Spatial lifecourse epidemiology

Lifecourse epidemiology is a conceptual model of epidemiological thinking that emerged in the 1990s and is now a mainstream paradigm in social epidemiology;[1] it focuses on long-term biological, behavioural, and psychosocial processes that link non-communicable disease (NCD) occurrence to physical and social exposures that act before disease endpoints, starting from the preconception period.[2] Such lifecourse exposures have recently been framed as the exposome, which can be further divided into the internal, general-external, and specific-external exposome.[3,4] However, the external exposome has been measured less than the internal exposome because of its complexity. In addition, environmental epidemiology is facing challenges in the assessment of the health effects of a large number of low-level correlated exposures. More accurate and sensitive measures of exposures than those currently available and the implementation of epidemiological studies over large areas are needed.[5,6]

This is where advanced spatial and location-based technologies, such as earth observation, sensors, smartphone apps, and the so-called internet of things, can step in and contribute to overcoming the data bottleneck that conventional epidemiology is facing.[7,8] The use of advanced spatial and location-based technologies forms the foundation of spatial lifecourse epidemiology (figure). Since spatial lifecourse epidemiology emerged in an era of transdisciplinary collaboration and team-science initiatives, it aims to use those advanced technologies to investigate long-term effects and mechanisms of measurable environmental, behavioural, and psychosocial factors on individual disease risk at an unprecedented degree of accuracy. For example, earth-observation technologies can measure multiple dimensions of the environment across time and space more accurately, broadly, and frequently than traditional technologies; Global Positioning System (GPS)-enabled devices can capture individual time-activity patterns; smartphone apps can track individual dietary intake and physical activity. With the support of Geographic Information Systems (GIS), all these measures can be processed and integrated to obtain precise estimates of individuals' external exposomes, which can further be associated with health outcomes.[9] Notably, earth-observation technologies can provide large-scale (even global) environmental measures and GPS technologies can provide momentary activity measures, both in a cost-effective way. Hence, these technologies make it possible to include all levels of variables—from the individual to the ecosystem—in spatial lifecourse epidemiological studies.

Earth-observation technologies feature the acquisition and processing of satellite data, and have been applied to a wide range of areas including public health;[10,11] however, they have not been involved in NCD studies as much as in studies of infectious diseases, which have been the subject of intensive spatial epidemiological studies.[12] Together with other technologies, earth-observation technologies have enabled inexpensive and high-throughput measurement of the general-external exposome in the context of lifecourse epidemiology, and the accuracy of such exposome measurements could match the accuracy of genome sequencing technologies at large scales.

Moreover, the high temporal-resolution earth-observation data can match repeated measurement of psychosocial and biological exposures in cohort studies better than do GIS data, validate retrospectively recalled exposure from questionnaires or historical records (eg, work histories) or, if such records do not exist, reconstruct past environmental exposures.

Earth-observation data are also more likely than GIS data to cover sensitive or critical periods. All these features

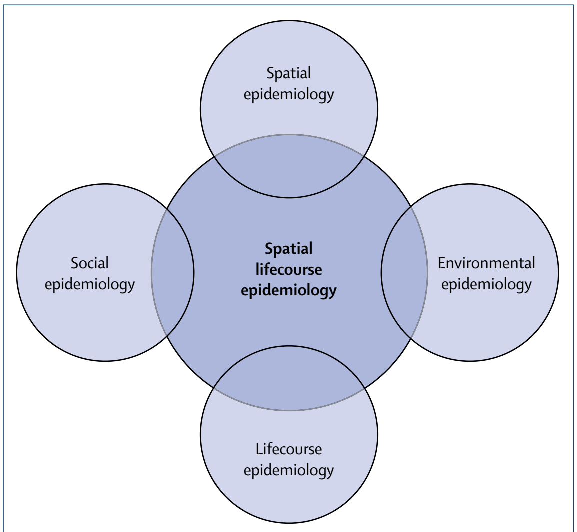

Figure: **Conceptual framework of spatial lifecourse epidemiology**

Panel: Specific aims of the International Initiative on Spatial Lifecourse Epidemiology (ISLE)

- Facilitate the use of state-of-the-art spatial and location-based technologies in human health research
- Facilitate data sharing, integration, and comparison of results across different contexts
- Develop protocols to format the reporting standards for studies in which spatial and big data are included in epidemiological studies
- Review on a regular basis the evidence on the long-term effects of environmental factors on NCDs and risk factors, and provide evidence to policy-makers for intervening in the environment and preventing environment-related and lifestyle-related NCDs
- Hold an annual or biennial symposium to discuss the state-of-the-art of spatial lifecourse epidemiology and deliver a postsymposium white paper that tracks the progress of spatial lifecourse epidemiology and updates the top research priorities in this field

will contribute substantially to improved strategies of disease prevention by refining the estimates of long-term cumulative exposures, the effects of exposure during sensitive or critical periods, and the definition of sensitive or critical periods.

Spatial lifecourse epidemiology can address several challenges of lifecourse epidemiology.[13] First, spatial lifecourse epidemiology outperforms lifecourse epidemiology in explaining temporal, geographical, and social patterns of disease distribution. Second, spatial data could assist in explaining underlying biological, psychological, social, and—in particular—behavioural processes that operate across an individual's life course or across generations. Third, spatial technologies can measure time-varying contextual variables, so the effects of changing contexts over time on the individual's life course can be investigated. Such frequent measurement of the environment will also offer increased opportunities to study gene–environment interactions. Fourth, spatial lifecourse epidemiology will provide fine-scale measurements over time, which has potential to overcome the modifiable areal-unit problem—faced by both lifecourse and environmental epidemiology[5]—and to detect small effects more reliably. Fifth, considering expensive labour costs and tight research budgets, volunteered GIS via smartphone apps can be used as a cost-effective source of geographic data and offer a number of fruitful paths toward collecting individual data and improving health behaviours through online citizen involvement. Finally, when translating knowledge into interventions and policy recommendations, earth observation data can measure many environmental factors at a large scale, so local epidemiology can be considered and interventions scaled up.

The International Initiative on Spatial Lifecourse Epidemiology (ISLE), established as a global trans-disciplinary collaborative research network, is comprised mainly of experts from the fields of epidemiology, spatial science, geography, nutrition, biostatistics, ecology, urban planning, health economy, and health policy. The ISLE envisions a planet where everyone can achieve their fullest health and wellbeing potentials and benefits—ie, where everyone can breathe, drink, eat, and act healthfully, and hence maintain a healthy status and enjoy the resulting multifaceted benefits (panel).

The 1st International Symposium on Lifecourse Epidemiology and Spatial Science was held on July 16–20, 2018, at the Lorentz Center in Leiden, the Netherlands. A group of multidisciplinary experts in the fields of spatial science, lifecourse epidemiology, environmental epidemiology, health geography, environmental science, and landscape ecology, gathered to share the state-of-the-art in each respective area, and were committed to deliver two scientific outputs: how spatial sciences and technologies can advance traditional lifecourse epidemiology, and the top-ten key research priorities in spatial lifecourse epidemiology.

Spatial lifecourse epidemiology is the intersection of spatial science and lifecourse epidemiology in an era of big data. The interest of spatial lifecourse epidemiology is to know not only when and where disease occurs, but also when, where, and how previous exposures occur, so the aetiology can be investigated and points of intervention identified. Spatial lifecourse epidemiology will accumulate evidence of long-term and lifecourse effects of environmental exposure on human health for intervention design and policy changes while preparing for the coming abundant true lifecourse data, and will also help to realise strategic global health goals and ISLE's overall vision.

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I declare no competing interest.

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