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SARS-CoV-2 emergence and diffusion: a new disease manifesting human-environment interactions and a global geography of health

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Abstract

SARS-CoV-2, and the disease it causes, COVID-19, is sweeping through the world, disrupting human activities everywhere. The consequences of this on-going event on societies are yet to be fully understood. The emergence of SARS-CoV-2 illustrates how human-environment interaction should be framing research on pathogen spillover. Furthermore, the geography of human contacts at various scales in our globalized and urbanized world affects its diffusion. Both elements plead for a robust backbone of geography of health, including land use, to understanding disease emergence and diffusion.

Keywords

Virus spillovers; infectious diseases; human-environment interactions; geography of health; land use

At the time of writing, 31 million cases of COVID-19 have been recorded worldwide (source: https://coronavirus.jhu.edu/map.html). The death toll is nearing a million, and the social, economic and associated health burden has been or may become far reaching [1–5]. While the pandemic is not behind us and will likely not be for months, we can already reflect on the geography of this historical event and the features that make it eminently spatial, environmental, and the manifestation of our complex relationships with our surroundings and the natural environment.

Framing the COVID-19 pandemic as a spatial, health-environment issue and identifying research priorities requires first to distinguish two phases. First, the emergence of a novel pathogenic virus, meaning its jump from a host species to the human species (also called "spillover" event), possibly through an intermediate host. Second, once in the human species, its diffusion by contagion through the world population.

The emergence of a novel pathogen as a manifestation of food systems

Since the first reports of a pneumonia of unidentified source in Wuhan, China, in December 2019, much has been said about wet markets in the region, and the role of various species as possible hosts (bats) and intermediate hosts (pangolins) [6,7]. Wet markets represent hot zones for spillovers and pathogen emergence of a range of viruses including coronaviruses and influenza viruses [8]. While there is currently a large consensus in the scientific community on the natural origin of the virus, precise knowledge about the location, timing and species involved in the spillover event is still lacking [9]. Therefore, it is important, rather than focusing on one specific context favorable to cross species transmission, to consider the ecological and evolutionary features of this process from the point of view of the virus. If we consider the spillover event as permitted by spatial and temporal overlap between wild and domestic species, and between wild species and humans, then wet markets offers plentiful opportunities, as has been observed for instance for influenza viruses [10,11]. These interactions point at various elements of food systems, the networks of activities related to, among others, food production, marketing and consumption. Extensive research now demonstrates that many geographic contexts offer opportunities for viruses to spillover (e.g. modes of livestock rearing, forest encroachment, urban growth), also for coronaviruses [12,13]. Bats, as a large reservoir, may play a prominent role [14], but that should not mean that we could focus on single human infrastructures or landscapes as such. It is only through transdisciplinary research keeping robust ecological questions at the center that we will be able to identify socio-ecological contexts relevant to pathogen emergence. Understanding the features of land use permissive of pathogen emergence, rather than land use types in particular, is key to tapping the potential of land management, as a spatial- and temporal-scale wise accessible risk assessment tool.

Rapid and large-scale diffusion as a manifestation of a globalized and urbanized population

While spillovers occurring in very rural, sparsely populated areas may bear little consequences at the global scale, the story can take a different turn when we consider that the world population is now in majority urban [15]. Several features of our emerging urban world are relevant to sustaining the contagious transmission that can lead to wide reaching diffusion. Many cities have large populations, growing at a sustained rate, thus having a large number of human hosts susceptible to a novel pathogen. Many are also getting increasingly dense, thus favoring large numbers of contagion-permitting contacts. The larger the clusters, the more connected they are to their hinterland and other places, including at the international level [16,17]. A geography of contact rates at various scales (local, national, international) is clearly at play in this pandemic. Further spatial covariates are likely to emerge when a thorough evaluation of the effects

of exogenous factors such as socio-demographics, economy and possibly pollution, as well as endogenous epidemic dynamic is carried out [18–20].

Epidemics affecting land use

In many areas, the pandemic of COVID-19 has acted as a magnifying lens on many fragilities of societies throughout the world [2]. Populations supporting themselves through informal economic activities, in countries with loose or no social safety nets, have been hard hit and this is true when looking at food production, distribution and consumption, and by extension to land use. There is a possibility that the production of food, goods and services will get reorganized spatially, both at the worker and the business level. Some countries have seen a surge in demand for locally produced food. The persistence of these changes is uncertain at this point, but the potential consequences of changes in consumption patterns may, like the virus, reach distant corners of food production systems and the livelihood of vulnerable food producers. This, in itself, will constitute a relevant area of research in the coming months.

Going forward with health-environment research

In our new (post-)COVID-19 world, what land use changes should we anticipate that may affect virus emergence risk, or more broadly association between health and the environment? We should strive to see beyond the wet market/pangolin issue and structure our thoughts around ecological processes permitting virus to spill over and use new niches, such as urbanized human populations, through the ways their food is produced, marketed and consumed. How human activities create favorable conditions for this jump is at the center of this question. The COVID-19 pandemic is joining several pathogen emergence events that we have witnessed over the past few decades [21], but is bringing a harsh light to many different aspects of a global geography of health, a research area that has a very clear and urgent place in the field of global change research.

References

1. McKee M, Stuckler D: **If the world fails to protect the economy, COVID-19 will damage health not just now but also in the future**. *Nat Med* 2020, **26**:640–642.

2. Lambert H, Gupte J, Fletcher H, Hammond L, Lowe N, Pelling M, Raina N, Shahid T, Shanks K: **COVID-19 as a global challenge: towards an inclusive and sustainable future**. *Lancet Planet Health* 2020, doi:10.1016/S2542-5196(20)30168-6.

3. Dinmohamed AG, Visser O, Verhoeven RHA, Louwman MWJ, van Nederveen FH, Willems SM, Merkx MAW, Lemmens VEPP, Nagtegaal ID, Siesling S: **Fewer cancer diagnoses during the COVID-19 epidemic in the Netherlands**. *Lancet Oncol* 2020, **21**:750–751.

4. Divala T, Burke RM, Ndeketa L, Corbett EL, MacPherson P: **Africa faces difficult choices in responding to COVID-19**. *The Lancet* 2020, **395**:1611.

5. Holmes EA, O'Connor RC, Perry VH, Tracey I, Wessely S, Arseneault L, Ballard C, Christensen H, Cohen Silver R, Everall I, et al.: **Multidisciplinary research priorities for the COVID-19 pandemic: a call for action for mental health science**. *Lancet Psychiatry* 2020, **7**:547–560.

6. Wu F, Zhao S, Yu B, Chen Y-M, Wang W, Song Z-G, Hu Y, Tao Z-W, Tian J-H, Pei Y-Y, et al.: **A new coronavirus associated with human respiratory disease in China**. *Nature* 2020, **579**:265–269.

7. Lam TT-Y, Shum MH-H, Zhu H-C, Tong Y-G, Ni X-B, Liao Y-S, Wei W, Cheung WY-M, Li W-J, Li L-F, et al.: **Identifying SARS-CoV-2 related coronaviruses in Malayan pangolins**. *Nature* 2020, doi:10.1038/s41586-020-2169-0.

8. Webster RG: **Wet markets—a continuing source of severe acute respiratory syndrome and influenza?** *The Lancet* 2004, **363**:234–236.

** Discussion on the role of wet markets in virus emergence throughout the world and on regulatory options for these and other contexts

9. Andersen KG, Rambaut A, Lipkin WI, Holmes EC, Garry RF: **The proximal origin of SARS-CoV-2**. *Nat Med* 2020, **26**:450–452.

*Discussion on the origins of SARS-COV-2

10. Gilbert M, Chaitaweesub P, Parakamawongsa T, Premashthira S, Tiensin T, Kalpravidh W, Wagner H, Slingenbergh J: **Free-grazing Ducks and Highly Pathogenic Avian Influenza, Thailand**. *Emerg Infect Dis* 2006, **12**:227–234.

11. Wang X, Jiang H, Wu P, Uyeki TM, Feng L, Lai S, Wang L, Huo X, Xu K, Chen E, et al.: **Epidemiology of avian influenza A H7N9 virus in human beings across five epidemics in mainland China, 2013–17: an epidemiological study of laboratory-confirmed case series**. *Lancet Infect Dis* 2017, **17**:822–832.

12. Johnson CK, Hitchens PL, Pandit PS, Rushmore J, Evans TS, Young CCW, Doyle MM: **Global shifts in mammalian population trends reveal key predictors of virus spillover risk**. *Proc R Soc B Biol Sci* 2020, **287**:20192736.

13. Li H, Mendelsohn E, Zong C, Zhang W, Hagan E, Wang N, Li S, Yan H, Huang H, Zhu G, et al.: **Human-animal interactions and bat coronavirus spillover potential among rural residents in Southern China**. *Biosaf Health* 2019, **1**:84–90.

14. Wang L-F, Anderson DE: **Viruses in bats and potential spillover to animals and humans**. *Curr Opin Virol* 2019, **34**:79–89.

15. United Nations, Department of Economic and Social Affairs, Population Division: *World urbanization prospects: 2018 : highlights*. 2019.

16. Rodrigue J-P, Luke M, Osterholm: **Transportation and Pandemics**. *Geogr Transp Syst* 2020,

17. Luke TC, Rodrigue J-P: **Protecting public health and globalfeight transportation systems during an influenza pandemic**. *Am J Disaster Med* 2008,

18. Bontempi E: **Commercial exchanges instead of air pollution as possible origin of COVID-19 initial diffusion phase in Italy: More efforts are necessary to address interdisciplinary research**. *Environ Res* 2020, **188**:109775.

19. Bialek S, Bowen V, Chow N, Curns A, Gierke R, Hall A, Hugues M, Pilivishi T, Ritchey M, Roguski K, et al.: **Geographic differences in COVID-19 cases, deaths, and incidence - United States, February 12-April 7, 2020**. *MMWR Morb Mortal Wkly Rep* 2020,

20. Mollalo A, Vahedi B, Rivera KM: **GIS-based spatial modeling of COVID-19 incidence rate in the continental United States**. *Sci Total Environ* 2020, **728**:138884.

21. Vanwambeke SO, Linard C, Gilbert M: **Emerging challenges of infectious diseases as a feature of land systems**. *Curr Opin Environ Sustain* 2019, **38**:31–36.

**a more extensive discussion of some of the arguments discussed here