Emerging zoonotic infectious diseases and accelerating anthropogenic change: the critical need for one health and planetary health perspectives

Essay Summary

The Anthropocene is characterized by accelerating ecological changes including climate change, forest fragmentation, agricultural land use and urbanisation. These are impacting our global ecosystems, altering the ecology of zoonotic infectious disease transmission and resulting in their increased emergence. Climate change is causing distributional shifts in mosquito and tick-borne infectious diseases such as Dengue and Crimean Congo Haemorrhagic fever, as well as waterborne diseases such as Cholera, leading to their increased impact. Forest fragmentation results in increased human exposure to wildlife zoonotic disease hosts, thus increasing the rise of diseases such as Ebola and Nipah. Agricultural land use has numerous effects on disease emergence; increasing human contact with zoonotic hosts (such as in Lassa Fever) whilst intensive farming involves mixing of wildlife and livestock causing interspecies transmission and amplification of zoonotic diseases (as seen in Avian Influenza and Japanese Encephalitis). Urbanisation creates ideal environments for the emergence of infectious diseases such as Lymphatic filariasis in the slums of low and middle income (LMIC) cities. Their globalised nature acts as a catalyst for the international spread of diseases such as SARS. The accelerating rate of anthropogenic change means that the 21st century will undoubtedly see significant increases in many other emerging zoonotic infectious diseases. The use of one health and planetary health perspectives to appreciate the role of anthropogenic change in this emergence is essential for us to prepare for, limit the impact of and prevent future outbreaks of these diseases

Essay

There is an increasing paradigm shift regarding the role of one and planetary health related factors in the emergence of zoonotic infectious diseases. Despite the decreasing overall trend in global infectious disease prevalence, they are still a significant threat, accounting for 20% of the global burden of disease and underpinning over 80% of international health hazards. Most importantly, zoonotic infectious diseases specifically account for 75% of all emerging pathogens in the past decade.(Murray et al, 2012) However, we have now entered the “Anthropocene era”, defined as the “the period of time during which human activities have had an environmental impact on the Earth regarded as constituting a distinct geological age.”(Merriam-webster.com, 2018) The Anthropocene is characterised by ecological changes including rapid climate change, forest fragmentation, altered agricultural land use and marked urbanisation. These accelerating changes are impacting global ecosystems, thus altering the ecology of zoonotic infectious disease transmission and resulting in their increased burden and emergence. I will structure this essay by outlining the four main anthropogenic ecological changes and use several case studies to outline how they promote increased emergence of zoonotic infectious diseases.

Climate Change

The first anthropogenic ecological change I focus on is climate change. Based on current trends, global temperatures will rise to 2 degrees centigrade (oC) above pre-industrial levels by 2050 and 3.2oC by 2100. (Intergovermental Panel on Climate Change, 2018) The resultant cascade of climactic changes have been described by the Lancet Countdown on Climate Change and Health as the ‘greatest threat to human health in the

21st century.'(Watts et al, 2018) A significant aspect of this health threat is the increased emergence and burden of infectious diseases, with the IPPC report in 2018 stating that climate change 'is causing local changes in temperature and rainfall thus altering the distribution of some disease vectors and water borne diseases.' (Intergovermental Panel on Climate Change, 2018)

With regard to zoonotic vector distributional changes, there are two main climate sensitive vectors: mosquitoes and ticks. Mosquitoes are climate sensitive, with increased temperatures causing a global increase in the vectoral capacity of Aedes Aegypti for dengue transmission of 3.0% compared with 1990 levels, and of 9.4% compared with 1950 levels. Since 1990, the annual numbers of dengue cases has doubled every decade and climate change is a significant driver of this. (Watts et al, 2018) Future climate predictions indicate not only an increased dengue transmission in endemic areas such as East Africa, but, more significantly, the establishment of dengue in current non-endemic areas such as North America and East Asia. Additionally, climate change will increase the severity of El Nino events, which will result in the increased intensity of current epidemic waves of dengue across South East Asia. (Watts et al, 2018) It is important to realise that Aedes Aegypti also carries other emerging zoonotic arboviruses including Chikungunya, Mayaro and Zika. These are likely to be similarly responsive to climate change due to their shared vector, and so their increased incidence is expected.

Tick vectors are also extremely climate sensitive, with recent research demonstrating the global expansion of common tick species into non-endemic areas (where cold winter temperatures previously limited their distribution). One example is the expansion of Crimean Congo Haemorrhagic Fever into southern Europe due to increased temperatures (which allow survival of tick vectors) and climate influenced changes in host bird migratory patterns. Similarly, climate change-induced temperature rises have been proposed as a significant driver of the increase of Lyme disease in the USA and Europe as well as the expansion of Severe fever with thrombocytopenia syndrome in East Asia. (Al-Abri et al, 2017).

Finally, cholera is the prime example of water borne disease emergence. Endemic cholera is predicted to increase due to warming seas which lead to an improved habitat for algal blooms, increasing endemic cholera expansion and its establishment in previously non-endemic areas such the Baltic Sea.(Lipp and Huq, 2002).

Forest Fragmentation

The next anthropogenic ecological change is the land use-induced change of forest fragmentation. Forest fragmentation is defined as the 'breaking of large, contiguous, forested areas into smaller pieces of forest, typically separated by roads, agriculture, utility corridors, subdivisions, or other human development.'(Adepoju and Salami, 2017) Deforestation is increasing globally, with 29.4 million hectares lost in 2017, particularly in tropical forests in Africa and Asia. (Global Forest Watch Institute, 2018) Human settlements which are in close proximity to forest margins that have been fragmented by deforestation are at heightened risk of exposure to animal reservoirs of zoonotic diseases and thus at increased risk of contracting zoonotic infections. Therefore, increasing deforestation and forest fragmentation is likely to promote the increased emergence of zoonotic infectious diseases globally. I shall illustrate this using two examples of Ebola and Nipah.

In the 2014-2016 West African Ebola outbreak, contact tracing determined that patient zero was a four-year-old in a rural Sierra Leone village who had direct contact with a fruit bat. Post-outbreak research revealed a high level of forest fragmentation in this area. Ebola spillover events to humans from wildlife reservoirs (which include fruit bat reservoirs and non-human primate intermediate hosts) typically occur in relatively populated forested areas where deforestation is increasing forest fragmentation. (Rulli and Santini, 2017) In these areas, there is increased human exposure to host wildlife either directly through physical contact or indirectly through increased consumption of bushmeat. Increasing deforestation and further forest fragmentation in West Africa is likely to cause future Ebola outbreaks.

Nipah virus is an emerging Hepniavirus with a mortality rate of 70%. The hosts are pteropid fruit-bats and viral transmission is through direct contact with bats, domestic animal infection such as pigs or contamination of food by urine or faeces. Again, forest fragmentation is being proposed as a key driver of Nipah emergence, as forest fragmentation in these regions has led to increased habitats for bats within rural settlements. This results in increased bat diversity and hence increased diversity and concentration of bat borne viruses next to human dwellings. Notable outbreaks to date include Malaysia 1999, recurrent Bangladeshi outbreaks throughout the 2000s and the 2018 outbreak in Kerala. Again, future outbreaks are predicted due to increasing forest fragmentation in South and South-East Asia. (Afelt and Frutos, 2018).

Agricultural land use change

Agricultural land covers 38.4% of the global land area and is increasing rapidly, particularly in Africa and Asia. This has numerous implications for the emergence of zoonotic infectious diseases, particularly at ecotones, which are transition zones between adjacent ecological systems. In these areas, wildlife and livestock mix creating ideal conditions for zoonotic diseases which involve both wildlife and livestock in their transmission cycle.

The conversion of non-farmed land to cropland has caused the emergence of the zoonotic haemorrhagic virus Lassa fever in West Africa. There has been an increasing frequency and intensity of outbreaks, particularly in Nigeria. The host for Lassa Fever is the Natal multimammate mouse, which is a common agricultural and household pest. The conversion of savanna to grasslands and croplands has led to an increasing mouse population resulting in increased spill over due to human contact. (Redding and Moses, 2016) Agricultural water management activities can also lead to increases in water-borne zoonotic infectious diseases. As an example, Rift Valley Fever epidemics in East Africa have been linked to the creation of dams and irrigation canals, as these provide increased breeding sites for mosquitoes. (Pepin et al, 2010) Similarly, fasciolosis rates have increased in incidence in Egypt as the snail hosts of this disease have adapted to the irrigation systems of the Nile Delta.(Mas-Coma and Valero, 2005).

The expansion of intensive farming in agriculture can lead to higher risk of zoonotic infectious disease emergence. The expansion of Japanese Encephalitis in South East Asia due to the combined increases of irrigated rice production and pig farming is one such example. The combination of irrigated fields (which increase the density of vectors and water bird hosts) and farming of pigs (which are the amplifying intermediate hosts) increases the risk of virus spillover into humans. (Metelka, 2015) Avian influenza emergence, which is arguably the most serious threat to global health, is also rooted in intensive and extensive farming practices, particularly in Asia. Rice paddies with adjacent duck farming in wetland areas bring wild water birds into close proximity with domestic water birds, thereby increasing the risk of influenza virus spillover from the reservoir host of wild birds to domestic water birds. The subsequent viral evolution and amplification into intensively farmed domestic poultry and pigs leads to the risk of human transmission. (Jones et al, 2013) Finally, there is increasing evidence that MERS emergence is linked to dromedary camel livestock with the spillover of MERS from it's bat reservoir. (Reusken and Raj, 2016).

Urbanisation

The final anthropogenic change is urbanisation. According to the UN, 55% of the global population lives in urban areas, and this is projected to increase to 68% by 2050, particularly in Africa and Asia. (UN DESA, 2018) These new urban centres and megacities will provide ideal settings for infectious disease emergence, as they can act as incubators for emerging infectious diseases and their globalised nature will allow their rapid evolution into global threats.

The increased epidemic potential is mainly related to the high prevalence of slums in LMIC cities. In sub-Saharan Africa, 62% of the urban population lives in slums. (UN DESA, 2018) The inadequate sanitation, poor housing and high population endemic to slums provides ripe opportunity for the emergence of numerous infectious diseases. Mosquito borne diseases such as dengue increase due to the adaptability of their vectors to the urban environment. (Neiderud, 2015) Soil transmitted Helminth infections such as lymphatic filariasis (which were traditionally rural diseases) are rapidly increasing in urban slum populations due to highly unsanitary conditions. Increased slum rodent populations lead to disease emergence, such as the massive increases of Seoul hantavirus haemorrhagic fever seen in Chinese cities. (Guan and Huang, 2009).

Urban centres can also act as catalysts for the rapid spread of emerging infectious diseases. Their high population densities allowing for their amplification into epidemics. Their globalised features of international trade and travel can lead to the rapid evolution of pandemics such as 2003 SARS outbreak.

Conclusion

Anthropogenic change is promoting the increased global emergence of zoonotic infectious diseases in several ways, and it is clear that we must look at their emergence through the lens of both one health and planetary health.

Whilst I separated specific diseases into specific anthropogenic changes above, the reality is that these changes do not occur in a vacuum, and there are usually multiple anthropogenic changes influencing the emergence of single diseases. Dengue increases in Latin America are being driven by both climate change and urbanization, whilst the most serious Nipah virus outbreak was caused by both forest fragmentation and intensive pig farming. (Afelt and Frutos, 2018) It is the cumulative effect of these ecological changes upon zoonotic infectious disease transmission that is increasing their global emergence. This should be counteracted by increased research into the complex nature of these influences upon transmission to enable us to unravel the specific factors that promote zoonotic infectious disease emergence.

The accelerating rate of anthropogenic change means that that the 21st century will see significant increases in emerging zoonotic infectious diseases. The use of both one health and planetary health perspectives on the role of ecological change in their emergence is essential. This will allow us to better understand the root causes of their emergence, and enable humanity to tackle them at their source to minimize their impact, and, ideally, prevent future outbreaks.

Biography

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