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Editorial

Zoonosis: Back to the Future of Parasites, Humans, and Living Together, such is their Destiny

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Most biological pathogens have a zoonotic origin, meaning at some point in the history of our planet, they “spilled over” (i.e., were transmitted) from animals to humans to become pathogens. Today, as human populations expand, urbanize, and encroach on wildlife habitats, interactions at the human–animal–environment interface are more frequent, facilitating these spillover events and increasing the risk of emerging disease in humans. Other factors, as agricultural intensification, wildlife trade, deforestation, and global travel further amplify the risk of such spillover, or cross-species transmission. Once introduced into human populations, some pathogens adapt to efficient human-to-human transmission, leading to outbreaks, epidemics, or pandemics.

Humans and animals have been in contact with each other since the earliest ages of humanity. First, human as prey for large carnivorous beasts, then as hunters, and finally as herders and domesticators of wild animals. As agropastoral societies blossom-med, humans were in constant contact with domestic and wild animals. All along, both humans and animals have been in contact with environmental biological pathogens, either in a synergistic or a parasitic state.

If we consider the course of evolution over the long term, the phenomena of cross-species transmission and host shifts by microorganisms occurred gradually: first among the microorganisms themselves - Earth’s earliest inhabitants - then among animals, and finally, very late in the process, among humans. We may therefore conclude that contemporary zoonoses are merely the modern expression of the evolution of life and the associated organic molecules, such as viruses. Viral spillover is entirely is entirely linked to the chance of encounters while the microbe's need to survive and evolve [1].

Ultimately, "all" viral infections have zoonotic roots. If we discuss the subject of zoonotic risk, viruses are a prime example; for the most part, they cannot survive outside of the host, and infection is their means of survival. But viruses are not part of the tree of life, as they are molecules and sometimes capable of self-replication or, more often, parasitic to a living host that receives them and lends them the necessary cellular machinery for reproduction. Infection is solely the result of the virus's need to reproduce and the chance encounter of the host and this parasitic molecule. The biological agents responsible for zoonoses are, in fact, the normal and millennia-old mechanism of the evolution of symbiosis, in the broadest sense of the term, between the environment, animals, and humans. This microbe “invasion”, which gave rise to infectious diseases, has existed since the first microorganisms appeared on Earth and took the opportunity to infect hosts, which they then exploited in one way or another, as symbionts or parasites, to reproduce, survive and evolve. Therefore, if we consider the Anthropocene era only (0.0000026% of the history of life), diseases have emerged, are emerging, and will continue to emerge; this is the very nature of our coexistence in the same environment of living and non-living biological agents at large. However, microorganisms pathogenic to humans are far less numerous, by at least 20 -to -50-fold orders of magnitude, than those that are beneficial (symbiotic) or entirely independent. It is estimated that approximately 97% of known biological agents are not pathogenic to humans [2,3]. It is also crucial to fully recognize that "living together" entails shared environments and ecosystems, and it is precisely here - within these environments - that microbes are most numerous, living freely and naturally and sometime jumping into animals, humans, or plants. But this is another story.

Nearly a century ago, when Charles Nicolle - winner of the Nobel Prize in Physiology or Medicine (1928) - articulated the fundamental principles underlying the fateful emergence of infectious diseases, as well as the proximity between humans and animals:

> "There will therefore be new diseases. This is an inevitable fact. Another equally inevitable fact is that we will never be able to detect them at their origin.... Infectious diseases did not all appear at once; they will continue to appear as long as humans exist."

This same Charles Nicolle (Nicolle,1933), in his reflections on “the fate of infectious diseases” written in 1933, enriched this concept of emergence with the idea that new diseases would reappear while others would disappear, often thanks to the intelligence and

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efforts of human societies [4]. He shared this vision with his students long before smallpox was eradicated, thus anticipating, with remarkable foresight, the evolutionary and historical dynamics of infectious diseases. Today, in a world still in constant turmoil, the focus in global health is on attempts to eliminate certain diseases. A few have been eradicated (smallpox or rinderpest), some have been advanced in this regard in certain populations or countries (poliomyelitis), while others are still being eradicated (neglected diseases), often hampered by inequality and poverty.

Too often, we are focused on the end game. Arguably, our greatest accomplishment in health was the eradication of smallpox, a unique achievement that was not without great expense as we pursued its final traces to the corners of the globe. But we will achieve global health for all; this is essential to our well-being above all else and to our long-term survival. Indeed, if we are to survive as a species, we must pivot from our focus on the end game, and instead focus on the beginnings, the moments where our symbionts shift from a natural peaceful coexistence to species infiltration. Surveillance and detection are our tools for this effort. Tactically, it makes more sense to observe and prepare for an invasive pest, rather than to only react once the enemies are at the gates.

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