

## – RETHINKING URBAN EPIDEMIOLOGY: Natures, Networks and Materialities

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### Abstract

*How should we understand the relationship between urban environments and infectious diseases? This article addresses this question from three particular perspectives: that of the materialities of health, that of nature and that of networks. The first perspective analytically blends biological dynamics, environmental influence and social practice. The second perspective, mainly influenced by multispecies ethnographies, foregrounds the liveliness and unboundedness of cities. Finally, the third perspective analyses how health is drawn into the domain of security. The article argues that while globalization and urbanization are often discussed as having triggered the emergence and spread of pathogens, urban epidemics are not self-evident and ‘natural’ consequences of these processes. They do not fall neatly into universal categories of space, modernity or risk; rather, they are produced and shaped by a range of social, political, biological and economic sites and scales. Accordingly, the emergence of pathogens depends on its articulation through specific analytical frameworks. This article suggests that a critical focus on how infectious diseases manifest themselves differently in different local contexts may not only provide insights into the manifold forms of urban life, but also into the multiple, complex and highly political constitution of health.*

### Introduction

On 20 July 2014, Liberian Patrick Sawyer disembarked from an ASKY Airlines flight to Lagos, vomiting and showing signs of illness. Although Sawyer was quarantined immediately and taken to the hospital upon arrival, he infected nine doctors and nurses, as well as several contact persons at the airport, and died five days later. Sawyer became known as Nigeria’s Ebola index case: he arrived amidst a historically unprecedented outbreak of Ebola fever in West Africa that swept across Guinea, Liberia and Sierra Leone. In contrast to earlier outbreaks, the epidemic did not seem to be confined to rural areas and smaller villages, but spread to the countries’ urban populations. Up to this time, Nigeria (Africa’s most populous country, which includes Lagos, a megacity with an estimated population of 17 million) had not reported any cases of Ebola infection, but all of a sudden Lagos’s high population density, its sanitary infrastructure and the complex mobility patterns of its inhabitants were discussed as posing a challenge to contact tracing and other infection control measures. This prompted the US Consul General in Nigeria, Jeffrey Hawkins, to invoke dreadful images of an ‘apocalyptic urban outbreak’. The World Health Organization described the situation as a ‘powder keg’ (WHO, 2014), and alarming visions of possible outbreak scenarios in Lagos spread across the media. What had happened here? And what would happen next?

This vignette articulates an important assumption in public health discourse: urban environments affect the health of their inhabitants.<sup>1</sup> While the 2014 Ebola outbreak in Lagos was successfully contained shortly thereafter and the anticipated

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1 Seen from a public health perspective, cities can be associated with a range of both positive and negative health outcomes. Among the positive effects of urban life on health—if only in some regions—is the accessibility of a stable public health infrastructure, including medical care, sanitation, waste disposal, housing and medical education. Conversely, cities are also widely identified with infectious diseases and, more recently, an increased disease burden associated with chronic conditions such as diabetes, obesity, asthma and cardiovascular disease (Schorb, 2008; Niewöhner *et al.*, 2011; Dean and Elliott, 2012).

scenario did not materialize, infectious diseases such as respiratory infections, AIDS and tuberculosis are still among the leading causes of death worldwide (WHO, 2011).<sup>2</sup> Occasionally, new and ‘emerging’ viruses raise concern among public health officials, the mosquito-borne Zika virus being one of the most recent examples: on 1 February 2016, Zika was declared a Public Health Emergency of International Concern owing to an increase in newborns diagnosed with microcephaly in South America (Check Hayden, 2016; WHO, 2016). In this regard, urban environments are often depicted as areas at risk of infectious disease outbreaks.<sup>3</sup> Between 1925 and 1950, infectious diseases constituted the leading cause of mortality among the populations of industrialized cities (McMichael, 2000: 1118). A wide variety of health threats characteristic of urban environments—ranging from poor sanitary conditions to malnutrition, polluted water, high population density and inadequate housing—created serious public health problems and provided a fertile breeding ground for microbial and viral agents (Hardy, 1993; de Landa, 1997; Vögele and Woelk, 2001; Hardy, 2005).

It is in this context that the emergence of disciplines such as urban health, initiatives such as the WHO’s Healthy Cities Network and journals dedicated to urban health topics seem to indicate that there is something peculiar about urban environments and their impact on human health<sup>4</sup> and that this problem is potentially global in scale. This observation presents a problem worthy of more detailed exploration: seen from a theoretical angle, the ways in which urban complexity can be distinguished from other kinds of complexity are still far from clear. What exactly constitutes ‘the urban’ within the complex assemblages of disease interactions?

Obviously, cities do not possess a universal form or structure, but are produced and formed in a variety of social, political, biological and economic sites and scales, and different analytical lenses might offer distinct frameworks to communicate about urban epidemics. Indeed, cities are affected differently by climatic conditions, life expectancies, water infrastructures, legal regimes, transnational mobility, financial resources, population density, health beliefs and practices, development plans and governance structures. These, in turn, have an impact on the emergence, problematization and management of disease and disease risks: vector-borne diseases, for example, are more common in regions with a warmer climate. Financial resources are required to build a medical infrastructure, and governance structures might determine the flow of resources and equipment. Densely populated areas are especially prone to outbreaks of infectious diseases, while local legal regimes require the management of index cases and contacts. Mobility hubs might serve as entry points for infectious agents, but also for medical expertise and vaccines. Health beliefs might facilitate or hinder treatment. In consequence, Helsinki, for example, faces different health problems to Port-au-Prince or Jakarta. But how, then, can the ‘urban’ aspect of urban epidemics be tackled?

According to the work of Neil Brenner and Christian Schmid, the ‘urban’ cannot be explored—theoretically and empirically—by referring to a predetermined, bounded, universal and self-evident formation. Within this approach, there is no indeterminate ‘outside’ to cities; rather, cities are understood as shifting in form, processual, connected to historical contexts and emerging at different spatial scales (Brenner and Schmid, 2014: 749–50). While such a perspective indeed offers a critical foundation for questioning any essentialist assumptions about the nature of ‘the urban’, it is of limited value for epidemiological strategies or public health interventions that depend on the identification of target groups and geographically confined areas of risk.

- 2 The urban dimension of Ebola is often explained with reference to the fact that containment measures in rural areas tend to be more effective than those in urban areas, and that patients suffering from the disease seek treatment in urban centres (Mylyne *et al.*, 2014; Nature Biotechnology, 2014).
- 3 Public health approaches such as the Healthy City Project assign importance to the notion that physical and social environments interact with the health of urban residents (see Ashton, 1992).
- 4 For anthropological contributions, see, for example, Dilger (2014) for a case study on urban health interventions in Tanzania, as well as Geissler *et al.* (2012) and Meier zu Biesen (2013).

Uncertainties and paradoxes such as these suggest the need for a wider analysis of urban epidemics, as these can be categorized and understood in a number of ways, of which this article examines three. One way would be to view infectious diseases as the result of biocultural interactions. In terms of this approach, the health and disease of urban inhabitants can be approached through an analytical blending of environmental effects (for example, population density, infrastructure, sanitary conditions), biological dynamics (for example, immune status, microbial performance) and social practices (for example, mobility patterns, burial rituals). For each of these dimensions, different dynamics are at play, from processes of population growth to practices of waste management, and from individual explanatory models to syndemic interactions at the micro-level. We might ask, for example, what concepts of environment undergird the identification of areas of risk, why some people seem to be more susceptible than others, and to what extent social processes are taken into consideration in the classification of vulnerable population groups. As illustrated by the example of Lagos, conventional models of urban health governance, and their institutional routines and norms, might be challenged in certain urban environments, but not in others.

A second possible lens—thinking about infectious disease outbreaks in terms of their entanglement with urban natures—highlights the manifold ways in which human and other life is interwoven. As a large number of urban epidemics—such as dengue fever, severe acute respiratory syndrome (SARS) and HIV—are of zoonotic or vector-borne origin, the question as to what kind of nature is at play becomes all the more pressing. This *liveliness* of cities (Hinchliffe and Whatmore, 2006) can be rooted in agricultural patterns (such as rooftop poultry or wet markets), in urban flows, nooks and crannies (ranging from rivers over sewage systems to puddles and mosquito breeding habitats), or in the very epidemiology of diseases themselves (Ebola outbreaks, for instance, are often discussed in the context of bush meat consumption). What urban nature actually entails, and how this influences our conceptualization of urban health, is itself up for debate.

Finally, if scrutinized through a biosecurity lens, the analytical focus might fall on the translation of outbreak events into local areas of intervention, and on the securitization of infectious disease in more general terms. Microbial emergence as a biosecurity issue is problematized and made visible within specific urban contexts, as pathogens are not only of biomedical significance, but also relevant to a number of other sociotechnical domains. Accordingly, biosecurity concerns arise in different areas of civil protection, food safety, public health and environmentalism, each field tending to stress the vulnerability of cities, each focusing on different aspects of urban environments (for example, water infrastructures, climatic conditions, global interconnectedness or the implementation of vaccination programmes). Within biosecurity approaches, we are able to focus on the topological dimensions of urban epidemics and infection control measures. Kezia Barker, Sarah Taylor and Andrew Dobson (Barker *et al.*, 2013) remind us that biosecurity practices do not simply constitute a response to disease events, but are part of a wider process of problematization and politicization. Perspectives such as these might give us a better grasp of how emerging pathogens are translated into local risks to be acted upon, how geopolitical boundaries are reinforced or circumvented in this process, and how the management of unruly matter affects the lives of urban inhabitants.

When seeking to understand how urban environments are configured as areas at risk of infectious disease outbreaks, a good starting point is the examination of the concept of *emergence* itself. Emerging infections are increasingly problematized in the context of urbanization and globalization processes, as these are believed to accelerate the emergence, development and spread of infectious diseases (often illustrated with

reference to empirical cases of SARS, avian flu and swine flu— see Alirol *et al.*, 2011; see also Saker *et al.*, 2004). By accepting this view of the emergence of infectious disease as a natural consequence of urbanization and globalization processes, we fail to see that the concept of emergence itself is only enacted within specific analytical frameworks. These frameworks, for example, the 1992 Institute of Medicine report (Lederberg *et al.*, 1992), consist of classification schemes, national and international surveillance systems, funding bodies and political rationales (see Washer, 2014). They determine what can be seen, known or said within the biomedical and political context of emerging diseases. Underlying assumptions concern the movement of pathogens from disease-ridden to disease-free areas. Scholars such as Paul Farmer, Márcia Grisotti and Fernando Dias de Ávila-Pires argue that the classification of an emerging infectious disease is contingent on reliable systems of notification and the conception of risk groups. According to these critical accounts, pathogens do not suddenly ‘emerge’ somewhere, for instance in the backyard of an Indonesian poultry farmer (see also Hinchliffe and Bingham, 2008a). In order to be classified as emerging, a pathogen needs to be linked to a specific disease, to a vulnerable population, to surveillance systems and to a territory (Farmer, 1996; Grisotti and Dias de Ávila-Pires, 2010; see also Füller, 2014). Consequently, a large number of pathogens and infectious diseases slip through the net. Similarly, critical biosecurity scholars note that emerging microbial agents are articulated and problematized through different political and normative frameworks in order to be transformed into microbial risks that can be calculated, known, managed or visualized. During this process, they achieve political and biomedical visibility. Possible domains of problematization include anxieties about bioterrorism, food safety, health or biosafety (Collier and Lakoff, 2008: 9–12; Dobson *et al.*, 2013; see also Caduff, 2008). Seen from these perspectives, the emergence, development and spread of infectious diseases do not simply rely on a given global order, but *coproduce* this very order.

Eventually, if cities are not self-evident and universal formations, and disease emergence is not a ‘natural’ event, then our task might be to understand how microbial threats are enacted differently within the multiple urban domains of health, bioterrorism, food safety or environmentalism, and how this process, in turn, configures very different urban forms and urban spaces.

In this article, I provide a synopsis of recent theories of urban health, urban natures and infectious disease ecologies. The growing number of diverse publications concerned with these issues bear witness to a stirring discussion, and as attempts to synthesize them would probably be regarded as fussy and reductive, I do not claim to present an exhaustive overview. Instead, I aim to frame the different approaches dedicated to the material consequences of globalized urban environments and to outline further research questions and challenges. The diverse ideas and concepts discussed in this article can be regarded as different lenses offering different ways of communicating about the complex subject of urban infections. Although I write from the perspective of cultural anthropology I include numerous sources and field-based approaches that have emerged from scholarship in cultural and human geography, political ecology and sociology, and bring them into dialogue with one another. The article is structured as follows. First, it explores the implications of urban health, taking into account the idea that disease as a biocultural event is contingent on environmental conditions and that the urban setting might be more than a locus of these interactions. Secondly, it focuses on the links between ‘nature’ and urban environments in order to underscore the dynamic and complex character of infectious disease aetiologies. Thirdly, it examines the political, social and theoretical responses to contagious outbreaks in urban areas to help us understand the lineaments of ‘networked diseases’ (Ali and Keil, 2008) and their prevention.

### Epidemics as biocultural events

Biocultural approaches include the study and analytical blending of biological dynamics, environmental effects and social practice. As medical anthropologist Margaret Lock (2012: 129) suggests, a biocultural focus may help us overcome simple 'culturalistic' cause-effect relationships and develop a more thorough understanding of human embodiment within distinct historical and spatial contexts. A first, substantial step in analysing the complex relationship between urban physical-material environments and the multitude of bodies (human and non-human) that inhabit them is to recognize the human body as a *molecularized* body, as a biocultural and embedded agent, as Lock claims (*ibid.*). In this context, geographer Nigel Clarke uses the example of the common cold virus to illustrate the ongoing openness of bodies to other forms of biological life: 'assorted seeping, dribbling, spraying of excessive bodily fluid [is] an indicator of an outgoing porosity that follows an earlier ingoing perviousness' (Clarke, 2004, cited in Greenhough, 2008: 1). In what follows, I shall discuss empirical accounts of the biocultural interaction of embedded bodies and urban environments in order to analyse their underlying assumptions about the urban and its impact on health.

From a global public health perspective, urbanization processes are widely associated with specific socio-political problems and risks to individual and public health, among which the expansion of slums and the rise of urban poverty are probably best known. The World Health Organization reacted accordingly and created the Healthy Cities Project in 1986, reflecting the socio-political significance of urban and community health. In their classic study on community health and the urban poor, Harpham *et al.* (1988) describe and classify health problems that are characteristic of, but not confined to, the urban poor. They draw distinctions between the following: (1) problems that directly result from poverty, such as unemployment, low income and malnutrition; (2) environmental problems caused, for instance, by lack of water supply, high traffic volumes, exposure to infectious agents and overcrowding; and (3) psychosocial problems, such as stress, depression and substance abuse. Urban environments, according to Harpham *et al.* (*ibid.*), demonstrate a tendency to combine health problems resulting from poverty and 'underdevelopment' with those usually attributed to industrialized areas. The authors strive to provide policy-relevant insights on how urbanization processes, funding constraints and restricted health care services directly affect the living conditions of the urban poor, especially in the global South. Overcrowding and high population density, international connectivity and the close proximity of different species also contribute to the fact that cities tend to be vulnerable to infectious disease outbreaks (although this vulnerability is distributed unequally between and within countries).

In 1991, medical anthropologist Carl Kendall explicitly associated infectious disease ecologies with urban built environments (see Kendall *et al.*, 1991). In their study on dengue fever and urbanization processes in America and the Caribbean, the authors show how local responses to infectious disease outbreaks may contrast sharply with public health education programmes (*ibid.*). Based on their analysis of the cities of Merida (Mexico) and El Progreso (Honduras) as urban social worlds and urban ecosystems, they claim that new disease ecologies emerge in tandem with the growth of slums and shanty towns: mosquito-borne infections such as dengue fever and malaria benefit significantly from stagnant water (puddles, flower vases, barrels, dishes) near residential areas, as the disease-carrying mosquitoes like to breed in standing water. Nevertheless, public health education in the affected areas has proven largely ineffective because it collides with people's explanatory models for disease: they attribute dengue fever to malicious 'winds' instead of to mosquito bites, or simply mistake it for the common flu.<sup>5</sup> Consequently, they argue that dengue fever has to be understood as symptomatic of changes in disease epidemiology (*ibid.*). One of the most striking

5 Similarly, see Aasgard Jansen (2013) for divergent aetiological explanations of the chikungunya epidemic on Réunion Island.

findings of their analysis is that multiple features of modernity, such as urbanization processes, transnational travel and trade, and the accumulation of garbage owing to a scarcity of community resources, contribute to the emergence of infectious diseases within urban areas, but these are also intertwined with local knowledge. On the basis of their findings, Kendall *et al.* amply demonstrate that neither technological solutions nor health education alone will help us overcome this complex assemblage of infectious disease aetiologies. The authors draw attention to the unequal processes of urban development worldwide and simultaneously sketch a general ‘rise of the city’, embedded in a larger framework of population growth, modernization and urbanization. In this context, rural areas are primarily defined by a lack of water infrastructure and education—but it remains unclear how this development is connected to urban environments and how these environments, in turn, are affected by urban expansion or urban development processes.

In recent decades, the global spread of the dengue virus has increased considerably, and a growing number of outbreaks, covering a wide range of tropical and subtropical areas, have been reported. For example, the *Aedes aegypti* mosquito is now found to be closely associated with human habitation and has become endemic in many urban areas (Rigau-Pérez *et al.*, 1998). The urgent need to develop sustainable and effective prevention measures is increasingly being recognized, and current research into the transmission cycles of the dengue virus has provided insight into how new larval habitats emerge from neglected swimming pools in the US (Reisen *et al.*, 2008), how socioeconomic, institutional, spatial and political contexts have an impact on mosquito management strategies (Shaw *et al.*, 2010), and how urban household waste such as coconut shells, pitchers and plastic containers contribute to mosquito breeding (Banerjee *et al.*, 2013). Overall, it is now increasingly clear that the epidemiology of the dengue virus is deeply intertwined with ongoing urbanization processes and the hybrid landscapes they create.<sup>6</sup> These accounts present the city as a breeding habitat that is strictly confined to the climatic conditions required for dengue mosquitoes to reproduce (usually tropical and subtropical areas). They focus on the mutual entrapments of waste or environmental management strategies and mosquito transduction processes that contribute to the emergence of mosquito-borne infectious diseases, and are particularly helpful in questioning their underlying spatialities and institutional routines. Subtropical urban and suburban areas are here described as contingent, risky and expansive. The assumed dialectical relationship between natural sites and urban environments, however, is transgressed by the mosquitoes themselves as they transform the ‘nooks and crannies of natural and urban spaces’ (Shaw *et al.*, 2010: 376) into breeding sites. Also, within these accounts, disease emergence is closely connected to particular historical moments, such as developments in the housing market, thus subverting any attempt to implement generic disease control strategies.

Other scholars have been attracted to airborne infections. Medical anthropologist Arthur Kleinman and colleagues (Kleinman and Watson, 2006) devoted a body of interdisciplinary work to the 2002/2003 SARS outbreak in China, particularly Hong Kong, which they analyse in terms of transmission, disruption and flow. SARS, a highly contagious respiratory disease caused by a coronavirus, was first identified in early 2003 and is believed to have started in the Guangdong province in China. Having infected a businessman travelling from Guangdong to Hong Kong, the virus spread rapidly from China to numerous countries worldwide and created a serious public health crisis. During the pandemic, global cities and international mobility hubs such as Hong Kong and Toronto seemed to play a key role in the spread of the disease. Much more than merely a site for emerging microbial and viral agents, urban Hong Kong proved to pose a specific problem for public health officials. A well-known example

6 In the context of dengue ecologies, the hybrid character of urban environments is attributed to the coexistence of formal and informal settlement features and the ecological niches this coexistence creates.

is that of Amoy Gardens, a large apartment complex with 17,000 inhabitants, where more than 300 persons were infected. Its residents experienced not only serious SARS-related stigmatization, resulting in unemployment, quarantine, social isolation and various services being refused (Kleinman and Lee, 2006)—the building itself seems to have facilitated the spread of the virus because of its specific microclimatic conditions and constructional features. Virally laden aerosols were transported via air shafts, plumbing systems and floor drains as well as via the multizone airflow between the flats (Yu *et al.*, 2004; Li *et al.*, 2005; McKinney *et al.*, 2006). Rumours and uncertainty spread, as Lee and Kwok Wing (2006) explain in their brief description of social suffering as a result of SARS:

The lay public ... speculated about the causes and means by which the infection was spreading: cockroaches, rats, sewage pipes, elevator buttons, or construction workers urinating nearby the apartment complex. Until the Amoy Gardens outbreak, most local citizens believed that they could avoid SARS by not leaving their homes. But now the home itself had become a dangerous site (Lee and Kwok Wing, 2006: 137).

In retrospect, the SARS crisis not only brought the unpredictability and contingency of microbial evolution into focus, it also unveiled the close interdependency of built environments, cultural aspects of infectious disease transmission (such as cleansing or food practices) and the (bio-)political regulation of pandemics. The authors' representation of Hong Kong reflects a specific historical time and focuses on processes of stigmatization, spatial divisions and spatial boundaries from a critical perspective. While they are sensitive to social inequalities, they show less interest in questioning dichotomous constructions of 'modern' cities and their (seemingly less modern) rural hinterlands. The city of Hong Kong is here juxtaposed with—presumably rural—ecozones where flu viruses breed 'cheek-by-jowl with farmers' (Watson, 2006: 202). An underlying assumption, as similarly represented by public health officials (Fuller *et al.*, 2013, Saker *et al.*, 2004), is that dangerous pathogens might suddenly emerge in the backyards of Southeast Asian farmers (for a critical network perspective, see Hinchliffe and Bingham, 2008a).

Medical anthropologist Merrill Singer and psychologist Scott Clair (Singer and Clair, 2003) sketch an alternative approach to the analysis of disease interactions in a sociocultural context. They conceptualize the city as an environmental condition and context; their points of reference are communities and populations in inner-city areas (without defining the characteristics, differences or boundaries of these areas). Whereas biomedical classification systems, as the authors state, rely on conceptions that understand diseases as 'distinct, discrete, and disjunctive entities that exist (in theory) separate from other diseases and from the social groups and social contexts in which they are found' (*ibid.*: 424), they suggest reconceptualizing diseases as contextualized events resulting from multiple biological interactions among certain health conditions (see also Draus, 2004, for an account of syndemic patterns of tuberculosis). Singer and Clair (2003) use HIV infection in injection drug users in three New England cities as an illustrative example of *syndemic interactions* between the virus, other major diseases (including hepatitis, STDs, pneumonia and symptoms such as abscesses are the most important) and homelessness. They show how poverty and social deprivation foster the emergence of viral synergisms and result in enhanced infections owing to a high density of pathogenic interactions.<sup>7</sup> The presence of the HI virus seems to

7 See Fullilove *et al.* (1999) for a socio-medical and psychiatric perspective on the syndemic interaction of violence, addiction and HIV in urban areas. See also Lubek *et al.* (2014) for a psychological account of AIDS and community health interventions in Cambodia, and Biehl (2007) on impoverished AIDS patients in Brazil and the political economy of drugs and treatment options.

trigger other infections, and this synergism appears to take advantage of homelessness. Similarly, sociologist Eric Klinenberg (2003) in his social autopsy of the Chicago heat wave of 1995 shows how cities in the US are characterized by new vulnerabilities. Social and ecological conditions such as social isolation, poverty, the downsizing and privatization of public health infrastructures, architectural features, the housing market and the delivery of social services, he claims, all contribute to the making of 'natural' disasters and the diverse impact thereof on local populations. He portrays the city of Chicago as a potentially lethal environment, characterized by degradation, fear and the fortification of public space. The city's physical, social and political structure is determined by larger demographic changes in the US. In his account, health can be attributed to functional social ties, a public health infrastructure, and—partially—to a specific ethnic background.

In these approaches, the issue is not the descriptive clustering of diseases in certain populations, but rather the identification and inclusion of environmental conditions as well as socio-political and economic determinants into anthropologically informed analyses of disease. Singer and Clair's work focuses primarily on 'disease interactions at the biological level that develop and are sustained in a community/population' (2003: 429). Thus, disease is understood as unbounded, but there is no discussion about whether the same might be true of urban areas. For our purposes here, the explanatory value of syndemic approaches therefore seems limited, as these approaches tend to focus on disease interplay within the human body, while placing far less emphasis on the constitution of urban environments as such (see, however, Singer, 2010, on ecosyndemics). Nevertheless, they provide a useful way of thinking about the multiple biocultural entanglements of urban bodies and the diseases affecting them.

Taken together, these lines of enquiry display very diverse social processes, ranging from community participation and environmental management strategies to stigmatization and the construction of spatial boundaries. However, what they have in common is a focus on cities as environments (Kendall *et al.*, 1991; Klinenberg, 2003), as environmental condition (Singer and Clair, 2003) or as habitation (Rigau-Pérez *et al.*, 1998; Banerjee *et al.*, 2013). These approaches also highlight the unequal distribution of risk and vulnerability between and within diverse local contexts, rendering some bodies more susceptible than others. Disease in these settings is described as interaction: two distinct and bounded entities (environments and bodies) interact. Consequently, this interaction is open to intervention, for example, through the building of infrastructure, the management of toxic exposure or the destruction of mosquito breeding sites. In other words, health in these accounts seems to result from the successful management of environmental risks and individual health-related behaviour; thus, infectious diseases are less of a natural disaster, but 'emerge' alongside social structures and inequalities in housing, health education or financial resources.

### **Urban natures and multispecies agency**

Against the backdrop of emerging infections, questioning the very constitution of the urban itself reaches far beyond the human body and human health alone, by bringing 'nature' and a multitude of other species back into analytical focus. Locating biological agents such as animals, microbes, fungi and plants inside the social production of urban space places emphasis on the *becoming* of cities, on transforming 'types into events, objects into actions' (Kirksey and Helmreich, 2010: 546), bodies into contact zones and spaces into networks (Haraway, 2008; Helmreich, 2009). The line of enquiry discussed in this subsection of the article requires close attention to the material and social dimensions of infectious disease aetiologies within urban settings. It also requires an openness to actors often regarded as marginally important in urban theory (including those we would rather live without, such as rodents, insects and



microbes), as well as engagement with biomedical and biological sciences. Clearly, an understanding of other biological actors is essential to an understanding of human health and human social, economic, political and urban life, since a large number of infectious diseases are of zoonotic or vector-borne origin. Zoonotic diseases (such as influenza, bovine tuberculosis, rabies and many viral haemorrhagic fevers) can be passed between humans and animals, whereas vector-borne diseases (such as malaria, dengue fever, plague and Chagas disease) are caused by viruses, bacteria or parasites transmitted through vectors such as mosquitoes or fleas between humans or between humans and vertebrate animals. They have different implications for social science or public health interventions. Many vector-borne diseases are confined to certain climatic conditions (often tropical or subtropical areas); however, a growing section of the human population is affected on a global scale. These diseases spread slowly and can only establish themselves once their vector is accommodated to its new habitat (a malaria outbreak in Nuuk, Greenland, is currently highly unlikely). Disease management in the case of vector-borne diseases might target the human population, the vector or the pathogen. Zoonotic diseases, by contrast, possess higher mobility, they might spread quickly and are not confined to particular geographical areas: an influenza outbreak in Nuuk is not at all unlikely. The management of zoonotic diseases needs to engage with human as well as with animal health and with the environments the species in question inhabit and produce.

Against this backdrop, urban political economy intrinsically addresses different ways in which nature is perceived and negotiated through environmental change or natural resource economies, and how it is contextualized in relation to political-economic trends (Goldman *et al.*, 2011). Gene Desfor and Roger Keil (2000; 2004), for example, draw on discourse analysis to describe how urban developments in Toronto and Los Angeles have been connected with ecological concerns, resulting in an attempt to redefine the relationships between nature, society and the economy. Desfor and Keil (2000) take local state institutions and political processes as a starting point to analyse the governance of growing complexity in world cities; they understand environmentalism both as a strategy of urban politics and as a discourse of liberation under neoliberal capitalism. Apart from the health concerns associated with environmental regulation processes (such as air and soil pollution), one of the striking findings, noted in Desfor and Keil's work, for my purposes here, is their advocacy to accept urbanization 'as the major condition of our living in the natural world, while recognizing the existence of a natural, physical, and biological world beyond the reach of urban life' (Desfor and Keil, 2004: 214–15; see also Desfor and Keil, 2000). Their understanding of urban ecologies is triggered by a crisis of the nature–culture divide that is apparent when looking at the governance of ecological problems in metropolitan areas. Urbanization processes are therefore depicted as conflict-ridden, complex and not territorially bounded.

In an attempt to analyse cities through a geopolitical lens, geographer Bruce Braun (2008) provides a glimpse into another dimension of the socio-material constitution of the city. In seeking to understand cities as biopolitical and topological spaces and to 'think the city through SARS', Braun focuses his attention on a set of previously absent actors—such as microbes and animals, but also technical features, such as sewage systems and airports—and their contribution to the city's socio-material composition. He suggests the need to understand the city as an unbounded and polyrhythmic space, that is, to stretch the molecular geography of urban environments beyond their built boundaries. As 'more-than-human' spaces (Whatmore, 2006), cities and the multitude of bodies and organisms that inhabit them are organized within global networks of interaction and disease transmission, as became apparent during the SARS epidemic. Braun explains the situation as follows: 'These networks are at once biological, technological, political, and economic, and they are at the same time local and global' (Braun, 2008: 265). In consequence, he argues, the surveillance, maintenance and

governance of urban health can no longer be based on local practices and local bodies, but are a matter of global concern, binding cities and the bodies that inhabit them into a global biopolitical order (Braun, 2007). Braun's approach captures a specific historical moment of urban governance and urban topology confined to the global cities of Hong Kong, Toronto, Singapore and Taipei. While he describes a kind of city in which the urban and the rural are entwined in 'city-nature-formations' (2008: 257), he presupposes that the concept of city-nature-formations relies on a dichotomist construction of cities and natures, but does not question or analyse it in detail. Therefore, he remains slightly vague as to how to capture urban biological worlds methodically, and exactly which biological mechanisms and which bodies might be important to this process.

Amidst the multiple and heterogeneous influences on the interdisciplinary field of urban natures, urban metabolism is another major area that attempts to engage with 'nature' and how the ecological processes inherent to cities have established their importance. In the broadest sense, urban metabolism provides a framework for looking critically at the material-semiotic flows of water, norms, energy, information, waste and knowledge that constitute the modern city. Although the concept of urban metabolism has a long heritage in political economy (Brenner *et al.*, 2011: 232), it tends to expand the methodological toolkit by incorporating some of the concepts developed within actor-network theory (ANT) and science and technology studies (STS), such as the integration of non-human actors and hybrids (Latour, 1993). Indeed, one way of understanding the dialectical relationship of nature and the city, as geographer Maria Kaika (2005) suggests, has been to trace the manufacturing of urban nature in Western metropolises by their spatial and material impacts, a construction process she call 'the urbanization of nature'. Interestingly, as Kaika (*ibid.*) shows, modernist ideas and engineering attempts to release cities from any natural processes, in fact, demonstrate opposite results, namely, the binding of nature and city, of complex ecologies of social, technological, scientific, material and biological agents, into a socio-spatial continuum. Urban and non-urban landscapes, as Kaika captures them, are in a state of perpetual transformation. Nature—dangerous or beneficial to health, microbial or *macrobial* (O'Malley and Dupré, 2007), in need of maintenance or decidedly uncontrollable—has thus always been an inextricable part of urban landscapes.

Further explorations of these complex urban assemblages include geographer Matthew Gandy's (2004; 2006) heuristic concept of the 'bacteriological city' used to analyse how the functioning of modern cities was nurtured by the emergence of large hydrological infrastructures. In nineteenth-century Europe, the dawn of bacteriological medicine brought about a reconceptualization of organicist interpretations of urban order in terms of sanitation, rationalization, hygiene and water purification technologies. As the invention of novel water supply systems ties the privacy of the modern home to larger urban physical metabolisms, the 'bacteriological city' as a distinctive socio-spatial area can be explored through the concept of Foucault's biopolitical dynamics. In order to capture the relationship between individual bodies and social discipline, Gandy (2004: 367) argues that it is useful to link ideologies of hygiene and cleanliness to the wider regulation of social order through public health campaigns, urban restructuring processes, water infrastructures and, finally, the construction of a public realm. Against the backdrop of municipal governance attempts, the rationalized modern city, rooted in nineteenth-century capitalist urbanization, facilitates the political control of urban space. While cautioning against teleological approaches of urban space, Gandy (2006) portrays the 'bacteriological city' as an assembled dynamic, fractured by underlying (political, economic and social) tensions and contradictions. European and North American industrialized cities are defined as coherent functional entities, in contrast to rural areas in India or sub-Saharan Africa, which are characterized by water scarcity. The concept of the 'bacteriological city' is insightful in so far as it

traces the hidden co-evolutionary dynamics of urban flows, which are simultaneously social, biological, political, technical and microbial. The visibility and politicization of urban epidemics, as seen from this perspective, is constitutive of—rather than a threat for—the modernization process.

Finally, scholars of assemblage urbanism pay attention to the materiality of the city's socio-nature, often without addressing power relations, capitalist urbanization or social inequalities. According to social scientists Ignacio Fariás and Thomas Bender (2010), contemporary urban life requires new forms of analysis in which the city is examined from a relational and decentred perspective. Fariás and Bender (*ibid.*) make productive use of ANT as a laboratory for urban studies scholars who perform empirical analyses by looking at issues of scale, ecology and sociotechnical practice. Thus, in order to draw attention to heterogeneous urban networks—multiple human and non-human actors and spaces condensing into what is termed 'urban assemblages'—Fariás and Bender (*ibid.*) argue we must come close to a critical scrutiny of the shifting terrains of social categories such as society, the global-local differentiation, structure, scale or city. The application of ANT to urban studies provides a metaphoric approach that is highly sensitive to 'urban complexity, of the unities and disunities, of the stabilities and instabilities, and especially the complex and heterogeneous networks of connection and association out of which the city as a social and a physical entity is formed and sustained' (Bender, 2010: 315–16). Because of this, the city consists of an assemblage of assemblages. A focus on human/non-human domains and hybrid collectives, might make other aspects of urban life—political development, urban governance or spatial development—fade into the background.<sup>8</sup> Anthropologist Nikhil Anand (2011) in his ethnographic work on hydraulic infrastructures in Mumbai aimed to combine political ecology approaches with science studies. His analysis focuses on the multiple ways in which settlers try to access the municipal water system. As access is only granted to those who can officially prove that they occupied their settlements before 1995, others have to mobilize social and material relationships in order to access water. Plumbers, engineers and politicians play a key role in these processes. Mumbai, as Anand depicts it, has to be understood as a settlement and a living condition mediated by unequal, topographical and hierarchical relationships. He shows how cities have to be actively claimed and made liveable by their inhabitants (although certain populations—for example, Muslims—are excluded from these claims). What is important in these accounts is a focus on the topography of the city as a politically and physically mediated reality, and as nature that is enacted in socio-political relationships, rather than treated as a passive substrate or a stable essence.

In order to provide substance to the sketched discussion of urban natures in the context of urban health analysis, developing a deep and informed understanding of the numerous biological agents whose lives, movements, metabolisms and bodies are closely linked to human social worlds is crucial (Kirksey and Helmreich, 2010). In their efforts to reintroduce the concept of microorganisms, anthropologists Heather Paxson and Stefan Helmreich (2014) propose a focus on 'novel natures' in which a broad range of organisms are enrolled in the process of history making, scientific practices and social life.<sup>9</sup> For them, these novel natures highlight the indeterminateness of biology,

8 For a critical evaluation, see Brenner *et al.* (2011).

9 Helmreich's ethnographic and multi-sited research focuses on marine microbes and their embeddedness in genomic, bio-informatic and oceanographic knowledge systems. Helmreich's analyses, ranging from lab practices to submarine excursions, consider how microbes are used to foster a scientific understanding of the origins of life itself, of climate change and of the development of new drugs. Paxson, by contrast, specializes in artisanal cheese making and generally understands raw-milk cheese as an ecosystem within specific human-made environments. Paxson, who conducted fieldwork among cheese makers in the US, describes how alternative agro-food politics, local soils, microbes, humans, cattle and taste merge in microbiosocialities, a notion that critically scrutinizes attempts to separate human from microbial life. Both authors argue that microbes serve as 'model ecosystems in a prescriptive sense, as tokens of how organisms and human ecological relations with them *could, should, or might be*' (original emphasis) (Paxson and Helmreich, 2014: 165). Microbial life in this sense has evolved from being a peril and threat to human health to becoming a promising model for an as yet undetermined biology.

which indicates that its manifold possibilities are yet to be explored. Their novel natures—as reflected in the microbial turn of biology and biomedicine—swarm with ‘organismic operations unfolding at scales below everyday human perception, simultaneously independent of and entangled with, enabling of, and sometimes unwinding of human, animal, plant, and fungal biological identity and community’ (*ibid.*: 2; based on McFall-Ngai *et al.*, 2013). Bacteria, then, highlight a particular condition of living within and alongside biological nature (*ibid.*: 20), namely, a shift away from ontological conceptions of life itself towards framing the question of how we wish to live with other organisms and what forms of life this would include (*ibid.*; see also Paxson, 2008). From the perspective of microbial agency and novel natures, then, the concept of infection cannot be confined to the interaction of two bounded, distinct and ontologically diverse entities (the host and the pathogen). Instead, humans and their habitations are always already partly microbial. Consequently, novel ways of intervention might not necessarily aim to interrupt interaction, but implement new ways of interaction.<sup>10</sup>

Accordingly, assemblage conceptions of urban life not only allow for the inclusion of socio-technical arrangements, but also for an (empirical and analytical) opening for the contributions of other species, be they microbes or macrobes.<sup>11</sup> As previous viral outbreaks of zoonotic diseases such as Ebola, SARS and avian flu have shown, urban spaces—even if parts of them are designed around the need to control and limit access—remain permeable and fragile. Indeed, although urban environments might seem to be exclusively inhabited by humans, current research shows that we share urban space and urban susceptibility with a number of fellow creatures. A great number of biological agents such as birds, rodents, insects and viruses are urban dwellers too, and many remain invisible to the human eye and effectively circumvent control technologies. The past few years have shown a growing inclination to bring other species back into discussions that have traditionally been dominated by a theoretical perspective focusing on *anthropos* alone (Kirksey and Helmreich, 2010). Swarms—or ‘clouds’ (Lowe, 2010)—of microbial and viral agents, for example, consider urban environments and their inhabitants to be ideal habitats. Multispecies scholar Alex Nading (2012; 2014) suggests bridging critical approaches of biosecurity on the one hand, and nonlinear approaches of emergence and becoming on the other hand, by focusing on entanglements: ‘from the perspective of entanglement, people, birds, pathogens, and spaces are connected in a process of “mutual becoming”’ (Nading, 2012: 69). In this context, Nading (*ibid.*), in his ethnographic study of local dengue control programmes in urban Nicaragua, explores the boundaries drawn between human and non-human actors through mosquito management strategies. His research shows that anti-dengue advertising campaigns that promote a participatory approach by integrating female community workers (*brigadistas*) into the regulation of urban mosquito populations seem not to have solved the problem. These campaigns depict a vision of disciplined households where humans and insects are kept strictly apart, and where the female members of these households are assigned full responsibility for sanitation. Nading, who joined several teams of local *brigadistas* during their search for hidden larval habitats (such as flowerpots, bottle caps and coconut shells), observed profound discrepancies between scientific attempts at separating humans from insects and the *brigadistas*’ belief in accepting their environment and households as places of multiple interspecies encounters. This ethnographic study—which draws on the empirical example of community health in urban Nicaragua—not only reveals why the call for

10 Beisel and Boëte (2013), in their ethnographic approach, show how genetically modified mosquitoes are technically transformed into public health tools in the management of malaria. Researchers are turning mosquitoes into experimental animals instead of focusing on diminishing mosquito populations. If this strategy is successful, that is, if genetically modified insects do replace the native species, nature will be redesigned by imitating its potential ability for self-organization.

11 See O’Malley and Dupré (2007) on the concept of macrobes.

more rigorous advertisements, education strategies and ‘more science’ is doomed to failure, but also describes how interspecies entanglements challenge scientific attempts at rationally ordering urban environments. It suggests that urban nature is the setting of the entangled relationship of mosquitoes and humans. However, the concept of entanglement does not necessarily allow us to locate or confine infectious disease risks within urban environments. Rather, the city here is depicted as vicissitudinous, as an open landscape and a community shaped by the downsizing of public health investment, but otherwise unstable in form or extension. Urban health is therefore closely linked to uneven urban development processes.

Anthropologist Ann Kelly and STS-scholar Javier Lezaun (Kelly and Lezaun, 2014) offer another ethnographic analysis of vector-borne diseases in urban contexts. They describe public health intervention strategies in Dar es Salaam as attempts to disentangle the human population from malaria-transmitting mosquitoes (see also Brown and Kelly, 2014). Mosquito control is carried out by Community Owned Resource Persons—local residents who are trained to target larval habitats. Larval control strategies aim to identify potential breeding sites and—in some cases—treat them with microbial larvicide. Kelly and Lezaun (2014) identify two different rationales underlying public health intervention strategies. In theory, these strategies aim to disengage mosquitoes from the urban public by mobilizing sanitary images from Tanzania’s colonial past. But in practice, the authors argue, larval control seems to focus on urban maintenance and the mobilization of political ideas contrasting with prevalent notions of the function and impact of African governments. The authors emphasize the mobile and shifting nature of the urban fabric: holes, pits, drains, construction sites, sewage ponds, containers, but also fences and private premises, offer numerous breeding sites for the *Anopheles* mosquito. The mosquito, in turn, has adapted to the rhythms and surfaces of its urban environment. In this approach, the city of Dar es Salaam is depicted in terms of contingency, cohabitation and flexibility. As the city’s surfaces shift and evolve, so do the political, social and moral dimensions of city life that have an impact on both insects and humans. The city and its rural hinterland are organized through a malaria geography, thereby questioning dichotomous constructions of disease-free and disease-ridden areas: boundaries are porous, cities are expansive and urban dwellers are characterized by their increased vulnerability to vector-borne diseases (compared to their rural counterparts). At the same time, it seems impossible to detach urban epidemics from their colonial past.

Identification and questioning of existing categories of environment and organisms and the boundaries through which they are constructed (Ingold, 2004; O’Malley and Dupré, 2007) are central to the task of theorizing about urban health from the perspective of cultural anthropology. Boundaries matter in urban health research, as I will argue in the next section of this article. They are particularly relevant for the identification and location of disease risks in specific environments and equally important for biomedical concepts of infection as such, as well as for the conception of disease management strategies and the idea of ‘microbial emergence’ itself. Anthropologist Tim Ingold’s (2004) reflection on ecological knowledge draws attention to the fact that our conceptions of the environment tend to rely on a hierarchic world order in which places seem to exist within themselves and organisms are independent of their surroundings. Places as territorial mosaics, according to this conception, can only be experienced and known by movements ‘from place to place’. Ingold (2004) argues for an *ecological* relationship between organisms (be they human or not) and their environments; however, he proposes conceptualizing this relationship as mutual and emerging when he writes, ‘In short, organisms no more interact with the environment than do individuals with society. Rather, ecological relations—like social relations—are the lines along which organisms-persons, through their process of growth, are mutually

implicated into each other's coming into being' (Ingold, 2004: 306; see also Ingold, 2000). If we are to take this argument seriously, then pathogens—and other organisms—do not spread along the lines of a pre-existing global order; rather, pathogens themselves and the technologies invented to manage them co-produce new global orders and new environments. Similarly, a number of scholars (Star, 1991; Tsing, 1995; Franklin, 2007; Haraway, 2008; Paxson, 2008) have argued for the social and conceptual inclusion of other species in order to promote a richer understanding of human health, ecological niches and development, and biodiversity. In her ethnographic work on environmental conflicts in Indonesia, multispecies scholar Anna Tsing (2005) rightfully claims to analyse global connections (ecological activism, global health movements, healthy city projects) from the inside and to move beyond generalized assumptions about local knowledge, freedom, transnational politics and humanism. By studying a broad range of actors, such as village elders, honeybee trees, UN funding agencies and rainforest tourists, Tsing describes how environmental activism is enacted in fragmented and sticky connections. Seen this way, through ethnographically informed research, world-travelling concepts, such as feminism and market rationality (but also risk and infection), are only effective at specific times and places. An understanding of how concepts of nature and environment are invoked in global environmental discourses, Tsing (*ibid.*: 4) argues, involves an understanding of the creative, unstable, awkward and unequal interconnections across differences. She employs the concept of friction—the sticky grip of encounter—to argue against notions of the homogeneous formations of culture, power and politics created by globalization processes. Tsing (*ibid.*) promotes the vision of global diversity and multiple global futures, rather than that of bringing about a culturally and biologically uniform world. Concepts such as friction enable us to rethink nature, environments and the biological beings that inhabit them as being in a permanent process of formation and becoming. They also enable us to understand the frameworks needed to make a universal knowledge of nature effective and true, and to thoroughly understand material and symbolic gaps that hinder powerful demarcations—such as nature/culture and human/non-human binaries—from travelling well.

Accounts such as these are particularly helpful in understanding why Western biomedical concepts of responsibility, risk or sanitation (see Kelly and Lezaun, 2014) might not be smoothly adapted in any local context, and why diseases such as malaria cannot be confined to a singular ontology and a stable essence that is easily approached by scientific rationality. In light of these approaches, it seems doubtful that disease risks can be located in specific features of the urban environment (see also Brown and Kelly, 2014). Instead, the particularities of political, biological, climatic, historical, social and economic contexts are of theoretical and empirical importance.

In sum, different scholars approach urban natures very differently. While some authors are concerned with ecological politics, others are more interested in the management of community health, or the topological relationships between different species. However, the approaches outlined above share a concern with *bios*, the liveliness and organic nature of cities: urban environments are here portrayed as life space, as landscape, as community, or as biosocial spaces. Their forms are unstable and expansive, and their geographies are not only of human origin, but organized through the activities of other species and organic flows. Accordingly, health is unpredictable and vicissitudinous—and it cannot be achieved by disentangling humans from other urban inhabitants, but only through living *with* nature, as proponents of these approaches argue. When we look at the concept of disease emergence from these perspectives, infectious diseases are already an intrinsic and intra-active (Barad, 2003) part of urban and other landscapes, instead of possessing an event-like and unpredictable character.

### Network approaches

Since the emergence of SARS in 2002/2003 and avian flu in 2003, scholarly interest in the intimate relationship of cities and the mobile and networked nature of infectious diseases has grown. As discussed above, viruses and other microbial agents are material-symbolic representatives of an emerging and uncontrollable nature. In this context, some pathogens (such as H5N1, anthrax, and MERS-CoV—Middle East Respiratory Syndrome Corona Virus) have come under scrutiny: their routes of transmission and their genetic makeup have been analysed, they have been politicized, and they are embedded in transnational surveillance systems. When an emerging virus arrives in the city, it represents ‘matter out of place’ (Douglas, 1966) and elicits a wide range of biomedical and sociotechnical countermeasures, mirrored by the escalating response schemes of pandemic preparedness. Other pathogens, however, pass unnoticed as they are neither classified as emerging, nor are they diagnosed or made visible to surveillance systems (for example, *Trypanosoma cruzi* or *Mycobacterium ulcerans*). Paradoxically, global networks simultaneously serve as threat and solution (Wald, 2008: 8). Intensified global flows of people, microbes, consumer goods, traffic and transport—connecting other organisms and other places to the bodies of urban residents—pose a massive threat to urban health, while they also create transnational collaborations, surveillance networks and the exchange of expertise and experts. The spatial dimensions of prevention and disease management in mobile fields present a number of challenges to scholars working within urban health contexts. When compared to (1) biocultural; and (2) multispecies perspectives on urban infections, network approaches tend to stress the relational character of infectious diseases, their topological dimensions and their translation into the domains of biosecurity. The establishment, maintenance, circumvention and erosion of territorial borders are of key importance to these approaches. Their empirical focus is on those pathogens that are highly visible (often airborne viruses) and considered to be of global significance—although, as critical approaches claim, the implementation of networked disease management technologies mainly meets the needs of Western states (Fidler, 2003; Davies, 2008; Washer, 2014).

Sociologist S. Harris Ali and political scientist and urban planner Roger Keil (Ali and Keil, 2008) bring attention to the conceptual links between globalization and cities as they became apparent during the SARS outbreak in 2003; the authors coined the term ‘networked disease’ as an approach to this complex relationship, as shown in this excerpt:

The SARS pandemic marked a historical change as cities ... have become once again places of heightened vulnerability. As the scales hierarchy of global cities becomes the conduit of disease transmission, another reality becomes visible: the global cities hierarchy is really a complex network of topological relations both externally (cities among one another) and internally (the capillary system of the globalized metropolis). What is central to such conceptualizations of both the relationship amongst global cities, and within global cities, are the notions of mobility, flow, and dynamism, and the consideration of such factors is perhaps best understood through more networked and topological understandings of the city (Ali and Keil, 2008: 5–6).

Based on the idea of a global cities network, their research focuses on the relationship between microbial traffic, institutional governance and the culture of civil society. Here, microbes transgress the urban–global dialectic. While Ali and Keil very aptly direct attention to the topological organization of emerging infections and the impact that urban environments and global networks have on the (re-)emergence of infectious diseases, it is far less clear—as the empirical cases of avian and swine flu have shown—whether the global distribution of emerging pathogens is organized in a predictable

pattern. Given the complex interactions described above, the biological and social realities of emerging viral infections will have their own dynamic. To this day, knowing which type of city will be affected most by the next pandemic is still not possible.<sup>12</sup> While the concept of networked disease is helpful for considering issues of scale and pace of disease transmission, a focus on the ‘vulnerability of the global cities network’ (van Wagner, 2008: 25) might simultaneously run the risk of reinforcing traditional outbreak narratives (see Wald, 2008).

The multifaceted issue of globalizing infectious diseases basically involves the insight that microbes (other than vaccines) live in a borderless world. Although it is widely accepted that the emergence of new viral subtypes, triggered by genetic reassortment, is served by the close proximity of different species (this is commonly attributed to rural areas, particularly in Southeast Asia and Africa—see Fuller *et al.*, 2013), scholars such as the British geographers Steve Hinchliffe and Nick Bingham (2008a) convincingly argue that defining a city by definite boundaries is impossible since cities and their agricultures are organized within the same network of interactions and disease transmissions, consisting of the numerous material and non-material flows described above. Multispecies interfaces, they say, are an integral component of a globalized modernity and its specific trade, traffic and consumption patterns, rather than resulting from assumedly ‘primitive’ and ‘pre-modern’ places.

In her empirical work on the SARS crisis in Hong Kong, sociologist Evelyn Lu Yen Roloff (2007) describes the urban governance of the epidemic as a restructuring process of established political hierarchies that enabled the public to articulate the (bio-)political needs of security and bodily integrity, if only temporarily. In her analysis of the activities of the Team Clean task force, a hygiene initiative, she pays close attention to the spatial dimensions of infectious disease management. According to internationally articulated objectives, the urban space of Hong Kong is categorized into high-risk and low-risk zones, with far-reaching consequences for their inhabitants. Whereas the residents of Amoy Gardens, a large and ‘high-risk’ apartment complex, had to face severe hygienic interventions such as quarantine and confinement, highly mobile but ‘low-risk’ international elites by contrast subverted restrictions. Giving empirical priority to representational features of the securitization paradigm places emphasis on educational messages, the visualization of risk, and the mapping of individual cases (but less so on individual agency, experiences or limitations). Roloff’s (2007) study makes it apparent that globalized and non-territorial threats such as SARS and avian flu challenge traditional concepts of urban space and its governance. As architectural historian Ben Campkin and geographer Rosie Cox (Campkin and Cox, 2007: 1) note, the spatialities of dirt and contamination (which are of major importance in the conception of hygienic interventions) might be made visible by reflecting on concepts and practices of cleaning and cleanliness. Thus, notions of blame and responsibility find a resonance in hierarchies of cleanliness and health (see also Aasgard Jansen, 2013). Roloff’s work stresses the city’s representational character—it is here where local, regional, national and international governance processes overlap and are decided, mirroring international and powerful fears of emerging pathogens. In this account, the borders of the city are thus boundaries of legal jurisdiction.

12 The difficulty of predicting the spread of pathogens is attributed to numerous issues. First, mathematically speaking, pathogens are emerging from non-linear systems that are difficult to analyse and model. Secondly, the genomic diversity of microbes adds further complexity. Thirdly, previously unknown emerging pathogens pose a particular challenge, as these are characterized by an absence of data for prior outbreak events. Ecologist Andy Dobson (2014: 1295) explain this as follows: ‘Ultimately, emergence and prediction are very different phenomena that have an asymmetrical and complex interaction with each other. Complex ecological and epidemiological systems have emergent properties, but the ability to predict these properties, or even their emergence, will be very limited until retrospective data are available to which some form of structural model can be fitted’. For debates on the spread of H7N9, see Butler (2013).



French anthropologist Frédéric Keck (2011a) takes a different—less Foucauldian—stance in which he finds the prevention of avian flu in Hong Kong to be embedded in a web of relationships (exceeding the web of mere power relations). Based on fieldwork performed in Hong Kong, Keck (2010) describes how the emergence of SARS seemed to confirm the hypothesis that new viruses originate in South China's ecology (which is characterized by close proximity of different species) and that they use Hong Kong as a point of transmission to spread globally. Keck draws on analogies between bioterrorists and pandemic threats to sketch how Hong Kong became a sentinel for avian flu and a biosecurity hotspot. Whereas many scholars of the existing literature on biosecurity make use of Foucault's notion of biopower, Keck understands biosecurity measures as the outcome of specific human–animal interactions. In his understanding, animals (being an important part of the chain of transmission) and their immune systems are transformed into sentinels for the emergence of pandemic flu viruses and therefore contribute to attempts to modernize Hong Kong into a bulwark of disease control. Hong Kong is portrayed as 'a place where live poultry is produced, exchanged, and consumed, or as a city where nature is at the same time controlled and proliferating' (2011b: 57). Thus, urban and rural environments do not represent a dialectical order, but are entangled and share certain characteristics (such as poultry consumption patterns). In this account, the city of Hong Kong embraces three functions: a sentinel post, a gateway to the distribution of agricultural and other products, and a sensitive border territory to the city's rural hinterlands such as Guangdong province. This account is instructive, as it captures multiple connections without squeezing them into linear and static networks.

In his anthropological study of diverging techno-political responses to emerging infectious diseases in the US, anthropologist Andrew Lakoff (2008) quite convincingly demonstrates how the scope, the underlying logics and the technologies of prevention have profoundly shifted over the past 30 years. Increasingly complex and globalized disease aetiologies have led current responses to emerging infectious diseases to draw on a variety of potentially catastrophic threats (generic emergency planning), based on imaginative enactment instead of on statistical calculations and aim to protect the critical infrastructure. Preparedness, according to Lakoff (2008), has become the most prominent underlying rationale of infectious disease governance.

Hinchliffe and Bingham (2008b), in their work on the governance of an avian flu outbreak in 2005/2006 in Cairo, portray a world in which biosecurity measures (a set of divergent practices such as import and hunting bans, border monitoring, culling and virological surveillance) were utilized to modernize and make the city safe. The Egyptian government targeted backyard and rooftop poultry as the main risk factors contributing to the spread of the virus. Suddenly the 'sights, smells, and noises of poultry' (*ibid.*: 1545) not only meant an unwanted disruption to representations of Egypt as a modern metropolis, but also seemed to pose a major risk to the city's human population. Experts killed and disposed of an estimated 34 million birds. Simultaneously, an agricultural crisis caused by the restructuring of the poultry industry struck the nation and ended in the breakdown of small local economies, food price increases and the proliferation of small-scale husbandry. When put together, these efforts resulted in food shortages and chaotic attempts to hide seemingly healthy chickens and ducks or to bring infected birds onto the market. In their critical approach, Hinchliffe and Bingham (*ibid.*) attempt to question the interaction of various disease and security ecologies in Egypt. They conclude that while some of the security measures (such as culling) may succeed in minimizing the number of potential hosts, the same measures also create new risks and new viral niches (such as numerous dead or hidden animals). To realize the dynamic and topological nature of biosecurity networks, referred to as 'netwars', they argue that one has to take into account their multiple interferences, adaptabilities

and accommodations. Current bio-surveillance approaches underestimate the non-human and build upon 'a logic of control and instrumentalism', and thus fail to adapt to the indeterminate nature of networks (*ibid.*: 1547). The city here serves as a focal point, where globalization processes are enacted—although the lived city as its inhabitants perceive it stands in stark contrast to the imagined city as it is represented by the government. Hinchliffe and Bingham (*ibid.*) represent networked diseases in the city as consisting of always impure, highly complex and topologically distributed orderings. They show something that is important for our purposes here: how transmission processes circumvent scalar logics.

In a similar attempt, Ash Amin and Nigel Thrift (2002) associate modern cities with a series of circulating networks rather than with a series of locations. Cities are made up of moving and emerging forces, of multiplicity, symbioses, little things and change, many of which escape the attempt to grasp them in encompassing concepts and controlling mechanisms. As a result, cities resist the Foucauldian panoptic gaze (Foucault, 1977) and possess an experimental nature. Amin and Thrift (2002) cite the work of Luhmann (1998) on ecologies of ignorance, arguing that 'the city is a complex imbroglio of actors with different goals, methods and ways of practice. Then, precisely because of this complexity, the city can never be wholly fathomed. There always remain parts that can never be reached ... gaps, blind spots, mistakes, unreliable paradoxes, ambiguities, anomalies, invisibilities' (Amin and Thrift, 2002: 92).

When taken together, network approaches mostly capture airborne infections and emphasize cities' functions as focal points, gateways, border territories or conduits of disease transmission. Thereby, they point to diverse attempts to govern microbial traffic either through the monitoring and surveillance of pathogens or the regulation of agricultural production and meat consumption, often framed as biosecurity technologies. Cities—based on this understanding—are not only shaped by circulation and flow, but are affected very differently by hierarchical modernization processes. Health is thus drawn into the domain of security and seems to be fundamentally ambiguous: while it results from successful governance practices, it is also portrayed as embedded in flows, and thus eventually not controllable and maybe even transhuman. Such studies of urban complexity and the traversing of organic boundaries make it apparent that anthropological research into global health governance and disease surveillance that is blind to the multitude of flows, bodies and processes contributing to urban life and urban health would quickly lead to a theoretical dead end with limited explanatory value. Conversely, it is not surprising that scalar logics might not be able to capture the complex and relational configurations of urban epidemics.

### **Messy materialities: future challenges**

Infectious diseases represent one of the most common causes of suffering, illness and death worldwide, and they are often attributed to urban environments. A focus on the material impact of urban environments on the health of its inhabitants might reveal a whole new set of questions about the interactions among host, pathogen and environment, and about how urban infections manifest themselves differently in different local contexts. Cities troubled by infectious disease outbreaks do not fall neatly into universal categories of space, modernity or risk; rather, they are produced and formed on a range of social, political, biological and economic sites and scales. Whereas emerging infectious diseases are often portrayed as a 'natural' effect of urbanization and globalization processes, critical biosecurity scholars have, however, pointed out that the concept of emergence itself is only enacted within specific analytical frameworks. The three different analytical lenses discussed in this article offer three distinct, but not necessarily mutually exclusive, frameworks for communicating about the complex subject of urban infections. First, biocultural approaches

productively blend and analyse biological dynamics, environmental effects and social practice. They present cities as environments, environmental conditions or as habitations, while simultaneously stressing that risks are distributed unequally between and within cities. In these approaches, disease might be understood as the interaction of two distinct entities: environments and the bodies that inhabit them. Second, approaches that focus on urban natures and multispecies entanglements understand other biological actors as essential to urban infectious disease ecologies. While they display the liveliness of cities, they also focus on their unstable and expansive character. Environments are thus never bounded, but entangled and open. Health, as seen through this lens, can only be achieved by living with—and not against—nature. Third, and finally, network approaches display the manifold ways that territorial borders are established, circumvented, maintained, politicized or eroded in infectious disease management. They stress the unbounded nature of urban environments by analysing governance processes. Scholars working in this tradition depict cities as shaped by circulation processes. Circulation processes, in turn, are organized in a hierarchical order. Within this hierarchical order, some pathogens and their urban habitats pass unnoticed, while others are highly visible and believed to be of political significance. Here, health is drawn into the domain of security.

Urban epidemics are moving targets, and research into urban epidemics is evidently shifting and multivalent. I will now briefly sketch some methodological and epistemological implications arising from this area of research, as considered from the perspective of cultural anthropology. One of the most striking qualities of urban epidemics is their inherent mobility. Studies of the networked character of infectious disease have shown how these are embedded in topological relations and networks that exceed their geographies. The anthropology of globalization (Tsing, 2005; Collier and Ong, 2008; Lowe, 2008) provides important impulses regarding the exploration of mobile and multi-sited phenomena such as migratory microbes, global health strategies and the circulation of agricultural products. This line of enquiry has shown that the analysis of globalization processes moves beyond an investigation of a growing global interconnectedness. Instead, a reconsideration of analytical categories of space, time, climate or nature—which are of equal importance to both the social sciences and public health—goes hand in hand with accounts that ramify different sites and aim to capture new paths of connection and association.<sup>13</sup> Outbreaks of infectious diseases with pandemic potential put political, ethical and technological pressures on the relationship between science, the market and the geographies of afflicted populations (Collier and Ong, 2008: 18). In order to delineate biosocial territories and connections and to track people, animals, pathogens or things moving through them, anthropology—and other ethnographic sciences—might need to evolve from their former committed localism.

This might be particularly significant when addressing the multiple embeddings and disembeddings as characteristic of globalized disease ecologies. Steve Hinchliffe, John Allen, Stephanie Lavau, Nick Bingham and Simon Carter (Hinchliffe *et al.*, 2013) in their multi-sited research suggest understanding parts of the environment as ‘borderland’ in the transformation and rearrangement of infectious spaces. In analysing the topologies of infected life, they argue that infectious diseases cannot be reduced to a simple and fixed geometry, and that biosocial spaces are never pure. Rather, disease is depicted as contingent and dynamic intra-action: health is not threatened by intruding pathogens, but life and pathogens co-evolve. Consequently, as they argue, attempts to separate infected from healthy life are doomed to failure. According to this conception, proximities cease to be well-defined, and cities have to be thought of as ‘topological landscape[s] of embeddings and disembeddings, where disease registers its presence through the density of its intra-actions’ (*ibid.*: 358). Seen in this light,

13 See Marcus (1995) on the emergence of multi-sited ethnography.

infectious diseases, as well as cities, cannot be confined within static realities. This observation provides different ways of understanding how new biosocial territories emerge and are organized, and might be useful for further research into the conception, application and implementation of biosecurity measures.

The observation that infectious diseases manifest themselves very differently in different local contexts accompanies a need to ask comparative questions. Disease emergence, biomedical intervention and policy responses vary from country to country and region to region. Ethnographic studies have shown how cities and urban populations are affected differently by SARS, avian flu or vector-borne diseases, with potentially far-reaching consequences for the population. In order to understand how urban outbreaks of infectious diseases demonstrate differences and similarities, and to understand how different urban settings enact different forms of health and disease, it might be useful to apply a comparative perspective. At the same time, comparative approaches are subject to their own limitations and challenges. They start with the assumption that it is meaningful to compare two settings along certain dimensions. Thus, it is essential to identify abstract concepts and categories that can be used across different contexts. But, as anthropological research has shown, even apparently common phenomena such as death, menopause, fertility or contagion display tremendous local differences in terms of categorization, definition, treatment and diagnosis, and can only be approached meaningfully as embedded in a particular context. It is therefore doubtful that comparative approaches enable us to discover universal causal explanations—although comparative approaches help us rethink the general applicability of theories and models of urban infections and their shortcomings (see Azarian, 2011).

As I have shown, sociocultural dimensions (such as dietary customs, burial rituals or kinship relations) and biological dimensions (such as host-pathogen interactions, the environment or specific genetic traits) are of equal importance in the transmission of pathogens, and herein lies an opportunity for interdisciplinary approaches. Anthropological studies of infectious diseases span a broad range of diverging diseases, geographical contexts and historical eras. They are often grounded in the localities, communities and settings that have been affected by infectious disease outbreaks. They have provided insightful accounts of the interactions between hosts and pathogens within diverging contexts and have often contributed to the understanding of complex disease ecologies and their potential control. Shirley Lindenbaum's (1979) study on kuru, a neurodegenerative condition, in New Guinea is probably one of the most prominent early examples. Anthropological approaches combining macro- with micro-sociological perspectives are relevant for understanding how human behaviour affects the transmission of pathogens, either by increasing or limiting the spread (Inhorn and Brown, 2009: 42–3). This means calling attention to the way in which infectious diseases both influence and are products of human practice, rather than representing singular, spontaneous or natural events. It also means engagement with people, animals and pathogens.

Ethnography aims to produce representations of the knowledge, actions and concepts of the people it studies by paying close attention to local actors and their involvement in processes, interactions, and so on. This can only be achieved by observing and questioning practices. Why do some people fall ill from infectious disease while other people stay well? How do people organize and experience their environments? Which treatments do people decide to use for an illness? How do people relate to other biological organisms? These are questions that anthropology has addressed and aims to answer.

Geographical studies of infectious disease ecologies, in turn, have been highly productive in showing how cities and infectious diseases are embedded in technological, political, environmental and social networks that exceed their geographies (see Anand, 2011). They have, among other things, developed topological understandings

of infectious diseases and continue to question the establishment, circumvention, modification and erosion of territorial boundaries. This is especially relevant to the analysis of infectious disease governance. When taken together, anthropological and geographical approaches might offer a deeper understanding of the social production of infectious spaces and their constitutive practices, policies, materialities and processes. Both depend on sustained empirical analysis and on interpretative theory, both might provide sources for critique and intervention—and both might benefit from an engagement with biotic materialities and processes (see Kirksey and Helmreich, 2010: 8). The implications of biological and medical approaches, and of knowledge regimes for social science studies of human–environmental interactions, need to be taken seriously. As the numerous studies discussed throughout this article suggest, infectious diseases are neither socially constructed, nor natural biological phenomena. Ethnographically trained multispecies scholars underscore the importance of understanding precisely how environmental, social and political dynamics serve to establish and sustain co-evolutionary links between different biological agents such as humans, plants, animals and microbes. Analytical concepts such as the molecularized body (Lock, 2012) might provide a good starting point for rethinking human embodiment within distinct biological, social, historical and spatial contexts beyond disciplinary boundaries.

In order to understand the impact of biological dynamics, environments, networked effects and social practices on the constitution of contemporary urban settings, it is crucial to take the concept of the urban seriously as both object *and* locus of empirical research. As a locus, cities offer a setting for ethnographic work. Ethnographic work here promises insights into how people experience and construct their environments, how they relate to other people and to animals or microbes, how political discourses are manufactured, and how health and disease are negotiated (see Kleinman and Lee, 2006; Keck, 2011b; Nading, 2012; Kelly and Lezaun, 2014). In turn, to think of urban settings as objects of research means to pay attention to their manifold forms, territories, expressions and dynamics, as well as their relationships with other places (Brenner and Schmid, 2014). A combination of both perspectives might provide useful insights into the interrelationship of urban forms and infectious diseases on different scales and at different sites. It might also help us gain a better grasp of how urban settings relate to other places, commonly referred to as rural, sub-urban or non-urban. Against this backdrop, numerous studies have pointed out the relational character, messiness and complexity of urban infections. The fact that urban disease ecologies and urban natures are messy and entangled means that it is impossible (from a theoretical perspective) to analyse urban health along predetermined categories of biological life or to understand them through abstract notions of their material properties. In addition, as I have shown above, the lives of other biological beings lie firmly within the scope of social science studies. On a conceptual level, empirical research into fluid and processual phenomena helps us rethink the limits of human agency. A focus on messiness might enable us to see things, connections, or nooks in what has always been there. It is noteworthy that the messy nature of urban infectious disease ecologies cannot be abbreviated to what is found in concepts. Some things, however, might remain unknown or unnoticed, maybe even unknowable. By unravelling formerly invisible things, connections or actors we enable them to enter new domains of theory, problematization or political action.

Finally, do we subscribe to the idea of accepting infectious disease risks as an inherent quality of urban environments? One possible solution is offered by Austin Zeiderman in his ethnographic approach to the management of environmental risk in Bogotá. Rather than investigating how the poor came to inhabit landscapes of risk, he suggests asking how zones of risk came to inhabit the territories of the poor (Zeiderman, 2012: 1572). Accordingly, it might prove beneficial to ask how the surveillance, anticipation, visualization, politicization and management of infectious

disease risks came to choose urban environments as one of their major targets. Critical biosecurity approaches analyse how infectious disease risks are enacted within complex assemblages of sociotechnical infrastructures, biomedical knowledge, different biological organisms and policies. Practices and technologies of emergency and resilience planning are performed, functioning as new tools of urban governance, and new areas of intervention emerge. The critical analysis of the classification, comparison and visualization of infectious disease risks has political dimensions, as the construction of new infectious disease risks might lead to socio-spatial transformation processes and specific urban futures.

As microbes and other pathogens are inextricably linked with human social, political, economic and urban worlds, infectious diseases are here to stay. This creates both opportunities and responsibilities for urban studies and the social sciences overall. By paying close attention to the material impact of urban environments and its effects on the health and the diseases of its inhabitants, we might develop a deeper understanding of the interactions between host, pathogens and environment, and of how infectious diseases manifest themselves differently in different local contexts. Eventually, this may not only provide insights into the manifold forms of urban life, but also into the multiple, complex and highly political constitution of health.

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