

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

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**Sophie O Vanwambeke<sup>1</sup>, Catherine Linard<sup>2,3</sup>,  
Marius Gilbert<sup>4,5</sup> and Simon Dellicour<sup>6,7</sup>**

<sup>1</sup> Georges Lemaître Centre for Earth and Climate Research, Earth & Life Institute, UCLouvain, Place Pasteur 3, 1348 Louvain-la-Neuve, Belgium

<sup>2</sup> Institute of Life–Earth–Environment (ILEE), Université de Namur, Rue de Bruxelles 61, 5000 Namur, Belgium

<sup>3</sup> Namur Research Institute for Life Sciences (Narilis), Université de Namur, Rue de Bruxelles 61, 5000 Namur, Belgium

<sup>4</sup> Spatial Epidemiology Lab (SpELL), Université Libre de Bruxelles, CP264/03, Av. F. Roosevelt, 50, 1050 Brussels, Belgium

<sup>5</sup> Fonds National de la Recherche Scientifique, Brussels, Belgium

<sup>6</sup> Spatial Epidemiology Lab (SpELL), Université Libre de Bruxelles, CP160/12 Av. F. Roosevelt, 50, 1050 Brussels, Belgium

<sup>7</sup> Department of Microbiology, Immunology and Transplantation, Rega Institute, KU Leuven, Herestraat 49, 3000 Leuven, Belgium  
e-mail: [Sophie.vanwambeke@uclouvain.be](mailto:Sophie.vanwambeke@uclouvain.be)

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.

At the time of writing, 35 million cases of COVID-19 have been recorded worldwide (source: <https://coronavirus.jhu.edu/map.html>). The death toll is now over 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 interaction between wild and domestic species, and between wild species and humans, then wet markets offers plentiful opportunities, but so do other contexts, 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 spill over, also for coronaviruses (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.

### Conflict of interest

We declare no conflict of interest.

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### References and recommended reading

Papers of particular interest, published within the period of review, have been highlighted as:

- of special interest
- of outstanding interest

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A more extensive discussion of some of the arguments discussed here.