Methods in Field Epidemiology
Dedication

To my husband, Daniel, and my parents, Gillan and Donald.

In memory of my brother, Ian MacDonald, who provided unwavering support of my endeavors during his lifetime.
# Contents

<table>
<thead>
<tr>
<th>Preface</th>
<th>xvi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acknowledgments</td>
<td>xvii</td>
</tr>
<tr>
<td>Contributors</td>
<td>xix</td>
</tr>
</tbody>
</table>

## Chapter 1

### Introduction

- References

## Chapter 2

### Introduction to Outbreak Investigations

- Introduction
- What Is an Outbreak?
- Outbreaks and Epidemics
- Case
- Cluster
- When Does a Number of Cases Become an Outbreak?
- How Are Potential Outbreaks Detected?
- Why Investigate Outbreaks?
- The Components of an Outbreak Investigation
  1. Verify the Diagnosis and Confirm the Outbreak
  2. Define a Case and Conduct Case Finding
  3. Tabulate and Orient Data: Time, Place, Person
  4. Take Immediate Control Measures
  5. Formulate and Test Hypotheses
  6. Plan and Execute Additional Studies
  7. Implement and Evaluate Control Measures
  8. Communicate Findings
Chapter 4 Is a Potential Outbreak Real?

Introduction ................................................................. 55

Step 1. Verify the Diagnosis ........................................... 56
Make Sure the Problem Has Been Properly Diagnosed .......... 56
Make Sure All of the Cases Have the Same Disease ............ 56
Rule Out Laboratory or Other Errors ................................ 56

Step 2. Define a Case ....................................................... 57
Clinical Criteria ............................................................ 57
Restrictions by Time, Place, and Person ............................ 57
Sensitivity Versus Specificity .......................................... 57

Step 3. Identify and Count Cases ...................................... 59
How to Find Cases ........................................................ 59
Challenges in Case Finding ........................................... 61
Information to Collect During the Case-Finding Process ....... 62
Using a Line Listing to Organize Data .............................. 63
How to Create and Manage a Line Listing ......................... 63

Step 4. Compare Observed with Expected Cases ................. 66
Calculating Incidence Rates ........................................... 67
Making Rate Adjustments .............................................. 68

Step 5. Rule Out Other Reasons for an Increase in Cases ....... 69
Mass Psychogenic Illness ............................................... 71

Summary ................................................................. 75
References ................................................................. 75

Chapter 5 Assembling and Equipping an Outbreak Investigation Team

Introduction ................................................................. 77

The Members of the Outbreak Investigation Team ................. 78

Equipping an Outbreak Investigation Team ....................... 79
Collecting Specimens and Samples ................................ 79
Line Listings, Epidemic Curves, and Literature Searches ....... 80
Documentation ............................................................ 80
Contents

Communication in Outbreak Investigations ........................................ 81
Collaboration in Outbreak Investigations ...................................... 84
Summary ......................................................................................... 94
References ...................................................................................... 94

Chapter 6 Hypothesis Generation and Descriptive Epidemiology ........... 97
Introduction ..................................................................................... 97
Review of Known Information on the Disease ................................. 98
What Information Do Investigators Need to Gather? ......................... 98
Resources to Learn More About Diseases ....................................... 101
Using Basic Information on Biology and Epidemiology to Initiate an Investigation ................................................ 102
Hypothesis-Generating Interviews .................................................. 104
Which Information Is Collected in Hypothesis-Generating Interviews? ............................................................ 105
Who Is Interviewed? ....................................................................... 107
How Is the Information Collected? .................................................. 108
What Do Investigators Do with the Information They Gather? .......... 108
Trimming the List of Exposures ....................................................... 109
Interviewing Tips ............................................................................ 109
Describing an Outbreak .................................................................. 111
What Is Descriptive Epidemiology? ................................................ 111
Time ............................................................................................. 111
Place .............................................................................................. 118
Person ........................................................................................... 121
Population ...................................................................................... 122
Pulling It All Together .................................................................... 125
Descriptive Epidemiology Versus Analytic Epidemiology ................. 128
Summary ......................................................................................... 128
References ...................................................................................... 129

Chapter 7 Epidemiological Studies in Outbreak Investigations ............ 131
Introduction ..................................................................................... 131
Observational Studies ..................................................................... 134
Cohort Studies ................................................................................. 135
Case-Control Studies ...................................................................... 136
Cross-Sectional Studies ................................................................... 138
Case Series ....................................................................................... 140
When to Use Which Study Approach .......................................... 141
How to Select a Study Type: Some Examples ...................... 143
When to Use More Than One Study .......................................... 145
## CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Study Details</strong></td>
<td>ix</td>
</tr>
<tr>
<td></td>
<td>Defining the Outcome</td>
<td>145</td>
</tr>
<tr>
<td></td>
<td>Case Identification and Selection</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>Defining the Exposure</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Choosing a Comparison Group</td>
<td>149</td>
</tr>
<tr>
<td></td>
<td>Sample Size</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Validity</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 8</strong> Hypothesis-Testing Interviews</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>Developing a Questionnaire</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td>Identify the Leading Hypothesis</td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>Identify the Information Needed to Test the Hypothesis</td>
<td>159</td>
</tr>
<tr>
<td></td>
<td>Identify the Information Needed for the Logistics of the Study</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Writing the Questions</td>
<td>161</td>
</tr>
<tr>
<td></td>
<td>Organize the Questions into Questionnaire Format</td>
<td>167</td>
</tr>
<tr>
<td></td>
<td>Include an Ending Statement</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Determine How the Information Will Be Managed</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Test the Questionnaire</td>
<td>173</td>
</tr>
<tr>
<td></td>
<td>Revise the Questionnaire</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td><strong>Chapter 9</strong> Data Analysis</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>174</td>
</tr>
<tr>
<td></td>
<td>Data Cleaning</td>
<td>177</td>
</tr>
<tr>
<td></td>
<td>Outliers</td>
<td>177</td>
</tr>
<tr>
<td></td>
<td>Minority Considerations</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td><strong>Summary</strong></td>
<td>178</td>
</tr>
<tr>
<td></td>
<td><strong>Sources of More Information on Writing Questions and Organizing Questionnaires</strong></td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>179</td>
</tr>
</tbody>
</table>

---

Note: The page numbers correspond to the page where the content is located in the book. The content is organized by chapters and sections, detailing the process of study design, hypothesis testing, and data analysis.
Contents

Summary ................................................................. 221
References ............................................................... 221

Chapter 11 The Public Health Laboratory's Role in Field Epidemiology and Outbreak Investigation ................................................. 223

Introduction ............................................................. 224
A National Network of Laboratories ........................................ 224
PulseNet ........................................................................ 225
The Laboratory Response Network ......................................... 225

Laboratory Biosafety Levels ............................................... 226
Biosafety Level 1 ............................................................ 226
Biosafety Level 2 ............................................................ 226
Biosafety Level 3 ............................................................ 227
Biosafety Level 4 ............................................................ 227

Functions of the Public Health Laboratory ............................... 228

Traditional Roles of the Laboratory in Public Health Investigations ................................ 229
The Role of the Laboratory in Public Health Surveillance ............... 229
Other Roles of the Laboratory in Public Health Investigations ......... 230

Collection of Clinical Specimens ......................................... 230
Collection of Food and Water Samples .................................... 233

Interpreting Laboratory Results ........................................... 235
Interpreting Tests of Food and Water Samples .......................... 236

Subtyping for Epidemiologic Purposes .................................... 237
Explaining Potential Outbreaks by Subtyping ........................... 238
Gaining Insight into the Source of a Problem Through Subtyping .... 239
Using Subtyping to Integrate Surveillance Information ............... 240

Summary ........................................................................ 241
Additional Resources ....................................................... 241
References ..................................................................... 241

Chapter 12 Environmental Health Components of an Outbreak Investigation ......................... 243

Introduction ................................................................... 243
Traceback Investigations .................................................... 244
The Steps of a Traceback Investigation ..................................... 245
Conducting a Successful Traceback Investigation ...................... 246
To Trace or Not to Trace? .................................................. 247
Traceback Investigations: Tanker Trucks and Sprouting Facilities .... 248
Contents

Environmental Health Assessments ......................................................... 249
When Should the Environmental Health Assessment Be Undertaken? ........ 251
Who Should Undertake an Environmental Health Assessment? ............... 252
Where Should an Environmental Health Assessment Be Undertaken? ..... 252
Conducting an Environmental Health Assessment .................................... 253
Important Considerations in Undertaking an Environmental Health Assessment ......................................................... 255
Summary .................................................................................................. 256
References ............................................................................................... 257

Chapter 13 Investigating Noninfectious Health Events in Public Health Practice ......................................................................................... 259
Introduction ............................................................................................. 259
What Is a Noninfectious Health Event Investigation? .............................. 260
The Resources Required to Investigate a Noninfectious Health Event ....... 263
Internal Management System ................................................................. 263
Written Operating Procedures ................................................................. 263
Staff ......................................................................................................... 264
Financial and Logistical Resources ......................................................... 265
Involving Responsible Groups and Individuals ....................................... 265
Basic Steps in Investigating Clusters of Noninfectious Disease .............. 266
Step 1: Initial Ascertainment of Health Events and Summarization of Relevant Data ................................................................. 267
Step 2: Assessment of Excess Occurrence ............................................. 269
Step 3: Determination of the Feasibility of Etiologic Investigation .......... 279
Step 4: Conducting an Etiologic Study ................................................... 280
Communications ..................................................................................... 280
Risk Communication ............................................................................... 281
Working with the News Media ............................................................... 282
Summary .................................................................................................. 283
References ............................................................................................... 284

Chapter 14 Forensic Epidemiology Investigations .................................... 287
Introduction ............................................................................................. 287
Forensic Epidemiology ........................................................................... 288
Examples of Health-Related Criminal or Terrorist Cases ....................... 289
Forensic Epidemiology Investigations .................................................... 291
Criminal Intent ......................................................................................... 292
Contents

Laws Governing an Investigation 293
Joint Interviewing 293
Evidence 294
Confidentiality 295
Media 296
Classified/Sensitive Information 296
Summary 299
References 299

Chapter 15 Geographic Information Systems for Field Epidemiology 301
Introduction 301
Maps 302
Geographic Information Systems 303
GIS Data Models 304
Displaying GIS Data 305
Spatial Resolution 306
Inputting Data into a GIS 306
Using GIS in Public Health 306
Infectious Disease Surveillance and GIS 308
WHO Public Health Mapping and GIS Programme 308
The HealthMapper 308
Roll Back Malaria Partnership 308
U.S. West Nile Virus Surveillance 309
Outbreak Investigation and GIS 311
Shigellosis 311
Using GIS to Track Sexually Transmitted Infections 312
Global Positioning System 314
Atrazine Exposure 314
Community Assessments and GIS 315
Community Assessment Methodology 315
Modified EPI Cluster Sampling 316
Using Rapid Surveys for Community Assessments 317
Role of Geographic Information Systems in Community Assessments 317
Getting Geographic Information Systems into the Field 318
Summary 318
GIS Resources 319
Additional Resource 319
Further Readings 319
References 320
Chapter 16 Special Considerations

Introduction .................................................. 323

The Incident Command System .............................. 324

Characteristics of ICS ........................................ 325

Additional Resources Related to ICS ...................... 329

Contact Tracing ............................................. 329

Use in Outbreaks ............................................. 329

Voluntary Participation, Informed Consent, and Confidentiality .... 329

Training for Contact Tracing ................................ 330

Contact Tracing Interviews ................................ 330

Additional Contact Tracing Techniques ..................... 331

Responsibility for Contact Notification .................... 332

Examples of Contact Tracing in Outbreak Investigations .......... 332

Example of Partner Notification in STI Outbreaks .............. 332

Legal Authority for Partner Notification ..................... 333

Confidentiality .............................................. 333

Summary ..................................................... 333

References .................................................... 334

Index ................................................................ 337
This genesis of this book occurred while I was a Centers for Disease Control and Prevention Epidemic Intelligence Service (EIS) officer assigned to the North Carolina Division of Public Health. I was in the midst of my first outbreak investigation and turnedsearchingly to the only field epidemiology textbook available at the time for specific guidance. I found the book fell short in describing with enough detail the many aspects of conducting an outbreak investigation. I needed more direction and instructions on how to carry out the important components that make up an outbreak investigation. The scope of this book took root during those two years as an EIS officer. Writing a book was daunting, but I felt compelled to work on this gap in the literature in a stepwise fashion. First, I launched the periodical *Focus on Field Epidemiology* (available at http://nccphp.sph.unc.edu/focus/index.htm). Each issue was designed to guide an epidemiologist through a facet of an outbreak investigation and other related topics by providing hands-on, practical instructions and examples to illustrate points. Later, I developed a graduate-level online course at the University of North Carolina at Chapel Hill called Methods in Field Epidemiology. As I thought through the course content and the trouble students and practitioners had with certain concepts, many more ideas came to me in terms of content for a textbook on this topic.

This book has been adapted from materials developed for other purposes. To write each chapter, I started with pieces that were developed for *Focus on Field Epidemiology* and the course Methods in Field Epidemiology, as well as other UNC Center for Public Health Preparedness training materials. These works were developed by teams and thus I have not used the term “author” for each of the chapters. The individuals listed as contributors worked on the materials used in writing the chapter text. Any errors are mine. All contributors have reviewed the materials and acknowledged their contributions to the content.

The target audience for this book is students and public health practitioners alike. The book covers many topics and is accompanied by numerous examples to illustrate the concepts. It can be used in academic courses that include topics such as outbreak investigations, applied epidemiology, and using epidemiology in public health practice.
Furthermore, it will be useful to practitioners who seek more direction and guidance to the methods used in field epidemiology, especially outbreak investigation. The chapters stand alone, generally, and follow the process that would be involved in an outbreak investigation. Additional chapters cover specific types of investigation such as forensic epidemiology, contact tracing, and environmental investigations, and resources that might be useful during investigations.

The focus of this book is applied epidemiology and how it is used in public health practice. It is not intended to replace a basic epidemiology textbook, but does go into great depth about using epidemiology in the context of applied public health such as outbreak investigation. Moreover, it is not intended to replace existing procedures or guidelines in local, state, or federal health departments. Instead, it should be used as a resource for training staff and providing further background on specific and sometimes complicated topics. This book is no substitute for experience and great mentorship.

I like to think of myself as a practicing epidemiologist. I borrow that term from physicians who, for their whole lives, say they “practice” medicine. The great thing about saying you practice a profession is that it implies you are constantly learning and building your skills. Epidemiology is much like medicine in that way. There is always more to learn, and experience is the best teacher, particularly when it is gained working as part of a team. I have learned a lot from many collaborators and colleagues. I hope this book is useful to you. I hope it helps you to keep learning, practicing, and protecting the public’s health in whatever capacity you can.
ACKNOWLEDGMENTS

This book was written from materials developed for other purposes, including Focus on Field Epidemiology (available at http://cphp.sph.unc.edu/), a series of newsletters designed to guide an epidemiologist through a facet of an outbreak investigation and other related topics by providing hands-on, practical instructions and examples to illustrate points; Methods in Field Epidemiology, a graduate-level online course at the University of North Carolina at Chapel Hill; and other training materials developed at the UNC Center for Public Health Preparedness (http://cphp.sph.unc.edu/). These source materials were developed by teams, and thus I have many contributors to acknowledge here and on each of the chapters, including: Laura Alexander, Lauren Bradley, Meredith Davis, Jennifer Horney, Morgan Johnson, Sandra McCoy, Sally Mountcastle, Amy Nelson, Sarah Pfau, David Rice, Matthew Simon, Cynthia Snider, Jeanette and Paul Stehr-Green, Michelle Torok, Andrew Voetsch, and Rachel Wilfert. I am very thankful to all the contributors for giving generous time to review the their affiliated chapters. Additionally, I want to thank Sarah Pfau and Gene Matthews, who charitably reviewed Chapter 14 on the topic of forensic epidemiology. Lorraine Alexander was instrumental in developing the Focus on Field Epidemiology periodical. Furthermore, I am very grateful to the Council to Improve Foodborne Outbreak Response (CIFOR) for allowing us to reprint a section of their Guidelines for Foodborne Disease Outbreak Response about the agencies that become involved in foodborne disease investigations. It is the best review of this topic I have ever seen. I wholeheartedly thank David Rice, whose help with writing and editing this work was instrumental. His persistence and commitment to seeing the book completed is greatly appreciated. I want to thank my father, Donald MacDonald, whose unrelenting enthusiasm for this project was often greater than my own, and my mother, Gillan MacDonald, who has forever been supportive of all that I do, big and small. Finally, I want to thank my husband, Daniel Rodríguez, for his constant encouragement for this work.
CONTRIBUTORS

Laura C. Alexander, MPH
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Lauren N. Bradley, MHS
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Meredith K. Davis, MPH
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Jennifer A. Horney, PhD, MA, MPH
Research Assistant Professor
Department of Epidemiology
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Morgan L. Johnson, MPH
Emergency Management Training Coordinator
New York City Department of Health & Mental Hygiene
New York, NY

Pia D.M. MacDonald, PhD, MPH
Research Associate Professor
Department of Epidemiology
UNC Center for Public Health Preparedness

UNC Gillings School of Global Public Health
Chapel Hill, NC

Sandra I. McCoy, PhD, MPH
Research Associate Professor
Department of Epidemiology
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Sandra I. McCoy, PhD, MPH
Institute of Business and Economic Research
University of California, Berkeley
Berkeley, CA

Sally B. Mountcastle, PhD, MSPH
Adjunct Assistant Professor
Department of Preventive Medicine & Public Health
University of Kansas Medical Center
Kansas City, KS

Amy L. Nelson, PhD, MPH
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Sarah Pfau, JD, MPH
Chapel Hill, NC

David B. Rice, MA
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Matthew C. Simon, MA
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC
Contributors

Cynthia J. Snider, PhD, MHS
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Jeanette K. Stehr-Green, MD
Clinical Assistant Professor
Department of Epidemiology
University of Washington School of Public Health
Seattle, WA

Paul A. Stehr-Green, DrPH, MPH
Affiliate Associate Professor
Department of Epidemiology
University of Washington School of Public Health
Seattle, WA

Michelle R. Torok, PhD, MPH
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Andrew C. Voetsch, PhD
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC

Rachel Wilfert, MD, MPH
Research Associate for Training and Education
UNC Center for Public Health Preparedness
UNC Gillings School of Global Public Health
Chapel Hill, NC
Rosemary M. Caron, PhD, MPH
Associate Professor
Department of Health Management
and Policy
University of New Hampshire
Durham, NH

Heather Henson-Ramsey, DVM, PhD
Division of Natural Sciences
and Mathematics
Lewis-Clark State College
Lewiston, ID

Katherine W. Reeves, PhD, MPH
University of Massachusetts Amherst
Amherst, MA

Timothy Forde, PhD, MPH
Associate Director
Science Education Programs
Oak Ridge Associated Universities
Oak Ridge, TN

Kacee C. Ernst, PhD, MPH
Assistant Professor of Epidemiology
College of Public Health
University of Arizona
Tuscon, AZ

Sara S. Plaspohl, DrPH, MH5, CIM, CIP
Instructor
Department of Health Sciences
Armstrong Atlantic State University
Savannah, GA

H. Eduardo Velasco, PhD, MSc, MD
Professor
School of Community Health and Policy
Morgan State University
Baltimore, MD
Dr. Pia D. M. MacDonald is a research associate professor in the Department of Epidemiology at the University of North Carolina Gillings School of Global Public Health (UNC SPH) and is the director of the UNC Center for Public Health Preparedness, the North Carolina Preparedness and Emergency Response Research Center, and the Certificate in Field Epidemiology Program in the North Carolina Institute for Public Health at UNC SPH. At UNC SPH, she leads the Team Epi-Aid program that provides graduate students with the opportunity to gain applied public health experience by assisting with outbreak investigations and other public health emergencies, while at the same time providing North Carolina’s local and state health departments with needed surge capacity.

Dr. MacDonald received a PhD in epidemiological sciences from the University of Michigan in Ann Arbor and an MPH in infectious disease epidemiology from Yale University and is certified in public health. From 2000 to 2002, Dr. MacDonald was an Epidemic Intelligence Service officer with the Centers for Disease Control and Prevention (CDC) assigned to the North Carolina Division of Public Health, Communicable Disease Branch.

During Dr. MacDonald’s tenure with the CDC, she worked on a variety of infectious disease outbreak investigations. These included outbreaks of human and canine blastomycosis, histoplasmosis among adventure travelers to Nicaragua, tuberculosis in an inner city social network, and Streptococcus group A toxic shock syndrome. She was also involved in many foodborne disease outbreak investigations, among them listeriosis in the Hispanic community associated with noncommercial Mexican-style fresh cheese, statewide Salmonella Enteriditis associated with eggs from a certain multi-state distributor, gastrointestinal illness associated with Staphylococcus aureus contaminated food at a wedding, restaurant-associated Salmonella Heidelberg, and gastrointestinal illness associated with Clostridium perfringens at a large company picnic. Through the Team Epi-Aid program she has continued to be involved in outbreak investigations in collaboration with state and local health departments such as hepatitis B, HIV, foodborne diseases, influenza, and SARS.
Dr. MacDonald’s work is focused on infectious disease surveillance, outbreak investigation, foodborne disease epidemiology, public health systems research, and public health workforce epidemiologic capacity development. She has authored or co-authored many scientific publications on these topics.