

Three-pronged pandemic prevention

The importance of biodiversity protection for disease prevention is now obvious from evolutionary, ecological and economic angles.

This is our third editorial in six months on the topic of COVID-19. The pandemic is preoccupying, but also the subject of rapid and fascinating research. Our 20 February editorial¹ already called for the protection and monitoring of biodiversity in order to guard against future pandemics, and that remains the key message. However, three recent studies have provided evidence to reinforce that conclusion, and their complementary evolutionary, ecological and economic approaches are worth highlighting.

Since the identification of SARS-CoV-2 and sequencing of its genome², there has been much interest in determining its evolutionary origin. Some of this interest is purely intellectual, but knowing the origin has important applied consequences both for this and future pandemics. Understanding how the virus has evolved can help predict its future trajectory and response to a vaccine; and understanding when and where the virus originated can help prioritize areas and species to monitor for future zoonotic emergence. Such monitoring can work at the level of identifying areas in which to monitor wildlife where there is a risk of spillover, and also help to identify where to monitor hospitals for early signs of an emerging novel pandemic once spillover has occurred.

Writing in *Nature Microbiology*, Boni et al.³ look at patterns of recombination in SARS-CoV-2 and related sarbecoviruses to determine the time since its most recent common ancestor with its closest bat-virus relative, and the possible route it has taken to reach humans. Unlike influenza viruses, recombination is common within subregions of sarbecoviruses, and the authors therefore used three different methods to remove recombined regions from their analyses as they would interfere with phylogenetic conclusions. They found that SARS-CoV-2 diverged from the reservoir of bat sarbecoviruses decades ago, and has presumably been circulating in horseshoe bats since then. They also show that, although the key ACE2 receptor-binding site is similar to that found in pangolin viruses, this is because the bat virus gene

has recombined and diverged, whereas the SARS-CoV-2 one is ancestral. This suggests that, while pangolins may still have had a role in transmission to humans, they were not needed for adapting the bat virus to humans. One major implication of this study is that it is likely that there are related viruses circulating in bats and other species that are already able to reproduce in humans if given the opportunity.

While it is clear that proximity of humans and wildlife is potentially problematic, it is important to note that habitat disturbance is a key factor in tipping the balance from potential to pandemic. Writing in *Nature*, Gibb et al.⁴ assess whether species that are reservoirs for human diseases become more prevalent in disturbed ecosystems. Using global data from the Projecting Responses of Ecological Diversity in Changing Terrestrial Systems (PREDICTS) biodiversity project (not to be confused with the United States Agency for International Development (USAID) PREDICT disease-monitoring programme⁵), they show that the abundances of rodents, bats and passerine birds that have been linked to human diseases tend to increase or remain constant when habitat is disturbed, in contrast to the decreases seen in other species from these same taxa. They also show that this effect is related to certain traits of these species, in particular a fast pace of life, which may simultaneously act as both a buffer against disturbance and offer less immune resistance to disease. Showing this effect on a global scale, defining which taxa it applies to, and providing mechanistic insight into why it happens, has strongly reinforced the message that habitat destruction will lead to more zoonotic disease.

Finally, writing in *Science*, Dobson et al.⁶ tackle the economics of preventing zoonoses through reducing wildlife disturbance. They contrast estimated figures needed to prevent deforestation, reduce and regulate wildlife trade, and monitor disease emergence through programmes such as PREDICT, with the coarsely estimated global cost of the pandemic to national economies. Perhaps unsurprisingly, in almost all scenarios, the cost of prevention over many years

is incredibly small compared with the damage caused by a single pandemic such as COVID-19.

These three studies, and many more like them, drive home a message that disease ecologists have been trying to communicate for years. But such messages have mostly been ignored by governments that had limited direct experience of epidemics. The complementary approaches used in the three studies also ensure that it is difficult to argue that wildlife itself is the problem, rather than the human interaction with it. You can't react to the first study by attempting to decrease the overall amount of biodiversity, because the second study shows that the very act of disturbing wildlife makes the problem worse. And the third study shows that paying each other to stay out of wildlife's way is a very small price to pay.

Now that COVID-19 and the research it is engendering have unequivocally demonstrated the importance of biodiversity to reducing risk of zoonosis, it is critical that these conclusions are taken to heart and acted upon. Prioritizing the Convention on Biological Diversity (CBD) process that will set the biodiversity policy framework for the next decade is one obvious way to do this. Active participation in the development and implementation of CBD targets should be moved higher up the political agenda and firmly integrated with other economic and environmental policy targets. And the full costs of disease must be included in economic calculations about the costs and benefits of biodiversity protection — to emphasize to political leaders the manifest value of these investments. □

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