# Emerging Diseases and Socio-spatial Disparities
## Lessons from Dengue Virus in Delhi

Olivier Telle, Richard Paul

In less than two decades, new viruses that were thought to have been controlled have re-emerged worldwide. Socially disadvantaged individuals and urban health inequities may help spread such diseases. Just as social sciences originally used diseases as a powerful prism to study inequalities in urban areas, there is now a case for using social sciences to analyse and solve global health issues.

Olivier Telle (*telle.olivier@gmail.com*) and Richard Paul (*rpaul@pasteur.fr*) are with the Centre national de la recherche scientifique, Institut Pasteur, Paris.

Over the past few weeks, Zika virus has been constantly mentioned on television and in newspapers. The scourge is the latest in a long line of recent highly publicised epidemics of varying severity, including Ebola, dengue, chikungunya, H1N1 and H5N1. Despite the great hope in the 1960s and 1970s that insecticides, antibiotics, vaccination and improved hygiene would eradicate infectious diseases, the increasing frequency of emerging diseases bears testament to our overconfidence.

Indeed, at the end of the 1990s, 20 years after having declared infectious diseases under control, the World Health Organization (WHO) asked its members to be prepared for an international crisis. While some infections were controlled, if not eradicated, new viruses emerged or the ones that were thought to have been controlled re-emerged. Dubbed as emerging or re-emerging diseases (ERED), they represent great threats for human life and well-being, as revealed by the recent outbreaks of Ebola in Africa, Zika virus in America and dengue in Delhi. The resurgence of viruses has to be contextualised within the socio-economic, political and sanitary evolution of the world, where urbanisation has taken centre stage. Socially disadvantaged individuals living in urban settings suffer from an increased burden of disease, and urban health inequities may provide a propitious environment for the expansion of emerging diseases.

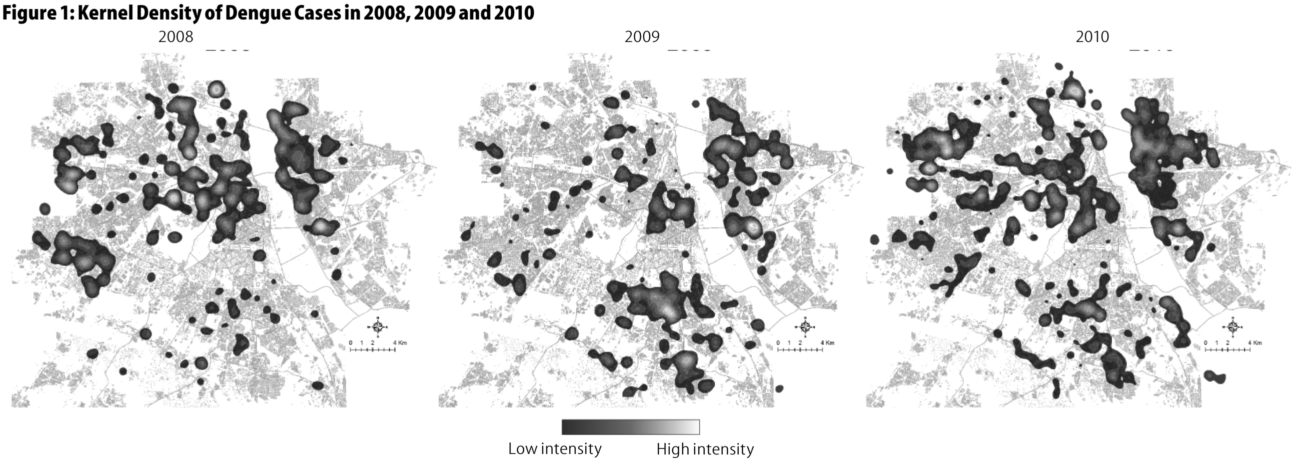
### Modern Urban Diseases

Social sciences have always seen diseases within the ambit of major urban concerns. For example, the hypothesis of an intimate link between socio-economic fragmentation and the incidence of urban pathologies was supported by studies in health geography (Vaguet 1986; Salem 1998). Echoing Chicago School (urban ecology), Henri Lefebvre (“right to the city”) or Marxist geographers, classical urban diseases such as cholera, gastroenteritis or plague were appreciated as proxies “revealing” disparities among areas, in access to basic urban amenities (hospitals, water). Since such diseases receded and given that the link between diseases and the "quality" of urban environment was always intimate, geography has tended to abandon the study of these diseases. The rise of ERED calls this classical model of geography into question.

Dengue is one of the major modern urban diseases that have swept through the tropics and subtropics over the last decades. This disease provides us with a unique case with which to understand the link between urbanisation and ERED. First, dengue is principally transmitted by a mosquito species, Aedes aegypti, that has become domesticated and has adapted to exploit an urban niche. As urbanisation has expanded, so has the distribution and prevalence of this mosquito species. Second, although the virus has been known for centuries, it spread worldwide during the 1980s, and has now reached alarming proportions in keeping with the massive extent of global urbanisation. Currently, more than 3.5 billion people are at risk of dengue virus (DENV infection) in over 100 countries—an estimated 390 million infections every year, of which 100 million cause clinical symptoms. The emergence of dengue has been concomitant with urban expansion and increased international connectivity that enable the spread of pathogens.

Delhi has been affected by dengue since the 1990s. Every year, dengue epidemics make newspaper headlines. The epidemics have become major social and political issues. Establishing the contribution of urban geography to the extent of the epidemic is a prerequisite to proposing potential solutions. Classical ways to underline the geography of a disease are: (i) to study the spatio-epidemiological model of the disease (dengue cases clustered in space, for example); (ii) to study the link between incidence rate of dengue cases and socio-economic disparities, including access to urban amenities and economic level and type of colony (slum, approved, non-approved, non-approved but regularised colonies). Dengue cases registered in 2008, 2009 and 2010 at sentinel hospitals were geocoded into a Geographic Information System and the environment of colonies was defined using information on property tax and population density (Telle et al 2016; Telle 2015). The number of cases registered in 2008, 2009 and 2010 are 1,253, 1,129, and 6,500 respectively.

**Figure 1: Kernel Density of Dengue Cases in 2008, 2009 and 2010**




Source: Telle et al 2016.

## Emerging Model?

The spatial diffusion process was determined through a spatio-temporal analysis of infected individuals: at the local-scale, dengue cases spread from one index case (the first individual being infected in one area) to the local vicinity, while at the city scale, individual mobility enabled a spread of the virus to other areas of the city (Telle et al 2016). This reveals that a majority of dengue infections appear to be realised in the colony of residence. A map of the density of dengue cases (Figure 1) reveals that in 2008, the highest concentration of cases were located in west, central and east Delhi; no important clusters were located in south Delhi, which house rich colonies. Although the 2009 Density Map (Kernel Density Estimation (KDE)) shows that as in 2008 the central and east Delhi were affected, south Delhi had high densities of infected individuals.

Globally, the density estimation reveals a different spatial distribution of the cases in 2008 and 2009 despite a similar number of dengue cases in both years (1,253 and 1,129 cases). Thus, even though the system appears globally stable (same number of individuals infected), certain instability is revealed at the meso-scale. This has an important consequence for case management, since it reveals that disease control cannot be based upon the previous year's geographical distribution. This likely reflects herd immunity, where individual immunity follows a previous infection and prevents viral dissemination. It, thus, provides protection for those individuals not previously infected. The result of this is that previously affected geographical areas become unfavourable for viral diffusion. The 2010 spatial pattern of dengue cases visually appears to be a combination of the two previous years with a much greater density, since four times more cases were registered.

Entomological studies revealed that houses in higher income areas had fewer Aedes aegypti larvae compared to houses located in deprived areas (Kumar et al 2015). However, despite a strong link between socio-economic status and Aedes index, the analysis of dengue in Delhi revealed that dengue affected the most deprived areas. However, high income colonies were infected as well despite lower Aedes population. This could be due to an unbalanced surveillance system, but our fieldwork confirmed the significant infection rate of rich colonies in comparison with other typology (recently planned areas, for example). In conclusion, it seems that the stochastic nature of where the virus first enters the city likely smothers any detectable socio-economic risk factors. Meanwhile, the size of a dengue (the number of cases per cluster) depends on the timing of its emergence: earlier clusters contain more cases, emphasising the need for early case detection and implementation of effective mosquito control around focal cases.

The study suggests that the dengue risk at the city scale cannot be predicted on the basis of socio-economic factors alone. While our findings need confirmation (such studies being too rare), this pattern seems to be observed in many other cities (Mondini et al 2009; Teixeira et al 2007; Donnat et al 2011). Researchers have observed this model for other ERED as well, since severe acute respiratory syndrome (SARS), chikungunya, West Nile virus, etc, demonstrate spatial and social ubiquity. It is unclear, to say the least, that the socio-spatial disparities make sense for emerging diseases in particular, but for other classical diseases as well. This redefinition of a classical paradigm of geography has strong implications since health planners/researchers have difficulties not only to find ways to tackle epidemics, but also to locate spaces/places in which to implement these strategies.

This gap between the socio-economic geography of risk and related geography of pathogens has to be linked with other environmental changes in cities. Metropolises and other urban centres are subject to phenomena beyond a simple change of scale and complexity. The increase in the amount of daily and periodic movement as well as long-term migrations are probably the main factor shaping the urban landscape of emerging cities. They are indeed more than ever open to a network of global cities and increasingly oriented to their peri-urban sectors and peripheries. As a consequence, spaces are hyperconnected at all scales (intra-urban, regional and national) and share risk factors related to ERED. If an individual can be infected by dengue during his/her diurnal mobility, this suggests that cities at the international/national scales and central areas of cities at the urban scale can be infected due to a convergence of infected individuals regardless of socio-economic factors. The progressive spread of a "new" urban model forces us to reconsider classical sanitary dichotomies between spaces that once appeared to be segregated.

## Mobilities in Research

Highlighting the spatial and social ubiquity of viruses is the first important step, but it has to be accompanied by long-term scientific research. Integrating urban mobilities as a proper component of geography of risk should lead to a better governance of diseases. Since individual and collective mobility often bypasses the local level, researchers have to go further than topographical distance to focus on topological/relational ones. This is the project of relational health geography (Cummins et al 2007), which aims to quantify these flows while offering, at the same time, theoretical perspectives on the role played by certain types of "places" in the diffusion of diseases. Due to the complexity of rising mobility, this type of study is still emerging and challenged by the lack of data, which leads researcher to use "proxies" (mobile phone data, for example). Such proxies are often not adapted to the risk population in question. However, new biological methods enable geographers to observe the interrelation between mobility and virus diffusion in cities.

Indeed, as strains of dengue virus are evolving from one week to another, virus sequences will enable us to follow strains in space and time and to link spaces sharing similar strains. Rather than estimating a priori diffusion of viruses according to individual mobility estimation, this will enable the observation of virus strain diffusion a posteriori. This type of study would, when carried out in a routine way, enable us to better understand the spread of diseases at different levels.

However, to understand clearly emerging diseases and related factors enabling their perpetuation in society, researchers have to focus on the way they are managed by health and political authorities. Urban change is indeed one reason explaining the hyperdiffusion of viruses, but we could also expect a social resilience in the face of the diffusion of these pathogens. We can now say without doubt that politics and society did not respond correctly to ERED. While very few such studies have been conducted on this problem at the international level, there are even fewer analyses of the urban governance of diseases, even though cities are epicentres of many emerging diseases and contribute significantly to their subsequent diffusion.

## Health Governance

Research dealing with the governance of ERED would note striking inequalities both between and within cities. In India, if dengue, for example, is relatively well-detected in Delhi, Kolkata and Puducherry (among others), the estimates are not equally accurate everywhere. Delhi has 38 sentinel hospitals, while Mumbai has only three and Chennai has two sentinel hospitals. This clearly shows why more dengue cases are observed in Delhi in comparison with these other cities. Studies conducted in communities of Chennai revealed that 90% of individuals were infected at least once by dengue in their lives (Rodríguez-Barraquer et al 2015). In comparison, our research in Delhi revealed that "only" 32% of Delhiites had already been infected by dengue fever, while the federal capital registered 10 times more cases than Chennai over the last 20 years. This confirms that the geography of a disease depends on the quality of the surveillance system (Telle 2011). However, such inequalities are found at more local scales. Delhi seems, for example, better managed than the other towns of its region, and at intra-urban scales, some colonies of Delhi might succeed in catching the attention of municipalities through the lobbying of resident welfare associations, as shown by other researchers (Tawal Lama-Rewal 2011).

Just as "local globalisation" is disconnecting the traditional link between the incidence of disease and socio-spatial disparities, governance of diseases is fragmented, depending on exclusion/inclusion of some spaces or communities in a given territory, for whatever reason (socio-economic factors, administrative frontiers, urban/rural dichotomy, etc). This is not only a problem for the inhabitants of these "invisible" spaces (Curtis 2004), since the virus will sooner or later reach spaces of other typology. For example, research conducted in Brazil suggested that, as in Delhi, central areas of Sao Paulo were affected during epidemic (Mondini et al 2009). However, the originality of this study was to demonstrate through virus sequencing that dengue strains being found in these "central" spaces were introduced from deprived areas at the beginning of epidemics. In Delhi, we similarly demonstrated a permanence of Aedes larvae in deprived colonies (Kumar et al 2015), where local temperatures were sufficiently high, despite the generally low temperatures across the city that should have led to seasonal reduction in mosquito activity. This local embeddedness of mosquitoes in specific environmental niches (areas with high density and poor access to infrastructure) during the pre-epidemic season may reinforce epidemics when climactic factors become seasonally favourable to mosquitoes. The hypothesis we develop is that the virus lurks in these types of spaces during the cold season, the non-transmission period.

While the current impact of vector control appears limited in all cities where it had been implemented, taking into account invisible and deprived areas in particular in disease governance should be one of the ways to control their spread, regardless of scales (colonies at the urban scale and countries at the international one). This implies a better integration of "invisible" areas—notably unauthorised colonies in urban areas—in the surveillance system and in the way they are managed.

The need to integrate deprived areas in global city governance has been pointed out many times, but rarely carried out. Managing ERED has one aspect in comparison with other types of urban governance: as consequences of unsuitable management, ERED can, in turn, affect global governance of cities (Salem 1998), all categories of individuals, and more particularly, the one who has access to the "state"—feeling under the risk of being infected. The Parisian urban landscape has, for example, been shaped by the political will to control diseases, which were affecting all types of population—notably the 1,832 cholera epidemic. The use of vaccines would seem to make urban management and focus on these invisible areas obsolete. However, vaccines are few and far between and often expensive. As highlighted by the emergence of Zika virus, there is always another potential ERED around the corner. We should now start to think of a resilient way to control it, with a long-term vision.

## Conclusions

In this perspective, it is crucial to understand how urban socio-spatial disparities and migrations are linked to diseases, who is infected and how they spread in and across given territories. It is also mandatory to observe the responses to epidemics: are ERED "controlled" only during epidemics, and is that the best way to improve disease control? How to circulate paradigms to control these "new" diseases worldwide? At a metropolis and city scale, how are socio-spatial inequalities and spatial inequities articulated in disease management? Finally, and probably the most important, what is the place of health in cities, and what resources are allocated to it? Just as social sciences originally used diseases as a powerful prism to study inequalities in urban areas, we now have to use social sciences to analyse and solve global health issues. To reduce the impact of ERED on health, these inequalities are the only components that societies can alter, since climate and mobilities are immutable, at least in the short and medium term.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