention measures. It is also vital that we identify potential geographical hotspots of increased zoonotic risk, monitor these areas and develop tools for rapid alert and intervention. We also need to take measures to prevent the trading and consumption of threatened species, while also imposing tighter safety controls on food products.

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. We must bear in mind that the structure and functioning of natural ecosystems is changing at an unprecedented pace due to human activity.

Amplification

For an epidemic to occur, a species leap is not enough: the virus must also infect a large number of people. If it only affects a few, the disease will die out quickly and the outbreak will be very local. Epidemics affecting humans probably appeared when the first large human settlements were developed. Concentrating the population into large cities facilitates the process of amplification; as a result, cities are exposed to epidemics, which is why we must prepare them and protect them against future epidemics. Population growth plays an extremely important role from an epidemiological point of view, as it increases the pressure on natural systems and makes amplification more likely.

Covid-19 is a good example. Wuhan has a humid, subtropical climate. It is the capital of the Chinese province of Hubei and more than nine million people live in its metropolitan area. The city is also a major educational hub, and is home to 1.2 million students. In December 2019, when the first cases of Covid-19 were reported in China, many people had gathered

in Wuhan to celebrate an important festival that brought together thousands of people from around the country. This was followed by celebrations for the Chinese New Year. 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 to amplify Covid-19, which according to our studies appears to have originated some months earlier outside the Wuhan market.

Propagation

After amplification, propagation to other areas, countries or continents must then occur. This requires movement on the part of human populations. Although humans have always moved around, our current levels of mobility are unprecedented in human history, and represent a critical epidemiological factor that increases the risk of disease propagation. For example, approximately 225,000 flights take place around the world every single day. Moreover, these movements are not uniform: most of them coincide with the world's main economic hubs. Wuhan is one of the largest economic and educational centres in China and has multiple links to the rest of the world. It is no surprise that Covid-19 quickly spread to other global economic hubs such as Milan, New York, London, Paris, Madrid and Barcelona, all of which share many interconnections. Amplification also occurred in these cities, after which the virus was spread to other secondary population centres. It is therefore clear that the propagation of Covid-19 is closely linked to the interconnectedness of our globalised world, and that it has also had a major impact on the global economy.

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Covid-19 shares certain traits with another epidemic, which affected Europe from the sixth to the eighth centuries and was known as the Plague of Justinian. The most severe outbreaks occurred in the years 541 and 542, and were caused by a bacteria (*Yersinia*) transmitted by the fleas carried by rats. Recent studies indicate that the pathogen originated in Asia. The epidemic spread throughout the Byzantine Empire, dealing a particularly severe blow to the city of Constantinople and the majority of the port cities in the Mediterranean region. During the two centuries that the epidemic lasted, it is estimated that between 25 and 50 million people died. The consequences were extremely severe and had a major impact on the economy of the Roman Empire, in light of its greatly reduced income from taxation.

Regions rich in biodiversity

Southeast Asia, the tropical and subtropical regions of Africa, Central America and the Amazon are the areas where a species leap is most likely to occur. Although they are all regions with a high level of biodiversity, they are not all equally likely to cause a pandemic. Southeast Asia is an emerging region that is undergoing strong economic growth, increased interconnectivity and major environmental impacts. It is also a densely populated region. These characteristics make it the most likely area to meet the three conditions mentioned above. Central America and the Amazon region are also home to an extremely diverse range of pathogens, as well as markets where wildlife is traded without any food safety controls. However, the population is less dense, particularly in tropical forest areas, and it is not as well-connected to the rest of the world. These factors reduce the likelihood that it will cause a pandemic, although the risk is not eliminated entirely. Instead, epidemics are much more local in scope. Moreover, the native peoples who live in tropical forests are better adapted to the pathogens that exist in their communities. Ebola is a good example: although outbreaks of this disease had occurred in sub-Saharan Africa prior to the 2014 epidemic, they had always been local in scope. Certain African populations have even developed antibodies for the Ebola virus [4]. So what changed in 2014? In recent years there have been environmental and socio-economic changes, including gradual deforestation and, in particular, increased movement of people.

We are part of nature

Often, from our anthropocentric perspective we forget that we are also part of nature. We are the product of this extraordinary life story that began some 3.7 billion years ago. However, for the first time in this story there is a species that is capable of understanding and even modifying and regulating the functions of the natural world, whether in terms of our environment or ourselves as a species. This places enormous responsibility on our shoulders, and we must learn how to manage it. One of the things we must learn as quickly as possible is that resources are finite and that we cannot just do whatever we want, because our actions have consequences — such as pandemics. The natural systems are changing at an unprecedented rate 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 parts 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 (such as the Asian hornet and the box caterpillar). In particular, we must prepare our cities to tackle future epidemics: in this respect, prevention, combined with rapid detection and intervention, will play an essential role.

2030 Agenda

The analysis shows that many factors contribute to the emergence and propagation of an epidemic, and demonstrates the importance of achieving the goals of the 2030 Agenda.

However, these goals cannot be achieved by the actions of governments, public administrations and companies alone: we must all work together. Taking into consideration our aforementioned responsibility as rational beings, the education of future generations — whether at school or university level — plays an absolutely vital role.

REFERÈNCIES BIBLIOGRÀFIQUES

1 — Frutos, R., López-Roig, M., Serra-Cobo, J. i Deavaux, C. (2020). "Covid-19: The conjunction of events leading the coronavirus pandemics and lessons to learn for future threats". *Frontiers in Medecine*. Doi: 10.3389/fmed.2020.00223

2 — Wolfe, N.D., Daszak, P., Kilpatrick, A.M., Burke, D.S. (2005). "Bushmeat Hunting, Deforestation, and Prediction of Zoonotic Disease Emergence". *Emerging Infectious Diseases* 11 (12): 1822-1827.

3 — Serra-Cobo, J., López-Roig, M. (2016). "Bats and emerging infections: an ecological and virological puzzle". *Advances in Microbiology, Infectious Diseases and Public Health* 972: 35-48. DOI: 10.1007/5584_2016_131

4 — Becquart, P., Wauquier, N., Mahlakõiv, T., Nkoghe, D., Padilla, C., Souris, M., Ollomo, B., Gonzalez, J.B., De Lamballerie, X., Kazanji, M. i Leroy, E.M. (2010). "High Prevalence of Both Humoral and Cellular Immunity to Zaire ebolavirus among Rural Populations in Gabon". *PLoS ONE*. DOI: <10.1371/journal.pone.0009126>.

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