Spatial Analysis in Epidemiology

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Abbreviations

AIC	Akaike information criterion
ASF	African swine fever
AVHRR	Advanced Very High Resolution Radiometer
AUC	Area under the curve
BPA	Basic probability assignments
BSE	Bovine spongiform encephalopathy
CAR	Conditional autoregressive
CEPP	Cluster Evaluation Permutation Procedure
CJD	Creutzfeldt-Jakob disease
CUSUM	Cumulative sum
DEMP	Density equalized map projection
DBMS	Database management system
DST	Dempster–Shafer theory
EET	Excess events test
EMM	Ederer–Myers–Mantel
ESDA	Exploratory spatial data analysis
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot-and-mouth disease
GAM	Geographical Analysis Machine
GIS	Geographic information systems
GPS	Global positioning system
HEPP	Heterogeneous Poisson process
HGE	Human granulocytic ehrlichiosis
ICC	Intraclass correlation coefficient
IDW	Inverse distance weighting
K-L	Kullback–Leibler
LISA	Local indicators of spatial association
MA	Moving average
MAUP	Modifiable areal unit problem
MCDA	Multicriteria decision analysis
MCDM	Multicriteria decision making
MCMC	Markov chain Monte Carlo
MEET	Maximized excess events test
MLR	Maximum likelihood ratio
NDVI	Normalized Difference Vegetation Index
NNA	Nearest neighbour areas
NOAA	National Oceanic and Atmospheric Administration
ODBC	Open database connectivity

OWA	Ordered weighted averaging
Pmax	Poisson maximum
SAM	Statistical Analysis module
ROC	Receiver operating characteristic
SAR	Simultaneous autoregressive
SARS	Severe acute respiratory syndrome
SD	Standard deviation
SIDS	Sudden infant death syndrome
SIR	Susceptible-infected-recovered
SLE	Systemic lupus erythematosus
SMR	Standardized mortality/morbidity ratio
SQL	Structured Query Language
TB	Tuberculosis
TIN	Triangulated irregular network
UMP	Uniformly most powerful
URISA	Urban and Regional Information Systems Association
VPD	Vapour pressure deficit
WLC	Weighted linear combination

Preface

Over the last 20 years, the application of spatial analysis in the context of epidemiological surveillance and research has increased in an exponential fashion. Having been involved in this field since 1988, first as researchers and then also as postgraduate teachers, we felt there was a need for a textbook that helps to guide epidemiologists and other biologists logically through the complexities of spatial analysis.

This book aims to provide a practical introduction to spatial analysis, by focusing on application rather than theory, and by drawing on a wide range of examples from both human and animal health, including vector-borne and infectious diseases and non-infectious conditions. We provide worked examples of the principal methodologies, using mainly the same disease dataset throughout, which allows for direct comparison of the various techniques and helps to demonstrate their comparative strengths and weaknesses.

The book is written primarily for postgraduate students and postdoctoral researchers embarking upon epidemiological studies that may require the use of spatial analytical methods. However, the methods described are also relevant to students and researchers dealing with spatial data in the fields of ecology, zoology, parasitology, environmental science, geography, and statistics. Whilst the book is written in plain language, avoiding jargon as much as possible, a basic understanding of epidemiology and statistics is assumed.

The sequence around which we have structured the book involves firstly visualizing spatial patterns in data, then describing these spatial patterns, and finally attempting to explain the observed patterns. This further enables us to predict changes in patterns and to use our explanations and predictions to inform decisions and to guide policy formulation. Following an introductory chapter, Chapters 2 and 3 address spatial data and the different ways in which they can be observed and presented. Chapters 4, 5, and 6 elaborate on the methods used to describe and quantify spatial patterns, while Chapter 7 looks at some of the methods that can be used to help explain spatial patterns, mostly in terms of environmental variables. Finally, Chapter 8 looks into ways of assessing disease risk and informing decision-making.

We have tried to be consistent with notation, but where this would lead to clumsiness have not forced ourselves to be so. Where notations deviate from the norm, the context should make this clear. At the risk of becoming fairly quickly outdated, we have included references to specific software programmes and provided links to websites. Whilst these all worked at the time of publishing we cannot guarantee their future validity.

The majority of worked examples presented in the book are based on data collected as part of Great Britain's national bovine tuberculosis (TB) control programme. A subset of the national database, comprising cattle TB data from the period 1986 to 1999 was used with permission from the United Kingdom Department for Environment, Food and Rural Affairs (DEFRA) and was kindly provided by Mr. Andy Mitchell and Dr. Richard Clifton-Hadley of the Veterinary Laboratories Agency (VLA).

The Animal Production and Health Division of the Food and Agriculture Organization of the United Nations (FAO) has supported this work as part of its mandate to build national and international capacity for the formulation of evidence-based disease control policies and strategies. In co-publishing the book, FAO hopes to promote its use among member countries.

The motivation to write this book came from our experience with epidemiological spatial analysis as researchers, as teachers, and as practitioners in policy formulation and advice.

Over the years, we have published numerous reviews on spatial analysis and geographic information systems (GIS) in epidemiology (Sanson et al. 1991; Pfeiffer and Morris 1994; Pfeiffer 2000; Robinson 2000; Pfeiffer and Hugh-Jones 2002; Pfeiffer 2004), have run short courses and distance learning modules in spatial analysis, and have taught spatial analysis as part of the masters' courses at the Royal Veterinary College and the London School of Hygiene and Tropical Medicine.

Through discussions with colleagues and postgraduate students in spatial analysis, it became clear to us that there is no spatial epidemiology textbook that provides a comprehensive introduction to the subject area, yet at the same time is accessible to the wider group of epidemiologists, covering issues from spatial data management to analytical decision support tools. We hope that this book will go at least some of the way towards redressing this shortfall.

We were very fortunate in being able to convince our co-authors Mark Stevenson, Kim Stevens, David Rogers, and Archie Clements to join us in this endeavour. Particular thanks are due to Kim Stevens who, apart from contributing her own material to the book, also took over the editing: without her we would not have been able to complete it.

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