ESSAY

Putting the pieces **together**

Capturing human behaviour

Understanding the dynamics of infectious-disease transmission demands a holistic approach, yet today's models largely ignore how epidemics change individual behaviour.

Neil Ferguson

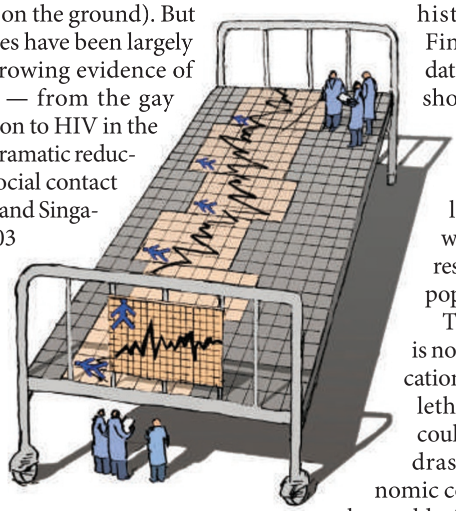
We live in an ever more connected, mobile and interdependent world, where small perturbations can have unpredictable and sometimes far-reaching effects. The paradox is that we increasingly demand predictability. From climate to car design, we expect the future to be anticipated, risks assessed and solutions to be rational. We have to be 'on top' of everything — including threats from infectious diseases.

In response to this trend, policy-makers increasingly turn to epidemic models as a tool in tackling potentially catastrophic outbreaks, from Britain's foot-and-mouth epidemic of 2001 and SARS in 2003 to the pandemic threat now posed by the H5N1 strain of avian flu. Better data, significantly boosted computer power and theoretical advances — particularly from the social sciences — have endowed models with a new realism. Yet fundamental limitations remain in how well they capture a key social parameter: human behaviour.

The subtlety in epidemic modelling lies in how the processes of human contact that underlie transmission and the biology of the host–pathogen interaction are represented. It is in this area that social science has had the greatest impact. Past models represented societies as 'compartments' of identical individuals all mixing randomly; the new paradigm is social networks characterized by either casual or intimate contact — the former being more relevant for respiratory diseases, the latter for sexually transmitted infections.

This is an improvement, but a limited one. The problem lies in the highly simplified way the description of disease and transmission is layered onto the social network, which gives a picture that is both biologically and socially flawed. Most glaringly, the effects of behavioural responses to epidemics are given short shrift. The social networks in most models are usually static, allowing scant interaction between the epidemic and individual or group behaviour, bar sick people staying at home — and not all models include that. For mild infections this level of sophistication may be justified, as we rarely fundamentally change our behaviour because of a cold; but increasingly, the evidence shows that faced with lethal or novel pathogens, people will change their behaviour to try to reduce their risk.

Organized measures such as quarantine, contact tracing or closure of public places are one way that behaviour can change, but people may also spontaneously modify their behaviour to reduce perceived risk. Public-health measures are often examined prospectively in models (although many retrospective studies of outbreaks only crudely capture the complexity of controls implemented on the ground). But individual responses have been largely ignored, despite growing evidence of their importance — from the gay community's reaction to HIV in the early 1980s, to the dramatic reduction in travel and social contact seen in Hong Kong and Singapore during the 2003 SARS epidemic. Even absenteeism resulting from illness or caring for sick dependants can significantly affect close-contact networks, by removing people from workplaces.



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By modifying the contact network, behavioural changes during an epidemic can give dynamics very different from the kind predicted by simple models. Most basic models assume that all parameters are static, but in fact people's responses often shift as an epidemic progresses. Individuals are most likely to change their contact patterns when mortality or the perception of risk is high, and resume normal life as the perceived risk declines. A case in point is the recent resurgence of risky behaviours in some gay communities following the widespread availability of combination antiviral therapy for HIV; another, the ongoing studies of how public-health measures and individual risk-reduction behaviour shaped the very different epidemic patterns seen in various US cities during the Spanish flu pandemic of 1918–19.

The challenge for mathematical modellers is that data are scarce, and often qualitative when they do emerge. An example from the UK foot-and-mouth disease epidemic is anecdotal evidence of more people failing to comply with biosecurity restrictions around farms once the epidemic was in decline, which may have contributed to that outbreak's long tail.

Bridging this data gap, and developing succinct yet realistic descriptions of epidemics' impact on social-network dynamics, will prove key to making models of lethal epidemics more accurate. Three avenues of research need to be pursued. The first is controlled epidemiological intervention studies to determine how modifying contact networks affects disease transmission. Another will be the integrated collation and analysis of epidemiological and, preferably, quantitative social data from historical epidemics. Finally, protocols and data-collection systems should be designed to track the number of people infected per day in a future lethal outbreak as well as the behavioural response of the affected population.

The time for this work is now: global communications mean that a novel lethal disease outbreak could trigger potentially drastic social and economic consequences across the world within days.

From a public-health perspective, the goal is improving our ability to predict and control epidemics — but that may first require new sociological models that are both predictive and quantitative. So the interdisciplinary approach remains vital, this time at the interface of epidemiology, sociology and the history of medicine.

Beyond public health, what is there in this enterprise to motivate sociologists, anthropologists or historians? Understanding behavioural responses to lethal infectious diseases may help epidemic modelling now, but over time it could reshape our understanding of the interaction between disease and society as one of coevolution. Historically, certain diseases have exploited social upheavals such as urbanization, and behavioural responses to disease risk — such as the hand-use bias in Indian dining habits — have become part of the cultural fabric. But we have barely begun to unravel the larger question of how disease has shaped behavioural norms and, through those, society as a whole. The answers may be surprising. ■

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