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Spatial Lifecourse Epidemiology Reporting Standards (ISLE-ReSt) statement

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ABSTRACT

Spatial lifecourse epidemiology is an interdisciplinary field that utilizes advanced spatial, location-based, and artificial intelligence technologies to investigate the long-term effects of environmental, behavioural, psychosocial, and biological factors on health-related states and events and the underlying mechanisms. With the growing number of studies reporting findings from this field and the critical need for public health and policy decisions to be based on the strongest science possible, transparency and clarity in reporting in spatial lifecourse epidemiologic studies is essential. A task force supported by the International Initiative on Spatial Lifecourse Epidemiology (ISLE) identified a need for guidance in this area and developed a Spatial Lifecourse Epidemiology Reporting Standards (ISLE-ReSt) Statement. The aim is to provide a checklist of recommendations to improve and make more consistent reporting of spatial lifecourse epidemiologic studies. The STrengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement for cohort studies was identified as an appropriate starting point to provide initial items to consider for inclusion. Reporting standards for spatial data and methods were then integrated to form a single comprehensive checklist of reporting recommendations. The strength of our approach has been our international and multidisciplinary team of content experts and contributors who represent a wide range of relevant scientific conventions, and our adherence to international norms for the development of reporting guidelines. As spatial, location-based, and artificial intelligence technologies used in spatial lifecourse epidemiology continue to evolve at a rapid pace, it will be necessary to revisit and adapt the ISLE-ReSt at least every 2–3 years from its release.

Spatial lifecourse epidemiology is an interdisciplinary field emerging at the intersection of multiple scientific disciplines including spatial science and lifecourse epidemiology. It utilizes advanced spatial, location-based, and artificial intelligence technologies, including Geographic Information Systems (GIS), remote sensing (RS), Global Positioning Systems (GPS), and machine learning, alongside longitudinal population and health data, to investigate the long-term effects of environmental, behavioural, psychosocial, and biological factors on health-related states and events and the underlying mechanisms (Jia, 2019; Jia et al., 2019a). Although all of these factors are relevant to all living organisms, this field routinely focuses on human beings. Enriching longitudinal cohort studies with temporally frequent and multi-scale spatial measurements and increasingly generated fine-grained spatial information (e.g., residential history and daily mobility patterns) is considered one of the highest standards for spatial lifecourse epidemiologic research. A spatial lifecourse epidemiologic study could also have its study population constructed from sources other than cohort studies, such as large administrative data sets that are linked at the individual level (e.g., population registers, education records, housing, tax, vehicle licensing, insurance, and medical records).

Spatial lifecourse epidemiology has great potential to contribute critical evidence on how lifecourse and long-term effects of individual-level behaviors and spatial exposures can influence human health. This field of study has grown rapidly over the past decade with examples including the effects of neighborhood socioeconomic factors, air pollution, green space, noise, and built environment features, as well as their changes (e.g., interventions), on the risk for chronic conditions including cancers, neurodegenerative diseases, Type 2 diabetes, cardiovascular diseases, chronic respiratory diseases, and mental health problems (James et al., 2016, 2017; Jia et al., 2019b, 2019c; Xiao et al., 2017; Pearce et al., 2016). This body of work has provided new and novel insights into health-environment relations including whether there are critical periods of exposure (e.g., during childhood) that affect health outcomes in later life, or the health implications of accumulative exposure to environmental insults across the lifecourse (Pearce, 2018). Also, evidence on the impact of environmental factors and their changes is increasingly needed, and could be used, for intervention design and implementation and policy changes (e.g., designing urban spaces, setting air pollution policies).

1. Reporting challenges in spatial lifecourse epidemiology

Lifecourse epidemiologic studies mainly report the characteristics of descriptive or etiologic samples (e.g., health surveys, objective health measures, medical records, and biomarkers), individual-level behaviors (e.g., physical activity), and links between such dimensions and health outcomes, where the STrengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement for cohort studies (von Elm et al., 2007) has been a major reporting guideline to follow. Spatial lifecourse epidemiology involves diverse forms of spatial (increasingly spatiotemporal) data obtained from a multitude of sources, as well as a plurality of increasingly innovative methods, and hence requires specific reporting guidelines that address the spatial components and how to link longitudinal health data to spatiotemporal data. These include (but are not limited to) the definition of exposures, and, when relevant, the name of spatial data sources, along with relevant spatial metadata, which may include resolution, extent, projection, etc. All such guidelines are not provided by the STROBE.

In some epidemiologic analyses, characterizing environments at the neighborhood scale provides one means of capturing individual-level exposures. Hence, defining neighborhood boundaries (i.e. contextual areas/units (Kwan, 2018)) and establishing neighborhood/contextual characteristics are critical tasks for the application of spatial and location-based technologies. However, neighborhood boundaries can be defined in numerous ways that can vary across the spatial data, methods (e.g., positioning technologies), analytic approaches (e.g., the standard deviational ellipse and individualized residential exposure model), and model parameters (e.g., buffer radius). Also, there is the individual-level spatial information, from place (or history of) residence to daily mobility tracks (e.g., second-level time-stamped GPS coordinates) (Lai et al., 2019). One further important issue regarding spatial dimensions is how the individual-level spatial information is being put in relation to the spatial environmental data. For example, one may draw a road-network buffer around one's place of residence to define a local context, and use that individualized buffer to compute any relevant exposure probabilities; one may use actual GPS tracks and draw linear buffers around these tracks, and so on. In other words, there are various ways to link different spatial datasets that needs precise documentation in order to facilitate reproducibility. Nevertheless, there has not been any guideline on how to report spatial data and methods in spatial lifecourse epidemiologic research, even in broader spatial epidemiologic research.

When evaluating a study or interpreting its findings, these and other methodological variances can create challenges for editors and reviewers, and pose difficulties in establishing comparability with prior studies. There is evidence that the quality of reporting of spatial data and analysis methods can vary widely (Jia et al., 2017). These reporting problems are made more challenging when the accuracy of representing and delineating contextual units in space and time (e.g., environmental data become increasingly dynamic) come into consideration (Kwan, 2012) and more spatial technologies (e.g., RS and GPS) are used (Jia et al., 2019d; Smith et al., 2017; Johnson et al., 2017). The quality of spatial lifecourse epidemiologic research, in particular, could potentially benefit from improved standardization and more robust quality assurance in reporting spatial data and methods.

Transparency and clarity in reporting will be increasingly important with the rising number of studies reporting findings of spatial lifecourse epidemiologic research, and the critical need for public health and policy decisions to be based on the strongest science possible. The use of reporting guidelines is being increasingly endorsed by scientific societies, research funders and journal editors (Husereau et al., 2013), and has been shown to improve reporting (Hua et al., 2016). The need for reporting guidance for spatial lifecourse epidemiologic research was recently identified by researchers and medical/public health journal editors (Jia, 2019; Jia et al., 2019a).

2. Aim and scope

The aim of the Spatial Lifecourse Epidemiology Reporting Standards (ISLE-ReSt) Statement is to provide recommendations, in the form of a checklist, to improve reporting of spatial lifecourse epidemiologic studies. The ISLE-ReSt Statement makes an initial attempt at consolidating the STROBE Statement for cohort studies and reporting standards for spatial data and methods into a single useful reporting guidance.

The primary audiences for the ISLE-ReSt Statement are researchers conducting and reporting spatial lifecourse epidemiologic studies, and the editors and peer reviewers evaluating the design, rigor, and potential impact of the work. The statement consists of a 26-item checklist and accompanying recommendations on the minimum information to be included when reporting spatial lifecourse epidemiologic studies. The authors' hope is that this statement will support the evolution of this tool into a practical means for spatial lifecourse epidemiologic studies to achieve greater comprehension, rigor, exposure, and impact, yielding improved reporting and, in turn, provide a stronger evidence base for public health decision-making.

3. Development of the ISLE-ReSt statement

The statement was developed by a task force supported by the International Initiative on Spatial Lifecourse Epidemiology (ISLE), which was established as a global, transdisciplinary, collaborative research network devoted to facilitating the use of state-of-the-art spatial, location-based, and artificial intelligence technologies in human health research (Jia, 2019). The ISLE-ReSt Task Force members were chosen by the founding director of ISLE based on their leading roles and/or academic expertise in several relevant fields (e.g., spatial epidemiology, spatial science), as well as their longstanding contributions to the advancement of spatial lifecourse epidemiology.

The ISLE-ReSt Task Force followed current recommendations for developing reporting guidelines within the health science community (Moher et al., 2010). The group undertook a comprehensive literature review for previous guidance in this area between July 2016 and June 2018, and identified a clear need for new guidance (Jia et al., 2017, 2019d, 2019e; Jia and Stein, 2017). As spatial lifecourse epidemiology aims to enrich cohort and other longitudinal studies by linking longitudinal health data to spatial data produced by advanced spatial and location-based technologies, the STROBE Statement for cohort studies was identified as an appropriate starting point. Items from this checklist were identified for inclusion and additional items added to develop a new checklist from a lifecourse epidemiology perspective. A list of items related to the reporting of spatial data and methods was proposed from a spatial technology perspective by a small group of experts, mainly with expertise in GIS, RS, GPS, epidemiology, and statistics; these were added to the STROBE Statement and formed the initial draft of the ISLE-ReSt checklist of reporting items. Funding was obtained to continue the work, and potential stakeholders were invited to attend the 1st International Symposium on Lifecourse Epidemiology and Spatial Science. The initial ISLE-ReSt checklist was discussed, modified, and validated by workshop participants and further by task force members, which included spatial technologists, epidemiologists, statisticians, methodologists, content experts, and journal editors from a wide range of scientific disciplines, including lifecourse epidemiology, environmental epidemiology, community health, spatial science, health geography, biostatistics, spatial statistics, environmental science, climate change, exposure science, health psychology, evidence-based public health, and landscape ecology.

The ISLE-ReSt Statement recommendations have been independently reviewed and subsequently revised by task force members. The recommendations are entirely those of the task force—the sponsors of the study had no role in study design, literature review, or writing of the final recommendations.

Table 1
ISLE-ReSt Statement—Checklist of items to include when reporting spatial lifecourse epidemiologic studies.

	Item No	Recommendation
Title	1	Indicate the primary exposure variable(s) and main outcome variable(s)
Abstract	2	Provide in the abstract an informative and balanced summary of objectives, methods (including study design, primary exposure variable(s) of interest, including data sources, and main outcome variable(s) of interest), results (association between primary exposures and main outcomes of interest), and conclusions
Introduction		
Background/Rationale	3	Explain the scientific background and rationale for the investigation being reported; provide a specific conceptual or theoretical framework/description of links between environmental and health variables included
Objectives	4	State specific objectives, including pre-specified hypotheses
Methods		
Study design	5	Present full description of study design, including a clear rationale for the spatial scale at which exposure was measured
Setting	6	Describe the setting, locations, and relevant dates (e.g., periods of recruitment, exposure, follow-up, and data collection)
Participants/Sample size	7	Give the eligibility criteria, and the sources and methods of selection of participants; describe methods of follow-up and how the study size was determined; describe approaches to link participant data to spatial locations (e.g., method, reference data set, coordinate systems, and software package used to geocode, % of participants geocoded to an address and/or a predefined areal unit)
Variables	8	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers; give diagnostic criteria, if applicable
Health data sources/measurement	9	For each variable of interest, give sources of data and details of methods of assessment (measurement); describe comparability of assessment methods if there is more than one group
Bias	10	Describe any efforts to address potential sources of bias
Quantitative variables	11	Explain how quantitative variables were handled in the analyses; describe which groupings were chosen and why, if applicable
Spatial data	12	*GIS*— Give data source (URL if open source data), time of collection, spatial resolution, and processing methods *RS*— Give the name and spatiotemporal resolutions of satellite sensors from which images are derived, dates images were taken, and any preprocessing procedures; provide the processing method and/or the citation for RS products *GPS(+accelerometer)*— Give the name, model, and measurement error of all devices, the interval, period, and duration of data collection *Smartphone app*— Give the details (e.g., measurement error) of the device used, the name and platform of the app used, the frequency and recording of location updates, and the method, period, and duration of data collection (e.g., food image-taking) Other sensor data— Specify the technology, developer, detailed usage and measurement error of the sensor, the frequency and recording of location updates, and the method, period, and duration of data collection
Spatial methods	13	*GIS*— Describe the method, justification, and software package used to produce spatial factors (e.g., buffer type and radius for defining contextual areas, codes used for extracting features from commercial data sets) and match spatial factors with health data *RS*— Describe the method and software package used to (pre)process images/products, produce spatial factors, and match spatial factors with health data *GPS(*and *accelerometer)* and *Smartphone app*— Give the numbers of valid days and hours per day required for a valid day, criteria for non-wear, and accelerometer count thresholds for intensity of activity, and the methods used to (pre)process tracked location data, define activity space, and validate the collected data (e.g., travel diary, dietary recall, and food frequency questionnaire)
Statistical methods	14	Describe all statistical methods (e.g., those used to control for confounding, clustering, endogeneity, and spatial autocorrelation), any methods used to examine subgroups and interactions, and any sensitivity analyses, including spatial inspection of residuals from models; explain how missing data, outliers, and loss to follow-up were addressed
Results		
Participants	15	Consider a flow diagram to report numbers of individuals at each stage of study and reasons for non-participation at each stage
Descriptive data	16	Give characteristics of study participants (e.g., sociodemographic, geographical, clinical) and information on exposures
Outcome data	17	Report numbers of outcome events or summary measures over time
Main results	18	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval); make clear which confounders were adjusted for and why they were included; report category boundaries when continuous variables were categorized
Other analyses	19	Report other analyses done (e.g., subgroup, interaction, mediation, and sensitivity analyses) and spatial autocorrelation diagnostics
Discussion		
Key results	20	Summarize key results with reference to study objectives
Interpretation	21	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Limitations	22	Describe limitations of the study (e.g., limitations of spatial data and methods used, temporal mismatches between health and spatial data, different spatial data sources at different time points, exposure misclassification issues, extent of reflecting real environmental exposure, potential direction and magnitude of bias, the uncertain geographic context problem, the neighborhood effect averaging problem, spatial and temporal non-stationarity, neighborhood self-selection, selective daily mobility bias, and selective migration)
Generalizability	23	Describe the generalizability (external validity) of the study results
Other information		
Source of funding	24	Give the source of funding and the role of the funders for the present study
Conflict of interest	25	Describe any potential for conflict of interest of study contributors in accordance with journal policy
Data sharing statement	26	Describe which data could be shared and how to access data (including codes of processing files).

GIS– Geographic Information Systems; RS– remote sensing; GPS– Global Positioning Systems.

4. Checklist items

The final recommendations are subdivided into seven main categories: (1) title; (2) abstract; (3) introduction; (4) methods; (5) results; (6) discussion; and (7) other. The recommendations are contained in a user-friendly, 26-item checklist (Table 1).

5. Concluding remarks

As spatial lifecourse epidemiology continues to rise in prominence as a discipline and related methods are in a stage of development and innovation, the number of published spatial lifecourse epidemiologic studies will continue to grow. More transparent and complete reporting of methods and findings will be important to facilitate interpretation of, and comparison across, such studies. We view the ISLE-ReSt Statement as an important starting point for standardizing reporting going forward in this research area. In addition to spatial lifecourse epidemiology, related research areas will also benefit from this timely reporting guidance, including spatial epidemiology, epidemiology drawing on electronic health records, big data analytics, meta-analysis, exposomics, and intervention research (e.g., smartphone-based and urban intervention research).

The strength of our approach has been our international and multidisciplinary team of content experts and contributors who represent a wide range of relevant scientific conventions, and our adherence to international norms for the development of reporting guidelines. We believe it will be important to iteratively evaluate the effects of implementation of this statement and checklist on reporting in future spatial lifecourse epidemiologic research, and revise the guidelines as the field advances. As spatial, location-based, and artificial intelligence technologies that collect and process spatiotemporal data in spatial lifecourse epidemiologic studies continue to evolve at a rapid pace (e.g., spatial data become increasingly fine-grained and more and more with high temporal resolution), it will be important to revisit and extend or improve the guidance at least every 2–3 years from its release.

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Appendix A. Supplementary data

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