Spatial Methodology Appraisal of Research Tool (SMART)

User Guide

Version 1.5 (2025)

DEAKIN UNIVERSITY | DRH DEAKIN RURAL HEALTH

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Introduction

What is SMART?

SMART is a quality appraisal tool specifically designed to evaluate the methodological quality of spatial research. The 16-item tool comprises four domains: (1) methods rationale, (2) data quality, (3) spatial data considerations, and (4) spatial analysis methods.

How was SMART developed?

SMART was developed in 2024 using a two-phase mixed-methods design, informed by expert consensus and a scoping review. Phase One utilised concept mapping methodology, a consensus-based approach with discipline experts. Phase Two consisted of an online validation survey. Validity testing demonstrated excellent content validity and expert agreement. The publication outlining the methodology can be found here. A follow-up study is currently underway to assess the tool's inter-rater reliability.

What can SMART be used for?

SMART can be used as a stand-alone quality appraisal of the spatial methodology in studies or in conjunction with an existing tool to ensure a methodological assessment of both the study design and spatial components. This user guide outlines each item of the tool and provides a description for assessment. The SMART form can be used to complete the appraisal. Ensure you have the latest version available on the website.

How to cite SMART?

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Guidelines for domains and items

Domain 1. Methods rationale

The *methods rationale* domain evaluates whether studies clearly justified the suitability of data and spatial methods to address their research question, aim, or objective(s). This domain is essential for understanding the relevance and applicability of findings to the specific geographic context being examined.

1.1 Did the study clearly define the research question or objective(s)?

This criterion assesses whether the study included a clearly stated research question that the authors aimed to answer.

Examples for response options	
Yes	"The objective of this study was to investigate the relationship between air pollution and the incidence of childhood asthma in Melbourne from 2015 to 2020."
No	The paper describes an exploration of 'health and environment' without a specific research question or clear objective.

1.2 Did the study provide sources and descriptions of all data used in the main analysis to address the research question or objective(s)?

This criterion assesses whether the study presented all details regarding the data used in the analyses to address the research question, as well as information on how these data can be accessed. This includes the data source, time of collection, spatial resolution, processing methods, and any relevant ethical considerations.

Examples for response options	
Yes	"Air pollution data were obtained from the Environment Protection Authority Victoria, collected between January 2018 and December 2022. These data were measured hourly at fixed-site monitoring stations across Victoria."
No	The data sources are listed, but there is no statement regarding their relevance to addressing the research question, nor is there any description of the collection methods, time period, or spatial scale.

1.3 Was there a clear statement justifying the suitability of spatial methods to address the research question or objective(s)?

This criterion assesses whether the study clearly justified the spatial methods to ensure they were suitable for answering the research question. A well-justified use of spatial methods enables replicability for future studies.

Examples for response options	
Yes	"Spatial regression was used because our objective was to assess whether proximity to pollution sources explains regional differences in asthma cases."
No	Spatial analysis is used; however, the rationale for using spatial (rather than non-spatial) methods is not explained.

Domain 2. Data quality

The *data quality* domain evaluates whether the data used in the study meet the specific requirements, address quality concerns, and are consistently defined and transparently reported, including any necessary processing.

2.1 Do these data meet the specific requirements of the study?

This criterion evaluates whether the data used in the study accurately represent the outcome of interest and possess the necessary characteristics and quality to meet the specific requirements of the study.

Examples for response options	
Yes	"Five years of routinely collected emergency presentation data (January 2015 to December 2020) was obtained from 38 Victorian public hospitals with 24-hour emergency departments, as well as additional rural urgent care centres in Victoria. De-identified episode-level data were extracted from the Victorian Emergency Minimum Dataset and the Rural Acute Hospital Data Register."
No	Data were limited to metropolitan hospitals only, had incomplete coverage in rural and regional areas, or were missing episode-level information for a subset of years studied.

2.2 Did the study address the quality of the data used in the analysis?

This criterion assesses whether the study addressed the quality of the data used in the analysis to ensure it was suitable, including data accuracy and completeness, as well as how missing data were handled. Additional details regarding data quality may include quality statements or metadata published by data providers.

Examples for response options	
Yes	"Data quality was assessed by checking for missing values, calibration procedures, and consistency between data sources. Where available, a secondary dataset was used to cross-validate key variables and verify completeness."
No	No mention is made of any assessment or discussion of data completeness, accuracy, or reliability.

2.3 Did the study describe any processing of data?

This criterion assesses whether the study described any data processing undertaken, including how missing data were addressed, data cleaning procedures, and transformations of variables, such as conversions from continuous to categorical data.

Examples for response options	
Yes	"Air pollution data were aggregated from daily values to monthly averages. Missing days were imputed using multiple imputation."
No	The analysis uses data without specifying its origin, processing method, or handling procedures for missing or outlying values.

2.4 Did the study use consistent definitions?

This criterion assesses the extent to which the study maintained uniform and clear definitions across key concepts, variables, and classifications (including geographic classifications and standards).

Examples for response options	
Yes	"Remoteness areas were classified according to the Australian Statistical Geography Standard (Remoteness Areas)." The definition was consistently applied throughout.
No	Definitions were inconsistent throughout the paper or were not explained.

2.5 Have assumptions and limitations about data quality been clearly described?

This criterion assesses whether the study described any assumptions and limitations about the data quality that may lead to invalid conclusions. It involves describing potential challenges, sources of error, biases, or uncertainties associated with the dataset used in the research. This may be related to data from a primary or secondary source or data collection method.

Examples for response options	
Yes	"The study acknowledged several assumptions and limitations related to data quality that may affect the validity of its conclusions. For instance, it assumed completeness of emergency presentation records, though some underreporting in rural areas was possible due to known gaps in regional healthcare data capture."
No	No mention of assumptions or limitations about data quality.

Domain 3. Spatial data considerations

The *spatial data considerations* domain assesses whether the study adequately considered spatial units, scales, resolutions, and temporal aspects relevant to the research question(s). This domain considers the complexity and potential biases unique to spatial research.

3.1 Did the study consider how the chosen spatial unit, scale, or resolution could influence findings?

This criterion assesses whether the study explicitly considered how the selected spatial unit, scale, or resolution could influence the findings. It evaluates whether the spatial methods were appropriately matched to the spatial properties of the data and aligned with the research context.

Examples for response options	
Yes	"Asthma rates may differ when aggregated at different spatial levels, which contributes to the modifiable areal unit problem. Larger spatial units can obscure neighbourhood-level hotspots that become visible when using smaller units."
No	No mention is made of how the choice of spatial scale could affect the outcomes or interpretations.

3.2 Did the study justify why the chosen spatial unit, scale, or resolution was appropriate for addressing the research question or objective(s)?

This criterion assesses whether the study explicitly justified the selection of a particular spatial unit, scale, or resolution. It assesses whether the justification was linked to the research question(s) or objectives and data availability.

Examples for response options	
Yes	"Mesh Blocks were selected for spatial analysis of urban environments, as it is the smallest spatial unit available from the Australian Bureau of Statistics."

No	The spatial unit used was not justified; it was described as being determined by available data without an explanation of appropriateness for the research aim. There was no consideration of alternative geographies or relevance to the research question.

3.3 Did the study consider temporal issues (e.g., time period, time series)?

This criterion assesses whether the study adequately addressed temporal issues relevant to the research question(s). It involves assessing whether the analysis appropriately incorporated and addressed temporal dynamics, time-related factors, or changes over different time periods.

Examples for response options	
Yes	"Health data and pollution measures were both from 2015 to 2020 to ensure temporal alignment of exposure and outcome."
No	No statement about time periods. Data from different years were analysed together without justification.

Domain 4. Spatial analysis methods

The *spatial analysis* domain focuses on the suitability of the spatial methods and models used, the presentation of analyses, and the robustness of findings through sensitivity analyses.

4.1 Were the spatial methods suitable to meet the specific requirements of the study?

This criterion assesses whether the spatial methods employed in the study were suitable to meet the specific requirements of the study. It evaluates whether there was a clear description of the methods and how they relate to the research question(s) or objectives.

Examples for response options	
Yes	"Geographically weighted regression was selected to account for spatially varying relationships across different parts of the city."
No	The chosen spatial method was unsuitable for addressing the study objective.

4.2 Did the study consider spatial relationships (e.g., area-level clustering, spatial correlation) in the analysis?

This criterion assesses whether the study employed suitable methods to detect and account for spatial relationships such as spatial autocorrelation, area-level clustering, or other spatial dependencies. It evaluates if the study provided a clear description of the modelling techniques used to assess spatial patterns and whether these methods were appropriate for addressing the research question(s) and the spatial characteristics of the data.

Examples for response options	
Yes	"We tested for spatial autocorrelation in our data using Moran's I statistic and mapped the residuals from our regression analysis to identify area-level clustering. The spatial patterns observed were taken into account when interpreting our findings."
No	The study analysed outcome rates by area but did not report any assessment or consideration of spatial clustering, spatial autocorrelation, or spatial patterning in the data

4.3 Were the analyses presented logically and clearly?

This criterion assesses whether the study presents the analyses logically and clearly, enabling readers to follow the study's progression from data to results easily. Clear presentation involves the sequence of steps in the analysis, as well as the clarity of explanations and visualisations (e.g., tables, graphs, maps). This also includes unadjusted estimates and, if applicable, modifiers, covariate or confounder-adjusted estimates and their precision (e.g., 95% confidence interval).

4.4 Did the study provide a clear interpretation of the results in the context of the research question or objective(s)?

This criterion evaluates whether the study presents a clear interpretation of the results in relation to the research question(s). This includes situating the findings within the context of the study and discussing how the results contribute to answering the research question(s) and their broader implications.

Examples for response options	
Yes	The study clearly interpreted the results within the context of the research question, discussing how the observed spatial patterns contributed to understanding the relationship between air pollution and the incidence of childhood asthma. The findings were linked to the objectives, including consideration of potential mechanisms and broader public health implications.
No	The study presented statistics and maps but did not provide an interpretation connecting the results to the research question or discuss their significance. There was no contextualisation of the findings or discussion of their implications for the study objectives.

4.5 Were there formal attempts to determine the robustness of findings to assumptions and data (e.g., sensitivity analysis, alternative models)?

This criterion assesses whether the study conducted formal robustness checks, such as sensitivity analyses, to evaluate the stability and reliability of the findings under varying assumptions or data conditions. This includes a clear description of the robustness tests conducted and their implications for the validity of the findings.

Examples for response options	
Yes	“Sensitivity analysis was undertaken to assess road travel accessibility to public hospitals in Australia using both proprietary and open-source network data. This analysis tested how variations in network data sources impacted accessibility measures.”
No	The study did not conduct any formal robustness checks or sensitivity analysis to assess how assumptions or data variability might impact the results.

References

Wood, S. M., Wong Shee, A., Alston, L., Mc Namara, K., Donaldson, A., Coffee, N. T., & Versace, V. L. (2025). The development and validation of Spatial Methodology Appraisal of Research Tool (SMART): A concept mapping study. International Journal of Health Geographics, 24(1), 14. https://doi.org/10.1186/s12942-025-00401-1

Wood, S. M., Alston, L., Beks, H., Mc Namara, K., Coffee, N. T., Clark, R. A., Wong Shee, A., & Versace, V. L. (2023). Quality appraisal of spatial epidemiology and health geography research: A scoping review of systematic reviews. Health & Place, 83, 103108. https://doi.org/10.1016/j.healthplace.2023.103108

Study details				
Reference:				
Domains and items	**Response option***			**Comments**
	Y	**N**	**O**	
Domain 1. Methods rationale				
1.1 Did the study clearly define the research question or objectives(s)?				
1.2 Did the study provide sources and descriptions of all data used in the main analysis to address the research question or objective(s)?				
1.3 Was there a clear statement justifying the suitability of spatial methods to address the research question?				
Domain 2. Data quality				
2.1 Do these data meet the specific requirements of the study?				
2.2 Did the study address the quality of the data used in the analysis?				
2.3 Did the study describe any processing of data?				
2.4 Did the study use consistent definitions?				
2.5 Have assumptions and limitations about data quality been clearly described?				
Domain 3. Spatial data considerations				
3.1 Did the study consider how the chosen spatial unit, scale, or resolution could influence findings?				
3.2 Did the study justify why the chosen spatial unit, scale, or resolution was appropriate for addressing the research question or objective(s)?				
3.3 Did the study consider temporal issues (e.g., time period, time series)?				
Domain 4. Spatial analysis methods				
4.1 Were the spatial methods suitable to meet the specific requirements of the study?				
4.2 Did the study consider spatial relationships? (e.g., area-level clustering, spatial correlation) in the analysis?				
4.3 Were the analyses presented logically and clearly?				
4.4 Did the study provide a clear interpretation of the results in the context of the research question or objective(s)?				
4.5 Were there formal attempts to determine the robustness of findings to assumptions and data (e.g., sensitivity analysis, alternative models)?				
Final assessment				
Accounting for all information provided in the article and supplementary material, could this study be replicated?				

Version information

Version	Stage	Changes made to SMART
Version 1.1	Concept mapping	• Items were revised for repetition and technical and grammatical consistency. • Three items were removed. Two items related to area-level clustering (item 3.5) and autocorrelation (item 3.6) were removed from the 'spatial data problems' domain, as these were covered by one of the items in the 'spatial analysis methods' domain. One item pertaining to multi-level models (item 4.6) was removed from the 'spatial analysis methods' domain, as it was covered by a second item in the same domain relating to suitable models (item 4.2).
Version 1.2	Post validation survey	• Items were revised for clarity and edited to incorporate participant suggestions from the validation survey. • Two items were removed. One item (item 3.3) with poor content validity and one pertaining to the justification of spatial measures (item 1.4) from the 'methods preliminaries' domain, which was covered by a second item in the same domain relating to the suitability of spatial methods (item 1.2).
Version 1.3	Revision	• Further clarification of the 'unclear' rating category by including 'other' and options to select: CD = cannot determine, NA = not applicable, NR = not reported.
Version 1.4	Usability testing	• Included 'objectives' alongside 'research question' in four items (items 1.1, 1.2, 3.2, 4.4). • An additional column was added to record any comments. • Included (e.g., spatial autocorrelation) as an example in 4.2 • Added a footnote that details response options.
Version 1.5	Pilot study	• Added 'yes' and 'no' response examples throughout the user guide to provide clearer guidance on item evaluation. • Reordered items 1.2 and 1.3 to present data-related items before spatial methods, reflecting conventional article structure. • Split item 2.3 into two components: the first part on data sources was moved into item 1.2 for clearer separation, while data processing remains in 2.3. • Items 3.1, 3.2, and 4.2 have been reworded to enhance clarity and limit ambiguity. • Domain names changed to 'methods rationale' and 'spatial data considerations'