

One Health approach is a pre-requisite to control SARS-CoV-2 pandemic

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The coronavirus disease of 2019 (COVID-19) caused by severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2) is the first pandemic and third zoonotic epidemic by a coronavirus. Failure to detect coronaviruses closely similar to SARS-CoV-2 in non-human animals to identify intermediate host of the pandemic renders all efforts as unsuccessful. However, several studies indicated that albeit bat being the natural host for SARS-CoV-2, it is not involved directly in disseminating virus to human; yet unknown, non-bat intermediate host(s) does the same. Possibility of pangolin to act as an intermediate species facilitating transmission of the virus to humans has been documented. Moreover, recent evidence has identified pangolins as potential reservoir species themselves. Identifying the intermediate host(s) is worthwhile with the aim to break a transmission chain of zoonotic event(s) that lead to the COVID-19 pandemic.

Likewise, reports of reverse zoonosis i.e., human-to-animal transmission of SAR-CoV-2 induced COVID-19 infections, which occurred naturally, were documented in companion (dogs, cats, ferrets), zoo (feline species and gorillas), farmed (mink), and wild (white-tailed deer) animals (Hale *et al.*, 2022). Reports of reverse zoonosis of COVID-19 have surfaced from various European countries, viz. Germany, Belgium, Denmark, Netherlands, France, Spain; United States of America, Canada; as well as Asian countries like China

and Thailand (Jo *et al.*, 2021). Predicted binding between angiotensin converting enzyme 2 (ACE2) receptor and spike protein of SARS-CoV-2, as observed in an *in silico* study, indicated that species of cetaceans, rodents, primates, and cervids had the highest risk for infection (Damas *et al.*, 2020). In order to develop an animal model for COVID-19, experimental inoculations were given to non-human primates, cats, dogs, raccoon dogs, North American deer mice, hamsters, ferrets, American minks, Asian small clawed otters, white-tailed deer, and Egyptian fruit bats. Consequently, the animals were found to be highly susceptible to SARS-CoV-2 infection (Murphy and Ly, 2021). To avoid reverse zoonosis and plausible secondary zoonotic event(s), detection of animals vulnerable to SARS-CoV-2 would be quite expedient. It will also assist in strengthening One Health approaches to control SARS-CoV-2 pandemic in future.

Prevalence, distribution, and genetic variation of SARS-CoV-2 strains were identified in free-ranging deers across Ohio, which raised one pertinent question. How did the virus get transmitted from man to deer? It was assumed that widespread human SARS-CoV-2 infections combined with human-wildlife interactions might have created the possibility of reverse zoonosis events from humans to wildlife. As the chances of evolution of SARS-CoV-2 are high, it becomes quite pertinent to determine

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specific virus lineages associated with infection, transmission, disease and persistence in deer (Jo *et al.*, 2021).

For virus transmission, species barrier was observed prominently, while experimental infection with SARS-CoV-2 was set up in some animals with poor virus replication (cattle, pig and dog) or no replication at all (poultry). Moreover, successive experiments revealing low level permissiveness of SARS-CoV-2 in pigs indicated plausible spillover in new animals after few mutations and genetic adaptation.

Evidence of secondary zoonosis encompassing animal to human SARS-CoV-2 infections were clearly noted in minks during mid of 2020 and in Syrian hamsters during initial 2022. In both the cases, after getting infections from animals (mink and hamster), human to human transmissions were also imminent. These incidents pointed out the potential of SARS-CoV-2 to adapt wider range of animals for its long-term existence on earth. Interestingly, evidence of human to animal and subsequent animal to animal transmission could also be found in mink farms of Netherlands, where SARS-CoV-2 spread took place between caged minks and stray cats. Surprisingly, SARS-CoV-2-positive minks were detected in several fur farms in Denmark (n=290), Netherlands (n=69), Sweden (n=13), Greece (n=23), USA (n=17), and Lithuania (n=4). Moreover, 2 mink farms in Canada and one each in Italy, Latvia, Poland, France, and Spain were also affected. On necropsy, lungs involvement was observed in the infected minks (Oreshkova *et al.*, 2020). Further, an outbreak in minks had an obvious connection either with the farmers or their family members, who showed symptoms of COVID-19 and/or were PCR-positive for SARS-CoV-2. Phylogenetic comparison of human and mink-

derived SARS-CoV-2 sequences proved that virus transmission might have happened from infected minks to humans (Fenollar *et al.*, 2021). Besides, several stray cats used for loitering at the mink-farms also tested positive serologically for SARS-CoV-2-specific antibodies, indicating the existence of animal-to-human and animal-to-animal transmission.

Airborne transmission of SARS-CoV-2 between cats might also be possible (Shi *et al.*, 2020). Both genetic and epidemiological results revealed that there were two independent incidences of hamster-to-human transmission. Further, it is anticipated that pet hamsters were naturally infected, which caused virus circulation within hamsters leading to human infections (Yen *et al.*, 2022). It was opined that SARS-CoV-2 might spill over to other unsuspected animal species and acted as a secondary reservoir for the virus, causing further adaptation and zoonotic spillover to humans.

Repeated interspecies transmission of SARS-CoV-2 infections may accelerate its evolution potential with generation of successive mutations upon selective pressure. The situation might be suitable for the virus for its long-term existence, but definitely not for humans.

Rigorous epidemiological surveillance studies based on the One Health approach should be given priority to identify susceptible domestic and free-ranged animals who might act as a potent reservoir(s) of SARS-CoV-2 infection threats to the lives of humans and animals. To control the present pandemic, strategic intervention for breaking potential transmissibility within and across animal species is warranted. In short, awareness, surveillance and rapid response for the plausible animal reservoirs of coronaviruses; besides appropriate quarantine and control policies are the need of hour for the animal and human welfare.

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