Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Time to spatialise epidemiology in China

Although many studies on the COVID-19 epidemic in China have been published since the outbreak began, very few, if not none, have been useful to real-time epidemic control. None have proposed methods to identify areas at risk or to allocate (or reallocate) scarce health-care resources at a fine enough scale to effectively inform epidemic control on the ground. This situation is common to many infectious diseases, particularly epidemics, which have become increasingly multifactorial and dynamic as a result of rapid urbanisation, population growth and mobility, globalisation of travel and trade, and climate change.[1,2]

Traditional epidemiological research has provided solid evidence for understanding the distribution (who, when, and where), risk factors, and possible control of diseases, mainly in a retrospective way, yet even prospective analyses are not done until infection has occurred, which makes it difficult to detect early risk of epidemics. Spatial epidemiology uses spatial data and methods to describe and analyse geographical variations in diseases and their risk factors (eg, genetic, demographic, socioeconomic, behavioural, and environmental).[3] In addition to the epidemiology of epidemics, technologies in spatial epidemiology also support other relevant aspects of research during an epidemic, such as population movement patterns at any temporal scale (eg, within a day, week, or month) and dynamic allocation (or reallocation) of health-care resources among hospitals (eg, within a city, province, or country). Spatial lifecourse epidemiology, going beyond spatial epidemiology, further incorporates digital and artificial intelligence technologies and real-time spatiotemporal data into traditional spatial epidemiological research.[2,4] Therefore, this discipline can not only help us to understand the epidemiology of diseases and epidemics with an unprecedented degree of accuracy (so-called precision public health), but also, with consideration of the real-world interactions among hosts, agents, and environments, it can detect early risk of epidemics. Hence, spatial lifecourse epidemiology can provide useful, real-time solutions to epidemic control on the ground towards precision epidemic prevention and control.[5]

However, high-resolution spatial epidemiological research has so far been missing during the COVID-19 epidemic. It is time to reflect on more upstream factors underlying such insufficient interdisciplinarity. One important reason for this insufficiency in China might be that courses on spatial epidemiology have been downplayed in the current curricula of schools of public health, as well as the absence of graduate programmes in spatial epidemiology. The insufficiency of spatial epidemiology in education might fundamentally isolate epidemiology from geography at an early stage. Without spatial epidemiology training and thinking, the value of integrating individual-level health and real-time spatial data across sectors cannot be seen. This situation has left data-sharing mechanisms and infrastructures (eg, data-sharing protocols, intersystem interface, and confidentiality protection mechanisms) unprepared for an epidemic in many countries. Consequently, spatial epidemiological research—eg, based on linking individual-level infected cases with respective location data from mobile service providers (eg, mobile phone signalling data) and smartphone-based apps (eg, social media and internet-based data)—has been hindered. Such research could have been done better in academia without violating confidentiality requirements if set up properly ahead of time; its results could have been more useful to decision makers than non-spatial or coarse spatial resolution results. Given China's leading roles in the field of public health in developing countries, we could reasonably assume that the gaps we have outlined might probably hold true in many, if not all, low-income and middle-income countries.

To precisely forecast where epidemics will occur, we need to incorporate the science of where—geography—into epidemic response and, more broadly, public health. Therefore, we are calling for action in both education and research in China. Spatial epidemiology should be developed as an independent and required basic course to be incorporated into the curricula of all public health schools in China. More importantly, graduate degrees in spatial epidemiology should be prioritised as an urgent need in the public health education agenda. More spatial epidemiology research centres and networks of excellence should be relocated to, or formed in, China for stimulating spatial epidemiological research. Such efforts could shift the centre of gravity for leadership, governance, and implementation of epidemic response

towards the developing regions that more urgently demand spatial epidemiology skills on the ground. This effort would protect the most susceptible regions in the world and eventually the whole world.[1]

We declare no competing interests.

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