Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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Preventing bat-born viral outbreaks in future using ecological interventions

The Coronavirus Disease 2019 (COVID-19) outbreak caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) was reported for the first time in December 2019, Wuhan, China (Khan et al., 2020). The COVID-19 then rapidly spread from the epicentre globally, and now characterized as a pandemic by the World Health Organization (World Health Organization, 2020). The high transmissibility of SARS-CoV-2, the lack of specific treatment and vaccines, and the unstoppable spread of infection have recently caused global health emergency, fear, and psychological stress among the public (Cohen and Kupferschmidt, 2020). Like SARS-CoV-2, other viruses including Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV), Middle East Respiratory Syndrome Coronavirus (MERS-CoV), Marburg virus, and Ebola virus, have caused major outbreaks in history. These outbreaks caused large numbers of fatalities, morbidities, and cost billions of dollars, worldwide (Allocati et al., 2016; Fan et al., 2019). Bats are reported as a natural reservoir for these viruses, especially coronaviruses (CoVs) which constitute approximately, 31% of their virome (Allocati et al., 2016; Afelt et al., 2018). These viruses are transmitted to humans either directly or *via* intermediate hosts (Chan et al., 2013; Allocati et al., 2016). Furthermore, higher species diversity (over 1400), longer lifespan (over 30 years), resistance to viral infection, and migration make them a huge reservoir for pathogens and give them higher chances to transmit pathogens to other species in vast areas (Allocati et al., 2016; Frick et al., 2019; Banerjee et al., 2020). In 207 bat species, 5717 bat-associated animal viruses have been detected in 77 different countries (Allocati et al., 2016). However, the elusive and nocturnal habits make them difficult to be studied (Frick et al., 2019) therefore, there could be more deadly viruses with epidemic and pandemic potentials if other bats species are studied.

Although bats are beneficial to our ecosystem, excessive deforestation, urbanization, and expanding the human population have altered the ecological niche of bats (Walsh et al., 2017). With the increasing demands of the growing population, deforestation and using land for agriculture have increased. For example, only the Southeast Asia (SEA) lost 30% of forest cover over the last 40 years. Furthermore, the population in SEA is expected to rise to 250 million by 2030 compared to 130 million between 2001 and 2011 (Afelt et al., 2018). In response to deforestation and urbanization, biodiversity, especially bats populations are adapting and setting up in the anthropized rural and urbanized environments, closer to human dwellings (Jung and Threlfall, 2018; Li et al., 2019). The anthropization near the vicinity of human populations generates a highly diverse environment that allows and accepts a wide range of bat species not encountered together before (Walsh et al., 2017; Jung and Threlfall, 2018). As a result, both bat diversity and bat-borne viruses increase close to human dwelling. The house light attracts insectivorous bats for insects, fields and orchards attract frugivorous bats, and barns and houses attract cave-dwelling bats. The interaction of higher bat diversity can lead to a higher concentration of bat-borne viruses which can be transmitted to human through direct contact, contamination by feces or urine, or domestic animal infection (Jung and Threlfall, 2018). Furthermore, the traits including gathering/grouping during roosting and feeding and unique adaptive immune systems are responsible for the persistent mixing of different viruses that can lead to generate recombinant, novel mutant, and/or reassortant RNA viruses (Chan et al., 2013). Therefore, bat-borne viruses could emerge in future with significant potential for causing epidemics and pandemics. Therefore, surveillance and monitoring are required in areas where humans and bats are closely interacting with each other. Our suggestions could help to prevent bat-borne viral outbreaks in future if seriously implemented.

1. **Forestation:** Deforestations are linked with the bat-borne viral outbreaks (Olivero et al., 2017). Therefore, there is an urgent need to stop deforestation and invest in afforestation and reforestation globally. In response to the viral outbreaks, billions of dollars are spent on eradicating the infection, providing services to humans, and developing diagnostic, treatment, and vaccination strategies. However, no or less attention is given to the primary level of prevention such as forestation and respecting wildlife habitats. The world should realize the importance of forests and the biodiversity carrying deadly viruses.
2. **Controlling human population growth:** China is the most populous country in the world and has experienced three large-scale bat origin COVs epidemics (Fan et al., 2019; Khan et al., 2020). Similarly, other bats related epidemics have been reported in areas with higher human population growth (Plowright et al., 2015). Therefore, there is a need to control human population growth. The unstoppable increase in human population growth will lead to deforestation for resources and land for agriculture and will expose those bat populations having novel deadly viruses.
3. **Bat hunting and consumption:** In Asia, about 56 bat species are hunted and consumed (Mildenstein et al., 2016). Furthermore, live slaughtering, handling, and consumption of undercooked bat meat may enhance viral transmission (Chan et al., 2013; Fan et al., 2019). Therefore, there is a need to stop bat hunting and consumption and raise public awareness about the risks associated with bats handling.
4. **Global ban on wildlife trade:** The unregulated wildlife trade can increase the risks of emerging new viruses with pandemic potentials as observed in the case of COVID-19 and other outbreaks (Boseley, 2020). Therefore, considering the national security, biosafety, public health, and economic issues, it is essential to stop the wildlife trade globally.
5. **Surveillance and monitoring:** Globally, extensive surveillance and monitoring wildlife, domestic animals, and humans are urgent and essential to predict emerging bat-borne viruses. The surveillance will provide immediate information about the source, intermediate host, information about where and when the spillovers occurred, and which virus has the potential to cause an outbreak.

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6. **Ecological research:** Research like investigating emerging viruses, ecological health, disease ecology, eco-evolutionary dynamics, wildlife population dynamics, and outbreak investigation and preparedness strategy knowledge is needed to control the spread of zoonotic pathogens and protect the global community.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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