 doi:10.20944/preprints202006.0040.v1

We need to address the underlying ecological determinants of COVID-19

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Word Count: 1409

Keywords: COVID-19; SARS-CoV-2; zoonoses; ecological; epistemology

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 4 June 2020 doi:10.20944/preprints202006.0040.v1

Abstract

The probability of zoonoses, such as the novel coronavirus (COVID-19), emerging is strongly related to remediable factors such as habitat encroachment and trade in wild animals. Tackling these underlying determinants is important to prevent future pandemics from the approximately 700,000 viruses with the potential to cause zoonoses. Reversing habitat destruction is also vital to halt the accelerating rate of extinction of a wide array of life forms - with all the adverse consequences these extinctions will have for human health. These insights depend on viewing health and disease from within an ecological theoretical framework. We therefore argue that preventing future zoonotic outbreaks as well as dealing with a range of contemporary health issues would be facilitated by grounding our health sciences in more a more explicitly ecological conceptual framework.

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The novel coronavirus (COVID-19) pandemic was not inevitable. Phylogenetic analyses reveal that COVID-19 was likely transmitted to humans from bats in the Yunnan province, China or from pangolins [1-4]. Whilst we cannot be sure of the route of transmission, bat zoonoses frequently result from human encroachment on wildlife areas [4-7], whereas transmission from pangolins is likely linked to their trade and consumption [3]. These transmission routes could be blocked via reducing encroachment and banning the trade and consumption of wild animals [2, 6-9]. Considering that there are an estimated 631,000 to 827,000 unidentified viruses that have zoonotic potential and that the same risk factors are likely to be key to the emergence of these as zoonoses it would be wise to use the current outbreak to address these underlying determinants [10]. This kind of reasoning stems from viewing disease within an ecological framework [9, 11]. In this article we make a broader claim about the utility of ecological thinking and suggest that a range of contemporary and future health crises would be better anticipated, comprehended and responded to if the health sciences were to more explicitly embrace an eco-social theoretical framework of health and disease.

The need for an explicitly eco-social theory of health

Theories are vital to structure our ideas so as to bring facts together in a way that they form a coherent whole and explain the causal connections between the facts [12, 13]. An optimal theory of the determinants of health and disease should provide an accurate portrayal of all the important determinants in a way that illustrates the interrelationships, the relative importance of the various determinants and facilitates proportionate and effective responses to threats to health [13]. If the theory conceals

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certain determinants or privileges certain causes over others, then it should be replaced by a theory which does not do this [13, 14].

An example of a necessary transition in theory, was the switch from miasmatic theories to the germ theory in the late 19th century [13]. Microbes were identified as being responsible for specific diseases and soon thought by many to be the major cause of disease [12]. In the ensuing decades further evidence would emerge to back up this theory of specific diseases being caused by specific agents: specific micronutrient deficiencies and particular toxin or occupational exposures were shown to be responsible for specific diseases and later on the link was made between specific genetic changes and individual diseases [13]. Thus specific environmental, microbiological and nutritional agents were thought to explain the majority of disease by the end of the 19th century [14]. This led to spectacular breakthroughs such as the development of numerous highly effective vaccines and laid the foundation of the biomedical individualist model of health and disease which has been the dominant theory for the health sciences over the past century [12, 15].

Unfortunately, this theory also led to a myopic focus on individual, cellular and subcellular levels at the expense of considering what was happening at population levels [12-15]. Critical ecological concepts such as carrying capacity and the relationship between biodiversity and emergence of zoonoses were largely ignored [12, 15, 16]. One of the results is that ecosystems around the world have been deteriorating for decades and the health sector has, until recently, paid little attention [15, 17-20]. As an example, our individual level focus has led us to pay close attention to individual species of medical interest, such as population dynamics of individual

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insect species responsible for arbovirus transmission but largely miss the fact that the total insect biomass has declined between 76% and 60-fold over the past few decades in different world regions [21, 22]. An estimated 40% of all insect species are now threatened with extinction [23]. Other phyla have experienced comparable declines [24] with overall extinction rates now being estimated to being 10 to 1000-fold higher than baseline rates [25, 26]. The consequences are vast for both planetary- and human-health. To take but one example, bees play a key role in food security through their role as pollinators [23]. They have however been dying in such numbers that in numerous regions bees now have to be artificially trucked in to pollinate fruit trees [23].

What underpins these massive population-declines and extinctions? Whilst factors such as global warming and widespread pesticide usage are important, habitat destruction is the principal cause [23, 26, 27]. Habitat destruction is thus driving not only the emergence of new zoonoses but also mass extinctions. An important ecological principle as far as habitat loss is concerned, is that the sustainable number of species declines by the fourth root of the habitable area [16, 26, 27]. Based on this and other considerations, prominent ecologists have estimated that around half the world's land and sea area needs to be left in its natural state to allow ecosystems to flourish and prevent ongoing mass extinction [26-28]. Currently only 13% of the land and 3% of the oceans are protected [26]. Approximately 40% of the world's land area is used for farming, of which three-quarters is used for livestock production [29, 30]. This physical encroachment has been accompanied by a larger syndrome of anthropogenic environmental changes such as greenhouse gas emissions and disruption of the global cycles of phosphorus, nitrogen, sulphur and rain water [15, 26]. Overall, it is estimated that we are currently exceeding the earth's biocapacity by at

least 50% [15]. Humans are crowding other life forms out of existence [31]. We have allowed individuals and corporations to divide the world up according to the right to unlimited private property without considering the ecological consequences (Figure 1)[23, 26, 31]. An ecological framework of health would take as one of its starting points the need to sustain a healthy environment – the basic foundation of health [19, 27]. If this requires 50% of the world's surface area to be protected, then this should be the target. Part of this 50% could be protected in a way that allows both biodiversity conservation and sustainable use [27]. Much of the remaining 50% would be required for food production [26, 30]. Given their considerably lower ecological footprints, vegetarian diets would need to be prioritized [19, 32, 33]. Likewise, consumption of wild animals would be discouraged so as to prevent the emergence of zoonoses [6, 9]. Of course, these considerations involve value judgements that cannot be imposed on populations [15, 27, 34]. The ecological perspective does, however, provide strong guidance as to what would be best for planetary and human health [15, 18].

The social component of eco-social

For three reasons, environmental reforms should be accomplished in a way that promotes a more egalitarian distribution of resources between people. Firstly, if resources are finite and 20% of the population consumes 80% of the resources, then the other 80% of the population will have to make do with the left-over 20%, which will likely be below the minimum required for health for some (Figure 1) [15]. Secondly, an extensive array of research has established that social and economic equity is good for health. Equality has been associated with a healthier social-fabric that results in lower violent crime rates, better mental health and improved overall health including longer life expectancy [35]. Thirdly, reforms cutting the human footprint are unlikely to

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be accepted by those living in destitution unless the brunt of the reform is disproportionately borne by the wealthy [15].

A range of health problems are better understood from an ecological framework

Cogent arguments have been made that a range of other health problems are best understood from eco-social perspectives. This includes the One Health perspective on antimicrobial resistance [36], increases in zoonotic and non-zoonotic infectious diseases [11], decreased diversity of the microbiota in westernized populations [37] and increased obesity and allergies in various populations around the world [15, 36, 38].

Conclusion

An important lesson of the COVID-19 pandemic is that humans uncontrolled consumption is placing excessive pressure on natural ecosystems. Unless reversed, the anthropogenic destruction of habitats will lead to the emergence of new zoonoses and accelerated extinction rates [23, 26, 27]. We might disagree on how much to reduce human's footprint and how best to accomplish this, but the evidence that we need to do this is undeniable [15, 20]. Reaching this conclusion does however require thinking at an ecological level. In our considered opinion, the prevention of future zoonotic pandemics and related crises will be assisted by the health sciences embracing an explicitly eco-social theoretical framework of health and disease.

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Figure 1. A schematic representation of interactions between humans, new zoonoses (represented by pangolins) and global ecosystems according to biomedical-individualist- (a) and ecological-conceptual frameworks (b). The individualist framework most closely approximates the contemporary situation where the world has been divided up between humans with little regard to planetary health and capacity. The majority of the world's resources are controlled by a minority of the human population (size of humans proportional to their ecological footprint) leaving the remainder of the resources over for the rest of humanity and other lifeforms. The combination of destitution, encroachment, appetite for wild meat and lack of regulation, result in a high exposure to bats and a large trade in wild meat [9]. These factors create a selection pressure for the emergence of zoonoses [4]. The human encroachment on the park, for example, leads to high exposure to bats which increases the probability of a spillover of a coronavirus that is preadapted to spread in humans [4, 39]. Biodiversity (represented by different colored birds) is crowded out by humans. In the ecological framework (b), natural ecosystems (forests) are allowed to flourish in roughly half the planet's surface area and there is a more equitable division of resources between people who occupy the remaining half. This plus cultural and legal sanctions against the consumption of wild meat dramatically reduce the probability of new zoonoses emerging. Biodiversity is ultimately able to return to pre-Anthropocene extinction levels.

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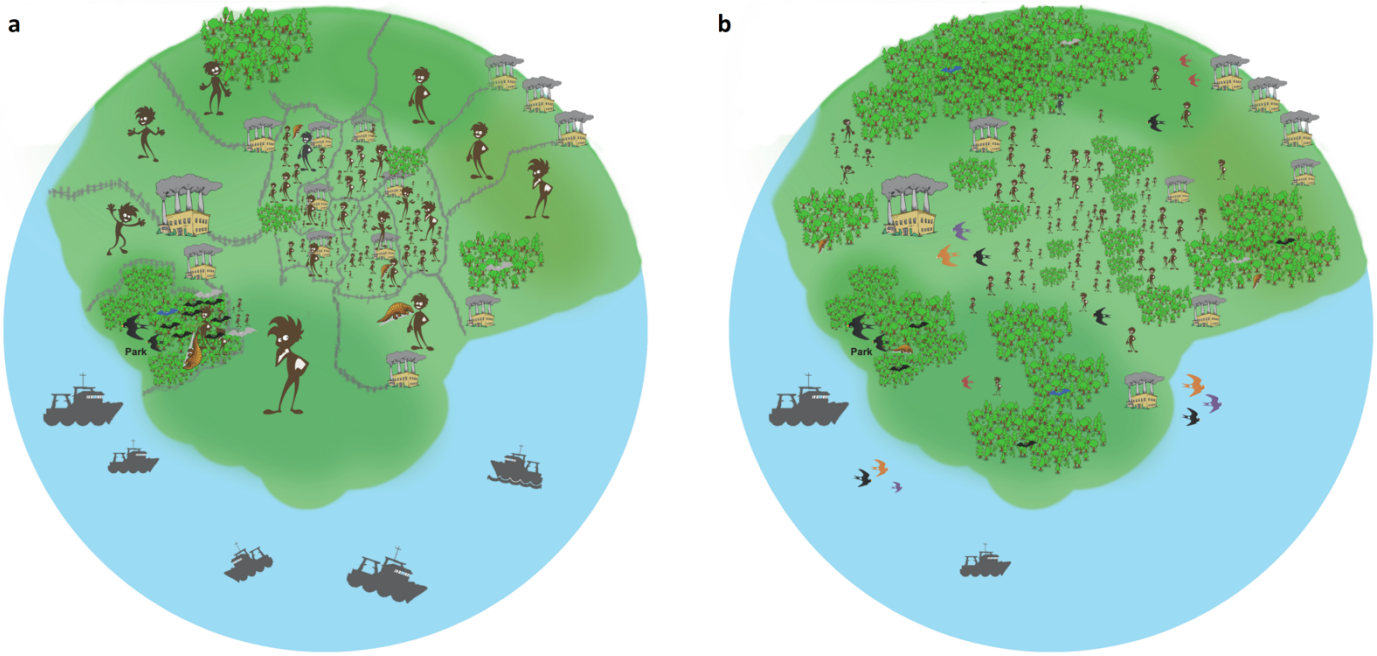

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