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ORIGINAL SCHOLARSHIP

Global change increases zoonotic risk, COVID-19 changes risk perceptions: a plea for urban nature connectedness

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ABSTRACT

Ebola and COVID-19 are textbook emerging diseases influenced by humans. Ebola is often considered a result of exotic nature threatening health. Conversely, COVID-19, emerged in an urban environment, entails risks worldwide. Geographical, virological and demographic differences influence risk perceptions and responses to both diseases. Because ecological understanding of urban human-animal relations improves disease risk assessment, we call for ethnographical exploration of this interface. 'Global Urban Confinement Measures' impact health by influencing disease perceptions, limiting nature access, and strengthening inequities. To prevent and mitigate zoonotic pandemics and their consequences, policy should promote nature connectedness, concert with stakeholders, and integrate nature-city-inhabitant interactions.

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Different risk perceptions with different zoonoses: towards 'shared risk'?

While COVID-19 dominates global news, comparisons are made with another well-known zoonosis: 'Ebola Virus Disease (EVD)', especially its 2014 West African episode. Like EVD, COVID-19 originated from viral spill-over from animals, but it resulted in a totally different epidemiology and societal response. As starting point for reconsidering the role of nature in cities, we focus on the striking extent to which COVID-19 surpasses EVD in global economic impact and societal response. The central position of China's economy, with interlinkages worldwide, has been proposed as a driver of this phenomenon (Maffioli 2020). We argue that their different geographic origins and setting also mediate response in policy and urban society (Figure 1), and expect debate on underlying mechanisms to continue.

In this argument, risk framing for adequate policy response is crucial, both by authorities (Peeri *et al.* 2020), and by the public (Betsch 2020, Lohiniva *et al.* 2020). Despite between-country differences (e.g. less strict containment, more attention for testing and contact tracing in South Korea: Tanne *et al.* 2020) more and more governments deemed risk levels sufficiently high to implement often unprecedented travel restrictions and population 'lockdown', initially focusing on cities (see Lau *et al.* 2020). Insofar as they are state-imposed and regard cities, we here refer to these public health actions as 'Global Urban Confinement Measures (GUCMs)'. They are considered to having contributed to mitigating the COVID-19 pandemic (e.g. Denis *et al.* 2020, Lau *et al.* 2020). Moreover, in data-poor conditions, as is often the case with little understood diseases or in the Global South, behavioural changes, combined with detection and surveillance, are crucial to reduce epidemic transmission in urban areas (Moss *et al.* 2016).

Although the practice and logic of confinement are ancient and partly similar actions were applied during EVD outbreaks (Peak *et al.* 2018), today's GUCMs render their effects tangible to everyone because they are per definition ubiquitous. Thus, health-related and other (economic, social) risks associated with COVID-19 and future emerging infectious diseases are currently hard to downplay, as they will directly influence control, preventive and reactive strategies in different countries. Next to contrasting media uproar, we also observe stark differences in risk perceptions underlying the responses to

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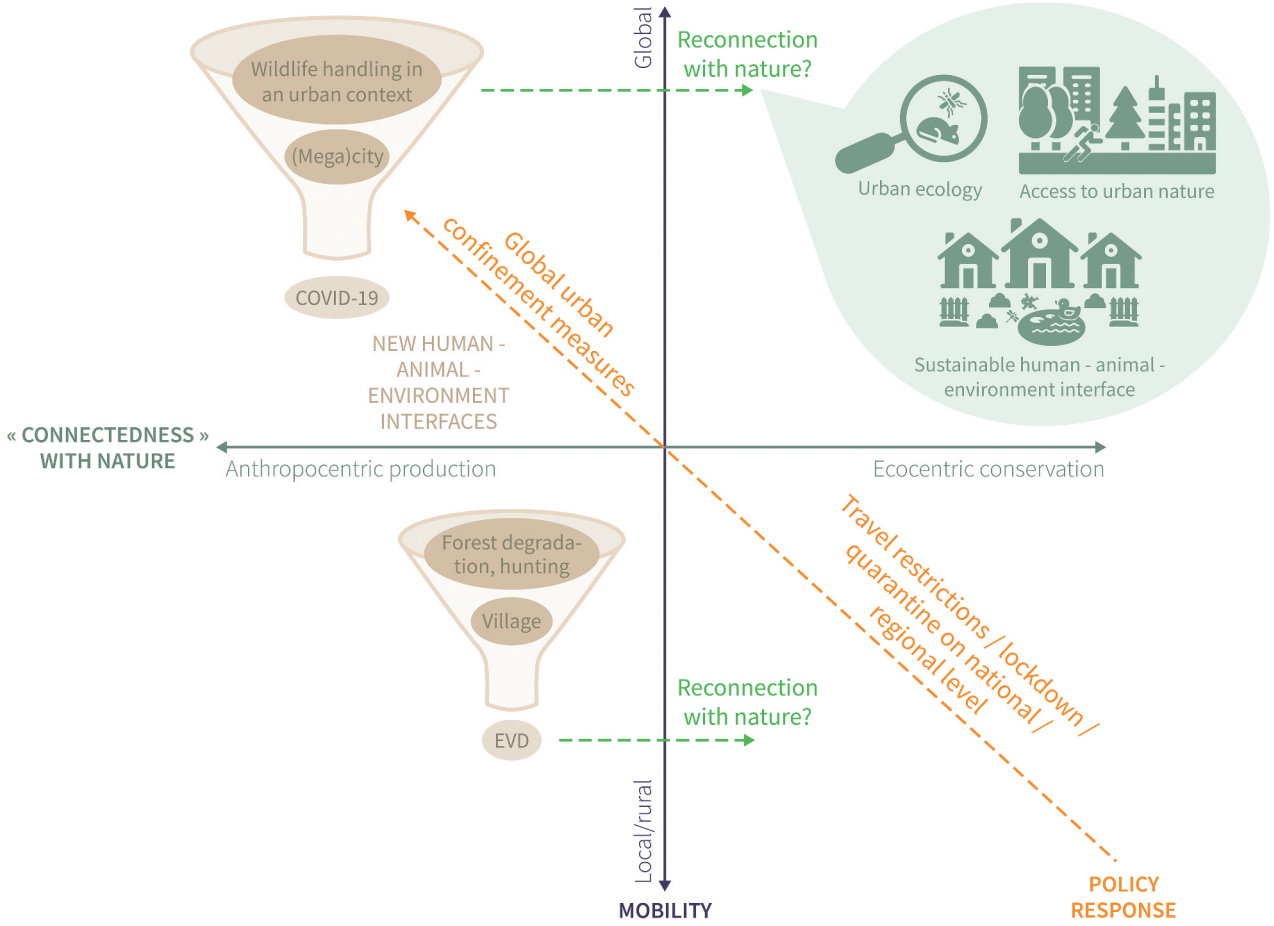

Figure 1. Scheme of how perceptions of nature, and land use at the human-animal-environment interface (horizontal axis) and the spatial scale of mobility (vertical axis) may relate to the intensity and scope of the policy response (diagonal axis). This is exemplified for the new human-animal-environmental interactions that constituted the outbreak contexts of mainly rural Ebola Virus Disease (EVD) and mainly urban COVID-19. The three axes and four quadrants demonstrate the inter- and transdisciplinarity needed to characterize the complexity of pandemics in (urban) society, and the positions of elements within this scheme remains open for interpretation. We propose that reconnection with nature at various levels may be a response mitigating the effects of the pandemic and of the policy response to it.

EVD and COVID-19, respectively. Like multiple other recent zoonotic outbreaks, and certainly as it hardly directly affected the Global North, public opinion may consider EVD restricted to 'exotic', often rural places where (proximity to) nature seems antagonistic to human health (Antoine-Moussiaux *et al.* 2019). This stance focuses on animals as a health threat to humans: 'us *versus* them'. It contrasts with a 'shared risk' perspective, in which animals are models and sentinels for understanding infectious disease and its environmental drivers, because humans and non-human animals share environmental and infection hazards (Rabinowitz *et al.* 2008). By contrast, COVID-19's societal impact is unseen in recent history: it is not limited to the Global South, and originated in Wuhan, an urban centre of economic activity. Transport duration of bushmeat, remoteness and low human population density limited chances of spreading EVD overseas, as it mainly depends on direct contact with bodily fluids of patients (Kümpel *et al.* 2015). Conversely, Wuhan's strong intercontinental transport links, and COVID-19's contagiousness (Peeri *et al.* 2020) prompted widespread adoption of GUCMs to avoid COVID-19 overrunning health systems (Figure 1). As such, GUCMs are both a crisis response, and an epiphenomenon confronting (predominantly) urban communities with a cosmopolitan vulnerability to zoonoses.

Even though proximity to nature is often low, the threat of zoonoses may create perceptions to further limit human-nature interactions in urban areas. We argue that this would be a mistake and render GUCMs unsustainable. On the contrary, COVID-19 should spur urban populations worldwide, often physically and mentally separated from nature, to also see the human-animal-environment nexus from a 'shared risk' perspective. Integrative approaches such as One Health, EcoHealth, and Planetary Health, jointly consider the health of humans, animals and the environment. These frameworks make the connections between the impacts on these three domains of health explicit and promote a holistic approach of the human-animal-ecosystem health nexus at the science–policy interface (Keune

et al. 2017). From a One Health perspective, we argue that the COVID-19 crisis gives the opportunity to consider these three research levels: (1) the study of ecological and evolutionary dynamics mediating disease transmission in urban environments, (2) the ethnography of individual interactions between humans and urban biodiversity, and (3) the community psychology of nature's role in public health and urban space.

The human-animal-environment interface in urban evolutionary ecology of disease

Within the human-animal-environment interface, anthropogenic landscape and habitat changes, as well as unregulated animal exploitation, facilitate zoonotic viral transmission (Johnson *et al.* 2020, Pratesi 2020) (Figure 1). Cause–effect relationships underlying zoonoses are however not straightforward; for example, highest transmission risks were suggested to occur at intermediate levels of land use change (Faust *et al.* 2018). Also, human-induced environmental and physiological stress in wildlife alter its pathogen dynamics (Plowright *et al.* 2015, Seltmann *et al.* 2017, Rohr *et al.* 2019 and references therein). Urbanisation may be another factor altering wildlife pathogen dynamics (Fountain-Jones *et al.* 2017) and increasing viral spill-over (Smiley Evans *et al.* 2020), hence the particular relevance to cities. Potential examples of new human-animal-environment interfaces (Figure 1) include increased human-animal contact through informal or low-biosecurity livestock keeping or wet markets, and unintended escape from laboratories close to city centres (examples in Houwenhuyse *et al.* 2018). Also, urban animal populations differ from rural conspecifics in microbial (Flandroy *et al.* 2018) and parasite communities (Rouffaer *et al.* 2017), which may affect the hosts' immunity. Unsurprisingly, the relatively recent discipline of urban ecology, intersecting with evolutionary mechanisms in the emerging field of 'urban evolutionary ecology', is relevant to urban planning and human public health (Rivkin *et al.* 2019). Given the complex interplay between these host-related and environmental factors, we cannot agree more with Trinh *et al.* (2018) as they state that 'One Health approaches will benefit from ecological and evolutionary studies that distill natural variation in host–microbe interaction into a more tractable number of general rules'. Because of these host-related and environmental factors, and given an adequate science–policy interface, translating urban ecology into urban design and planning could be one of the many possibilities for research supporting public health decision-making (see Sallis *et al.* 2016). There are strong indications that connectedness (both mental and physical) with, and awareness about nature are related to nature's health benefits (Frumkin *et al.* 2017). Therefore, we wonder whether better comprehension of the human-animal-environment interface is also beneficial to human and environmental health, which would be complementary to the purely practical advantage of better-informed public health policy response. Still, all early warning systems failed to prevent or contain the COVID-19 epidemic. The reasons why still need to be analysed in depth, but scientific awareness and understanding of the medical and veterinary relevance of these biological interactions will clearly not suffice in avoiding and tackling urban zoonotic outbreaks and their effects (see the phenomenon of 'late lessons from early warnings' in the field of risk assessment: EEA 2013). We have no indications that people's behavioural compliance to GUCMs implies awareness of, let alone changed attitudes towards, urban ecology at the human-animal-environment nexus. We suggest this crisis should therefore serve as an occasion to rethink the role of nature in the city and vice-versa at two other levels, too: the shared interests of urban dwellers and non-human animals, and the community psychology of urban nature and health.

Human animal health in medical anthropology

The role of non-human animals in urban health is multifaceted. Animals can be hosts to zoonotic diseases, with COVID-19 as compelling example of the impact of bushmeat trade and consumption in cities. Animals can also be disease vectors, e.g. for dengue or malaria, as mosquitoes find good breeding grounds under urban conditions. In this context, Kelly and Lezaun (2014) explain that public health interventions often aim at 'interspecies distancing' including extinction. (At present it is hard not to draw a parallel with ongoing COVID-19-related GUCMs.) Urban planning therefore influences connections and cohabitation between humans and mosquitoes and other animals in their 'shared built environment' (see Kelly and Lezaun 2014). As mentioned above, insight into the ecology of disease has management applications. It allows, e.g. vector control to not only rely on insecticides but also human behavioural changes, vector modification, improved housing, or removal of trash that offers mosquito breeding grounds (Arunachalam *et al.* 2012, Finda *et al.* 2020, Forsyth *et al.* 2020). Given adequate awareness and scientific understanding, we therefore propose to reconsider cohabitation with pathogens instead of eradicating them within fragile 'ultra-hygienic societies'. Recent developments in this context include the Microbial Theory of Health, encouraging 'targeted hygiene' focusing only on high-risk sites, surfaces and practices for pathogen transmission (Scott *et al.* 2020); the medical applications of the Hygiene Hypothesis on the positive immunoregulatory role of certain pathogens (Versini *et al.* 2015); and the Microbiome Rewilding Hypothesis. The latter hinges on the link between biodiversity loss and altered microbial exposure leading to immune dysregulation among urban populations. The hypothesis

proposes that restoring urban biodiversity may therefore rewild environmental microbiomes in urban nature. They could then benefit human health through immune protection and hence disease prevention (Mills *et al.* 2017). We suggest to investigate how urban space can be redesigned for restorative urban gardens that benefit human well-being (*sensu* Thwaites *et al.* 2005) but also create space for cohabitation with animals and environmental rewilding. Since anthropogenic pressures obviously impact the risk originating from human-animal contact, the above-mentioned 'shared risk' perspective becomes all the more relevant. Indeed, public health policy should look beyond managing animals to benefit human welfare and disease control. The complex dynamics of human-animal encounters require a 'multispecies ethnography' (Brown and Nading 2019). A practical example could be changing the existing zoonotic cycles diagram used in life sciences and public health to visualize infections with both animal and human hosts. These diagrams far from simply summarize the epidemiological reality of human-animal transmission. They are unique ways of sketching forms, patterns, and relations, visualising different aspects of interspecies existence. In their graphical choices, they convey a peculiar vision of health and nature, often translating a myth of mastery of nature by humans (Lynteris 2017). This means they are most often centred around the survival of the human species (over the non-human species), representing wildlife as a threat, and showing traditional rural customs as a cause for transmission (Thys 2019a). This visual framing, entering the realm of the 'us *versus* them' thinking, should be questioned and modified. This calls for research to better understand how visual representations might support 'shared risk' framing. We therefore ask more attention for an emerging medical-anthropological field: 'human animal health' (Brown and Nading 2019).

Moving beyond animals and towards urban green spaces at societal level, we witnessed that COVID-19 and its lockdown scenarios highlighted the role of urban nature in human equity and well-being. Importantly for urban planners and other policy-makers, urban nature, apart from its health benefits, is also linked to beneficial environmental effects relevant at abovementioned levels, such as species conservation (Hartig *et al.* 2014, Helm 2020).

An environmental health and ecopsychological lens on COVID-19 impacts on urban individuals and societies

We think the many beneficial effects of nature exposure and reconnection with nature are strongly underestimated (Figure 1). They include children's academic achievement and healthy development (Kuo *et al.* 2019), cognitive functioning, emotional well-being, and other dimensions of mental health (Bratman *et al.* 2019). Moreover, nature connectedness, in the sense of a persistent awareness of the interrelatedness between one's self and nature, correlates positively with sustainable behaviour (Zylstra *et al.* 2014, Whitburn *et al.* 2019). While GUCMs force human beings to reshape their relation amongst themselves and with urban space and nature, such measures proved poorly inclusive towards the urban population's entire socioecological diversity (*sensu* Greenaway and Turetsky 2020, i.e. with respect to the distribution of social groups under given settings of the physical, political or social environment). GUCMs aggravate unequal access to urban nature which undermines their acceptability. Disadvantaged slum populations with poor housing, limited access to water and mobility and high population density typically have poor access to nature in their close proximity, potentially further compounded by GUCMs. Also, avoiding human gathering in public spaces may result in a proportionally bigger loss among slum dwellers since they typically spend more time outside and are practically unable to abide to confinement rules. This may change their lives from difficult to unbearable. COVID-19 also underscores another perspective of human inequity regarding nature and urban space. Disadvantaged populations are disproportionally affected by various communicable and non-communicable conditions (e.g. diabetes, hypertension, likely also tuberculosis) making them more vulnerable to COVID-19-induced morbidity and mortality (e.g. Boffa *et al.* 2020, Denis *et al.* 2020). Such conditions often thrive in disadvantaged and more densely populated urban areas because of a variety of reasons, including closer social and physical contact among humans, lack of space/nature to perform physical activity or to grow fresh and healthy food, increased promotion of and access to processed food, etc. (De Man *et al.* 2019). Inequity from pre-existing comorbidities is likely compounded even more through positive feedback loops. Indeed, 'collateral damage' results from higher risks of nosocomial (hospital-acquired) COVID-19 transmission among people attending health services, fear-induced decrease in health-seeking behaviour and decreased health service availability due to COVID-19. Thus, GUCMs defy urban environmental justice in various ways. When aiming at urban environmental justice, the planning of urban green spaces needs to be considered together with aspects of citizens' health and their social networks, within the framework of the city as an integrated socio-ecological system (Enssle and Kabisch 2020). Indeed, approaching human, animal and environmental health in an integrative way may contribute to environmental justice (Rüegg *et al.* 2018). Without this integration, a disconnection of nature follows, and we propose that GUCMs in that case aggravate an already major current public health challenge (see Anguelovski 2016, Corburn 2017).

We suggest this indicates insufficient dialogue about the potential effects of GUCMs amongst

citizens, civil society and decision-makers (including parliaments), and a lack of translation by decision-makers of expert recommendations. Indeed, expert-derived information requires stakeholder involvement and shared problem framing to be rendered into so-called socially robust knowledge (Cornell *et al.* 2013). Knowledge integration and co-production are indeed necessary for any One Health approach to be successfully implemented into policy (Rüegg *et al.* 2018). Without societal debate, we expect societal response to health challenges like COVID-19 to be unsustainable, as GUCMs exacerbate existing inequities. Compliance to GUCMs is however a combined product of agency of individuals and communities, urging us for a community psychology perspective. GUCMs remove citizens' sense of individual control. Resulting isolation can cause or worsen negative feelings (e.g. loneliness, anxiety, depression symptoms). This makes people ill at ease in cities in times of COVID-19. In contrast, during EVD outbreaks different reaction dynamics occurred, as movement from rural to urban areas was observed (Fallah *et al.* 2018). We question how urban populations feel about the trade-off between the benefits of GUCMs of lowering infection risk, and their negative consequences. Also here, considering a less anthropocentric, non-'us *versus* them' stance is worthwhile: exposure to urban nature has proven mental health benefits (e.g. through psychological restoration: Hartig *et al.* 2014). It may contribute to reduction of health inequalities (WHO 2016) e.g. through healthier behaviour (e.g. physical activity) that would limit above-mentioned co-morbidities, and may contribute to behavioural changes towards environmental sustainability (Nisbet and Zelenski 2011, Ives *et al.* 2018, Whitburn *et al.* 2019). We hypothesize a positive feedback loop whereby more access to urban nature forcibly close by (due to GUCMs) mitigates GUCMs' negative effects, but also makes city dwellers' attitudes less prone to causing environmental impact, e.g. habitat degradation, contributing to future pandemics. For example, we expect well-distributed, attractive urban green to promote outdoor leisure, contributing to health and pro-environmental behaviour. We therefore propose that ensuring sufficient access to (urban) nature and exploring its ecopsychological aspects (see Fisher 2013, Roszak et al. 1995, Vakoch and Castrillón 2014) will help rendering potential future GUCMs inclusive, educational, sustainable and transformational. An avenue for implementation may be urban agriculture, which provides diverse ecosystem services to urban dwellers, society and the environment (Cartiaux *et al.* 2018).

We indeed cannot predict the potential sustainability benefits of GUCMs. Relevant to the urban human-animal-environment nexus are increased wildlife sightings (Bates *et al.* 2020) and potentially higher valuation of urban nature (Helm 2020). Across continents, local improvements in urban air quality were observed, exemplified by reports from Milan, Italy (Collivignarelli *et al.* 2020), Rio de Janeiro, Brazil (Dantas *et al.* 2020) and Salé, Morocco (Otmani *et al.* 2020). However, these studies also mention stark contrasts between pollutants, and between the city and its surroundings because of influences from adjacent areas with different land use. Also, already in China, these positive environmental impacts are expected to be temporary (Wang and Su 2020). Worldwide, COVID-19-related decreases in, e.g. conservation management, conservation enforcement, scientific attention or ecotourism revenue may have adverse environmental impacts (Bates *et al.* 2020, Helm 2020).

Perspectives for policy extension across North and South: not a one-stop-shop

There are indications that human psychology is adapted to local disease ecology situations: collectivism may work against infections under high pathogen prevalence (Thys 2019b and references therein), encouraging more international comparative approaches to infectious disease and health policy. While we focus here on environmental and psychosocial aspects of health, it merits investigation whether a 'shared risk' perspective can also foster cross-cultural or cross-national comparisons inspiring policy response to COVID-19 and other zoonoses. What COVID-19 will mean for cities in the Global South is as yet hard to fathom, with their sharply visible inequities experienced by urban slum populations, and with transmission noticeably from well-to-do travellers to poorer communities (e.g. Manderson and Levine 2020). As the Global South accounts for the fastest urbanisation worldwide, and with that, most of global demographic growth, its cities hold great interest and potential for sustainability; regrettably, they are underrepresented in research (Nagendra *et al.* 2018). We cannot stress enough that GUCMs are clearly no one-stop-shop implementable in an identical way in the Global North and South alike (see also Manderson and Levine 2020). While lockdown measures have been implemented throughout countries that strongly differ social-politically and geographically, also within the North strategies for surveillance and reduction of transmission vary widely between states, among others influenced by resource availability, culture, governance and legislation (Cohen and Kupferschmidt 2020). New Zealand scientists advised their government that looking at responses in a set of Asian countries may be informative (Wilson *et al.* 2020). Although COVID-19 may have simply arrived late in Africa and there is no certainty whether the African epidemics will remain

small (Martinez-Alvarez *et al.* 2020), COVID-19 seemed to progress slower in Africa, and important lessons have been learnt from EVD (Nuwagira and Muzoora 2020). We therefore hope that best practices from this pandemic may inspire urban policies cross-continentally. We also hope that instead of seeing nature as a threat, more nature connectedness and less anthropocentric interactions with nature may render future such policies more sustainable (Figure 1). For example, given the zoonotic importance of human-animal-environment interactions and the potential of animal disease models, better understanding of hosts, vectors and parasites necessitates additional research. The call for multispecies ethnography in human animal health reflects the need to grant urban animals and nature space to avoid transmission in new human-animal-environment interfaces. These efforts in urban ecology and medical anthropology would in our view contribute to pandemic prevention. Lastly, the mental and physical nature health benefits extend not only to avoiding pandemics but also to reacting to them and their consequences. Therefore, to mitigate harmful effects of future pandemics and the ensuing GUCMs, we urge urban planners and other policymakers to ensure equitable access to urban green.

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