

## Anthropogenic Ecological Changes and Spill Over of Viruses-A Review

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### Abstract

Biodiversity protects ecosystem against infectious diseases. Increased human contact with wild life have caused high impact diseases such as SARS, Novel Corona virus, Nipah Virus, Ebola fever and many more. Anthropogenic activities such as hunting, farming, human encroachments, wild life trade, introduction of domestic species, bush meat hunting, road building, mining and increased human wildlife contact rates have lead to massive decline in biodiversity and increased risk of spilling over of dangerous viruses from animals to humans primarily due to host shifts. Human preference to high meat diet is also on rise in many countries. Wet markets have significant contribution in amplifying epizootic virus transmission and increased human exposure. Species in the primate and bat orders harbor a number of zoonotic viruses. Our destruction of nature, loss of habitat and biodiversity possibly tend to promote viral emergence. Invasion of undisturbed places leads to more and more exposure and create habitat where viral transmission is easier. Interference with a natural environment/habitat can, therefore, worsen the health risks. The erosion of biodiversity may lead to proliferation of species that are most likely to transmit new diseases to humans. Preserving habitat, biodiversity and natural environment is therefore one of the essential issues that cannot be put at the back any more.



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### Introduction


In this world of rapid globalization, the essential issues that is far more important for humans have been losing sight of. One is the importance of preserving the environment and our bio-diversity.<sup>1</sup> With increased spillover of infectious diseases from

wildlife to humans, there is loss of biodiversity at a disturbing rate.<sup>2</sup> Researchers have concluded that biodiversity protects ecosystems against infectious diseases.<sup>3</sup> Loss of species can be dangerous for the spread of pandemics.<sup>4</sup> Newly emerging viruses from wildlife hosts such as Severe Acute Respiratory

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Syndrome (SARS), Novel Corona virus, Ebola fever, Hantaviruses, Marburg viruses, Nipah virus, Hendra virus, Human Immunodeficiency Virus type 1 (HIV-1), HIV-2, and Influenza are shown to have negative impact on public health.<sup>5</sup> Studies show that Zoonotic diseases (an infection that is transmissible between humans and animals), results in severe illness and hence death of more than two billion people every year.<sup>6</sup> The root cause of these diseases is possibly increased human contact with wildlife. Transmission of viruses from domesticated animals to humans is far more than wild mammal species.<sup>7</sup> Contribution of rodents, bats and primates has been found to be approx 75% in hosting the viruses.<sup>6</sup> It is believed that like other viral diseases transmission of Covid-19 pandemic is also due to close contact between wildlife and human life, and is a recent example of host switching from animals to humans. The major driver of similar emerging infectious diseases is the 'spill-over' of pathogens from domestic to wildlife animals fostered by the most common factor i.e. anthropogenic movements to new geographic locations, known as 'pathogen pollution'.<sup>8,9,10</sup>

Anthropogenic activities leading to erosion in biodiversity has increased the risk of spillover of viruses. A number of infectious diseases have emerged over the time and rapidly transmitted within human populations owing to various anthropogenic reasons such as globalization in trade and increased contact of human and wildlife.<sup>5</sup>

#### **Disturbance in Food Chain**

Infectious agents interact with both hosts and non-hosts via food webs and ecosystem.<sup>11</sup> Humans get almost 80% of their calories from vegetable sources, fruits and grains, and remaining 20% is from meat, poultry and fish. But since, 1985 the trend has changed and people are feeding more on non-vegetarian sources leading to rise in meat-to-plant ratio, India and China contributing most towards it.<sup>12</sup> These countries have been able to support high meat diets due to advancement in their economy. This change in ratio may cause disturbance in natural food chain leading to invasion of humans in the animal habitat posing a threat to the biodiversity.<sup>13</sup> As the meat consuming population has increased over the years swiftly, the chances of food-borne pathogens have also increased immensely, esp. from pigs and chickens,<sup>14,15</sup> thus creating an

enormous diversity in the wildlife – livestock- human interfaces and consequently the enhanced risk of zoonotic diseases.<sup>16,17</sup> In countries like India, the lack of education and abandoning infected animals have worsened the issues of infectious diseases.<sup>18</sup>

#### **Cross Species Transmissions**

Researchers suggest that outbreak of zoonosis is on rise as pathogens are transmitted very quickly from animals to humans and subsequently to new places. Scientific studies suggest that almost 75% of all emerging diseases infecting human population are zoonotic i.e. of animal origin.<sup>19</sup> There are number of reports<sup>20</sup> which suggest that large percentage of diseases that infect humans originate in animals.<sup>21</sup> Wildlife rich natural environment harbors a number of viruses and pathogens which have threatened humans recurrently in terms of their potential to cause new diseases<sup>22</sup> as the source for novel corona virus was linked to Bats and Pangolins, although genetic analysis suggested an unidentified animal as well.<sup>23</sup> Anthropogenic activities have consistently increased the spillover of viruses as the NIPAH virus in Malaysia advanced due to intensive pig farming resulting in epizootic virus transmission.<sup>24</sup> The NIPAH is, therefore an example of infectious disease emergence due to human induced ecological changes as the cultivation of orchards attracted fruit bats (genus *Pteropus*), reservoirs of NIPAH virus. Similarly, H5N1 virus infection is another example of cross species transmission.<sup>5</sup>

#### **Ecological Changes Brought about by Humans can Impact Disease Emergence**

Zoonotic viruses are mostly contained in the primates and related species. The major factors promoting viral emergence are the geographical distribution of host species, wildlife trade, inclusion of domestic species, the behavioral separation and loss in habitat and biodiversity. Deforestation, habitat destruction and fragmentation, and conversion into anthropogenic environments are the immediate contributors of zoonotic diseases.<sup>25</sup> The cutting of trees, killing of animals, caging them and sending them to markets disrupts the whole ecosystem and releases the viruses lose from their natural hosts which requires a new host usually a human. The corona outbreak, emergence of Ebola pandemic and other dreadful diseases are directly linked to the environmental change and human behavior.<sup>26</sup> Climate change is presumably one important

underlying driver of disease emergence in a number of cases, for instance directly transmitted pathogens (e.g., hantavirus, Ebola virus) and vector-borne or water-borne diseases, such as malaria, dengue, and cholera.<sup>27-32</sup> Human activities such as logging, mining, road building and rapid urbanization due to population growth has intervened the wildlife and many species have come in closer contact with each other. The cost of human economic development is the birth of several zoonotic diseases.<sup>22</sup> Such zoonoses are possible due to various factors such as , worldwide travel, trade, agriculture expansion, deforestation, habitat destruction, and urbanization resulting in increase of contact between human population and domestic as well as wild animals, and hence increasing spillover events.<sup>33,24</sup> Lederberg *et al.*<sup>34</sup> called such events as 'Epidemiological bridge' that accelerates the link between agent and naïve population. Invasion of undisturbed places leads to greater exposure and creation of habitats where transmission of viruses is easier including exposure to new ones. Anthropogenic activities *viz.* disturbing the forests and habitats are responsible for the real damage to the natural environment and health risks associated with it.

#### **Rodents and some Bats Thrive when we Disrupt Natural Habitats**

Bats are identified as the natural hosts for most of the known CoVs in humans.<sup>35</sup> Chinese Rhinolophid bats were found to have a genetically diverse form of SARS-CoVs. Similarly, from Chinese horseshoe bats (family: Rhinolophidae) in Yunnan province another two novel CoVs were abstracted, which were found to be similar to SARS-CoV clearly indicating the Chinese horseshoe bats to be the natural reservoirs of SARS-CoV.<sup>36,37</sup> These SARS like CoVs require animal hosts and undergo some mutations, as they cannot directly affect the humans<sup>38</sup> *viz.* the civet and camel are the intermediate hosts of SARS-CoV2 and MERS-CoV. Erosion of biodiversity leads to proliferation of species that may transmit new diseases. As discussed earlier bats have been found to be reservoir of viruses.<sup>39</sup> However, Bats are losing its habitat at a frightful rate. It has been hypothesized that few incidents such as climate change, forest fires and associated haze have greatly affected the flying fox movements.<sup>40</sup> The forests, which are used by bats for its food and roosting are disappearing at an alarming rate due to urbanization. The possible

causes can be human disturbances such as guano mining, tourism, the wind energy production, hunting and commercial bushmeat trade which may cause hindrance in winter hibernation of bats resulting in decline in bat population.<sup>41</sup> Twenty four bat species are enlisted as critically endangered by IUCN (International Union for Conservation of Nature).<sup>42</sup> Bats act as reservoir hosts for various emerging as well as existing viruses (Rabies, Lyssaviruses, Hendra and Nipah, Henipaviruses, Ebola and Marburg filoviruses, and SARS corona virus), without getting infected themselves.<sup>43,44</sup> A research study states that bat have rapid rate of host transmission without causing any pathogenicity to the hosts.<sup>45</sup> They have an advanced interferon pathway which protects their cells from mortality resulting in a persistent infection. Bats themselves do not show any remarkable symptom as its antiviral defense system keeps the viruses in check.<sup>45</sup> However, other species that comes in their contact may not have such advanced immune system and hence can be badly affected by the rapidly evolving viruses leading to generation of new deadly viral diseases. As contact between intermediate and hosts is a prerequisite for virus transmission therefore optimum separation by geographical, ecological and behavioral factors may prove to be helpful in stopping the spread. The CoVs which are of pangolin origin are found to be 99 % identical with SARS-CoV-2, inferring the SARS-CoV2 to be of pangolin origin too.<sup>46</sup>

#### **Conclusion**

A novel interaction between a number of species in one place either in natural environments or in wet markets increased the chances of spill over events. Man made ecological changes coupled with interference with natural habitat, directly or indirectly leads to destruction in biodiversity. Animals, a rich source of biodiversity are openly slaughtered and sold in urban markets with no drainage.<sup>18</sup> Anthropogenic activities have resulted in over exploitation of wildlife raising the spillover the viruses. There is a need to be attentive towards the interaction of human life with wildlife. A safe co-existence with wildlife can keep us away from such pandemics otherwise wildlife has more viruses to give us. Unless or until we educate and aware the people about ecological disruptions driving diseases, we should prepare ourselves for worst possible scenario i.e the next one will certainly

come. Conservation of biodiversity and natural environment is a crucial step for the present time and is the need of hour. As coronavirus rampages through the world, there has been an unintended side effect-cleaner air and cleaner water, because of the lack of anthropogenic activities. In a very real sense, nature has bounced back.<sup>1</sup> The essential learning from corona crisis is "Man is only the guest of nature". It is high time for a clear understanding of what truly matters for our future.

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#### Conflicts of interest

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#### References

1. Back to 'essentials' is one positive from corona crisis. <https://www.tribuneindia.com/news/comment/back-to-essentials-is-one-positive-from-corona-crisis-73078>. *The Tribune*. Retrieved on April 19, 2020.
2. The University of Montana. "Does biodiversity loss leads to an increased disease risk?" *ScienceDaily*. [www.sciencedaily.com/releases/2018/07/180718152240.htm](http://www.sciencedaily.com/releases/2018/07/180718152240.htm). 18 July 2018. Retrieved on May 10, 2020.
3. Keesing F, Belden L K, Daszak P, Dobson A, Harvell C D, Holt R D *et al*. *Nature*. 2010; 468: 647-652.
4. Gilbert N. More species means less disease. *Nature* (2010). <https://doi.org/10.1038/news.2010.644>. Published on Dec 01, 2010. Retrieved on May 10, 2020.
5. Parrish C R, Holmes E C, Morens D M, Park E C, Burke D, Calisher C H *et al*. Cross-Species Virus Transmission and the Emergence of New Epidemic Diseases. *Microbiol. Mol. Biol. Rev.* 2008; 72(3): 457-470
6. John Vidal. Human impact on wildlife to blame for spread of viruses, says study. *The Guardian*. <https://www.theguardian.com/environment/2020/apr/08/human-impact-on-wildlife-to-blame-for-spread-of-viruses-says-study-aoe>. Published on Apr 08, 2020. Retrieved on Apr 17, 2020.
7. Field HE. Bats and emerging zoonoses: henipaviruses and SARS. *Zoonoses Public Health*. 2009;56(6-7):278-284. doi:10.1111/j.1863-2378.2008.01218.x
8. Cunningham A.A, Disease risks of wildlife translocations. *Conserv. Biol.*1996; 10: 349–353.
9. Daszak P, Cunningham AA, Hyatt AD. Emerging infectious diseases of wildlife--threats to biodiversity and human health [published correction appears in *Science* 2000 Mar 10; 287(5459):1756]. *Science*. 2000;287(5452):443-449. doi:10.1126/science.287.5452.443
10. Vitousek PM, Mooney HA, Lubchenco J, Melillo JM. Human domination of the earth's ecosystems. *Science*. 1997; 277: 494–499.
11. Selakovic S, de Ruiter PC, Heesterbeek H. Infectious disease agents mediate interaction in food webs and ecosystems. *Proc Biol Sci*. 2014;281(1777):20132709. Published 2014 Jan 8. doi:10.1098/rspb.2013.2709
12. Doucleff M. Between pigs and anchovies: Where humans rank on the food chain. NPR. <https://www.npr.org/sections/thesalt/2013/12/08/249227181/between-pigs-and-anchovies-where-humans-rank-on-the-food-chain>. Published on Dec 08, 2013. Retrieved on Apr 17, 2020
13. Bonhommeau S, Dubroca L, Pape OL, Barde J, Kaplan DM, Chassot E, Nieblas A. Eating up the world's food web. *Proceedings of the National Academy of Sciences*. 2013; 110 (51): 2061720620; DOI: 10.1073/pnas.1305827110
14. CIWF (2013) Zoonotic Diseases Human Health and Farm Animal Welfare Report. [https://www.ciwf.org.uk/media /37561\\_23/Zoonotic-diseases-human-health-and-farm-animal-welfare-16-page-report.pdf](https://www.ciwf.org.uk/media /37561_23/Zoonotic-diseases-human-health-and-farm-animal-welfare-16-page-report.pdf)
15. Gilbert M, Conchedda G, Van Boeckel TP, *et al*. Income Disparities and the Global Distribution of Intensively Farmed Chicken

- and Pigs. *PLoS One*. 2015;10(7):e0133381. Published 2015 Jul 31. doi:10.1371/journal.pone.0133381
16. Jones BA, Grace D, Kock R, *et al*. Zoonosis emergence linked to agricultural intensification and environmental change. *Proc Natl Acad Sci U S A*. 2013;110(21):8399-8404. doi:10.1073/pnas.1208059110
  17. Hassell JM, Begon M, Ward MJ, Fèvre EM. Urbanization and Disease Emergence: Dynamics at the Wildlife-Livestock-Human Interface. *Trends Ecol Evol*. 2017;32(1):55-67. doi:10.1016/j.tree.2016.09.012
  18. Chauhan AS, George MS, Lindahl J, Grace D, Kakkar M. Community, system and policy level drivers of bovine tuberculosis in smallholder periurban dairy farms in India: a qualitative enquiry. *BMC Public Health*. 2019;19(1):301. Published 2019 Mar 13. doi:10.1186/s12889-019-6634-3
  19. Taylor LH, Latham SM, Woolhouse ME. Risk factors for human disease emergence. *Philos Trans R Soc Lond B Biol Sci*. 2001;356(1411):983-989. doi:10.1098/rstb.2001.0888
  20. A survey of Zoonoses programmes in the Americas. Rio de Janeiro, Brazil. Pan-American Foot- and- Mouth disease center (PANAFTOSA) of the Pan American Health Organisation; 2016. 1-11.
  21. Jones KE, Patel NG, Levy MA, *et al*. Global trends in emerging infectious diseases. *Nature*. 2008;451(7181):990-993. doi:10.1038/nature06536
  22. John Vidal. Tip of the iceberg': is our destruction of nature responsible for Covid-19? The Guardian. <https://www.theguardian.com/environment/2020/mar/18/tip-of-the-iceberg-is-our-destruction-of-nature-responsible-for-covid-19-aoe>. Published on Mar 18, 2020. Retrieved on Apr 17, 2020.
  23. Lam TT, Jia N, Zhang YW, *et al*. Identifying SARS-CoV-2-related coronaviruses in Malayan pangolins. *Nature*. 2020;583(7815):282-285. doi:10.1038/s41586-020-2169-0
  24. Daszak P, Cunningham AA, Hyatt AD. Anthropogenic environmental change and the emergence of infectious diseases in wildlife. *Acta Trop*. 2001;78(2):103-116. doi:10.1016/s0001-706x(00)00179-0
  25. Sehgal RN. Deforestation and avian infectious diseases. *J Exp Biol*. 2010;213(6):955-960. doi:10.1242/jeb.037663
  26. Jim Robbins. The ecology of disease. The Newyork times. July 14, 2012.
  27. Lafferty KD. The ecology of climate change and infectious diseases. *Ecology*. 2009;90(4):888-900. doi:10.1890/08-0079.1
  28. Rogers DJ, Randolph SE. Climate change and vector-borne diseases. *Adv Parasitol*. 2006;62:345-381. doi:10.1016/S0065-308X(05)62010-6
  29. Patz JA, Olson SH, Uejio CK, Gibbs HK. Disease emergence from global climate and land use change. *Med Clin North Am*. 2008;92(6):1473-xii. doi:10.1016/j.mcna.2008.07.007
  30. Gubler DJ, Reiter P, Ebi KL, Yap W, Nasci R, Patz JA. Climate variability and change in the United States: potential impacts on vector- and rodent-borne diseases. *Environ Health Perspect*. 2001;109 Suppl 2 (Suppl 2):223-233. doi:10.1289/ehp.109-1240669
  31. Kolivras KN. Changes in dengue risk potential in Hawaii, USA, due to climate variability and change. *Clim Res*. 2010; 42(1):1-11.
  32. Mills JN, Gage KL, Khan AS. Potential influence of climate change on vector-borne and zoonotic diseases: a review and proposed research plan. *Environ Health Perspect*. 2010;118(11):1507-1514. doi:10.1289/ehp.0901389
  33. Daszak P, Cunningham AA, Hyatt AD. Emerging infectious diseases of wildlife--threats to biodiversity and human health [published correction appears in *Science* 2000 Mar 10;287(5459):1756]. *Science*. 2000;287(5452):443-449. doi:10.1126/science.287.5452.443
  34. Lederberg J, Shope RE, Oaks SC. Emerging Infections: Microbial Threats to Health in the United States. *National Academy Press*, Washington; 1992.
  35. Vijaykrishna D, Smith GJ, Zhang JX, Peiris JS, Chen H, Guan Y. Evolutionary insights into the ecology of coronaviruses [published correction appears in *J Virol*. 2007 Aug;81(15):8371]. *J Virol*. 2007;81(8):4012-4020. doi:10.1128/JVI.02605-06
  36. Ge XY, Li JL, Yang XL, *et al*. Isolation

- and characterization of a bat SARS-like coronavirus that uses the ACE2 receptor. *Nature*. 2013;503(7477):535-538. doi:10.1038/nature12711
37. Lau SK, Woo PC, Li KS, *et al*. Severe acute respiratory syndrome coronavirus-like virus in Chinese horseshoe bats. *Proc Natl Acad Sci U S A*. 2005;102(39):14040-14045. doi:10.1073/pnas.0506735102
38. Corman VM, Muth D, Niemeyer D, Drosten C. Hosts and Sources of Endemic Human Coronaviruses. *Adv Virus Res*. 2018;100:163-188. doi:10.1016/bs.aivir.2018.01.001
39. Calisher CH, Childs JE, Field HE, Holmes KV, Schountz T. Bats: important reservoir hosts of emerging viruses. *Clin Microbiol Rev*. 2006;19(3):531-545. doi:10.1128/CMR.00017-06
40. Chua KB. Nipah virus outbreak in Malaysia. *J Clin Virol*. 2003;26(3):265-275. doi:10.1016/s1386-6532(02)00268-8
41. Why bats are threatened? <http://www.batcon.org/why-bats/bats-are/bats-are-threatened>. Retrieved on April 06, 2020.
42. Bats. <https://defenders.org/wildlife/bats>. Retrieved on April 06, 2020.
43. Halpin K, Young PL, Field HE, Mackenzie JS. Isolation of Hendra virus from pteropid bats: a natural reservoir of Hendra virus. *J Gen Virol*. 2000;81(Pt 8):1927-1932. doi:10.1099/0022-1317-81-8-1927
44. Young PL, Halpin K, Selleck PW, *et al*. Serologic evidence for the presence in Pteropus bats of a paramyxovirus related to equine morbillivirus. *Emerg Infect Dis*. 1996;2(3):239-240. doi:10.3201/eid0203.960315
45. Brook CE, Boots M, Chandran K, *et al*. Accelerated viral dynamics in bat cell lines, with implications for zoonotic emergence. *Elife*. 2020;9:e48401. Published 2020 Feb 3. doi:10.7554/eLife.48401
46. Lam TT, Jia N, Zhang YW, *et al*. Identifying SARS-CoV-2-related coronaviruses in Malayan pangolins. *Nature*. 2020;583(7815):282-285. doi:10.1038/s41586-020-2169-0