

Essential Epidemiology

An Introduction for Students and Health Professionals

FOURTH EDITION

Now in its fourth edition, *Essential Epidemiology* is an engaging and accessible introduction to the foundations of epidemiology. This text introduces the core concepts and shows the essential role of epidemiology in public health and medicine across a broad range of health monitoring and research activities. It draws on cases from chronic and infectious diseases, with vibrant contemporary, historical and hypothetical examples that enable students to engage with the content. Complex mathematics are kept to a minimum in the main text with more advanced concepts presented as optional extras for those who want more detail.

With more than 90 questions and answers to work through in the print book, and hundreds more in the enhanced eBook, this is an essential resource for students, practitioners and anyone else who needs to interpret health data in their studies or work. Epidemiology's most important goal is to bring rigour to the collection, analysis and interpretation of health data to improve health at a global scale. *Essential Epidemiology* is highly regarded as a resource that provides readers with the tools to achieve that goal.

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Penelope Webb
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Foreword

This is already the fourth edition of *Essential Epidemiology*! This excellent textbook is the core textbook of many undergraduate and graduate programs in epidemiology and public health.

For us at Wageningen University, The Netherlands, this book, which we used to call ‘Webb and Bain’, is our background textbook in epidemiology and public health for several undergraduate programs on campus and online, from Nutritional Epidemiology to Health and Society. Each year we strongly recommend that our ~400 national and international students use this as their background textbook.

We have used this book from its first edition since it outlines the key concepts of modern epidemiology in an accessible and motivational way, especially for those without a strong background in mathematical concepts. It is timely, methodologically strong and encourages students to develop independent critical epidemiological reasoning. It therefore covers what we want our students to know as the core of epidemiology and public health.

The book is very readable and accessible for individuals from different backgrounds, different nationalities and for those whose first language is not English. It is well structured, alternating short pieces of text with many illustrations, good examples and useful exercises, making it an attractive read, even when, in this online era with many distractions and short attention spans, reading and learning from books may be a challenge. One of the biggest compliments for this book in our program was given by an international Master’s student who thought epidemiology was far too difficult for him. He was discouraged by all the definitions, formulas and concepts (e.g. odds ratio, relative risk, incidence, attributable risk). I strongly encouraged him to use this book. Although he at first claimed that reading a book was not for him, he took my message seriously, worked through the book and passed his exam with flying colours. Afterwards he contacted his classmates to recommend this book. He also reminded those from middle- and low-income countries how important the contents are for those who need to deal with the steep rise of chronic diseases in their countries.

Not only is this book a great support for students to engage in more active learning, it also helps us, the teachers. The various examples and exercises in the book as well as the material on the companion website, including slides for lectures, are very helpful for further background and teaching. The online material also contains recommendations for further reading and links to useful websites.

This book makes the field of epidemiology and public health even more fun to work in. We need good epidemiologists, especially in this time where smart, efficient but certainly appropriate study designs are key, and we need to be able to make sense of ‘big data’. This also makes it a good read for those involved in other disciplines, such as medicine and sociology.

This fourth edition is again refreshed based on suggestions from students and teachers. Compared to the third edition, the text is slightly re-ordered, examples are updated and parts are rewritten to improve clarity. In particular, the eBook and online presence are improved, which makes it even more accessible to us all.

I am sure you will enjoy it as much as we do in our programs.

Ellen Kampman

*Professor of Nutrition and Disease
Division of Human Nutrition and Health
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Preface

This book grew out of our collective experience of teaching introductory epidemiology both in the classroom and to distance students enrolled in public health and health studies programs in what is now the School of Public Health at the University of Queensland. It started as a detailed set of course notes we wrote because we could not find a single epidemiology text that covered all of the areas we felt were important in sufficient detail. As the notes were to be used primarily by distance students, we tried hard to make them accessible, using lots of examples, minimal jargon and equations, and by engaging readers in ‘doing’ epidemiology along the way. Feedback from students and colleagues convinced us that the notes were both approachable and practical, and the result is this text, which we offer as a practical introduction to epidemiology for those who need an understanding of health data they meet in their everyday working lives, as well as for those who wish to pursue a career in epidemiology.

For the first revision, we listened to the feedback we received from instructors and students, and tried to simplify and clarify some of the trickier bits of the original text while maintaining a ‘hands-on’ approach. New and expanded topics included a look at some of the ways in which we measure the burden of disease, deeper discussion of issues relevant to ethics and privacy, appendices covering life tables and calculations of confidence intervals for common epidemiological measures, and a glossary. With our new co-author Andrew Page, and inspired by colleagues at a workshop on methods of teaching epidemiology convened by Professors Diana Safarti and John Lynch at the University of Otago, New Zealand in 2014, we injected some more contemporary approaches to causal thinking, bias and confounding to the third edition. These changes were most obvious in Chapter 4 (study design), which we restructured to show more clearly how each design contrasts with the ‘ideal’ (counterfactual) experiment, Chapter 7 (bias) and Chapter 8 (confounding), and Chapter 10 (association and causation). We also refined the final chapter, building on the earlier material to consider the role and value of epidemiology in translational research.

In this fourth edition, we have updated information relating to real-world public health problems and programs, and have further refined the material relating to the counterfactual approach to causality (Chapter 10) and relating to infectious diseases (Chapters 12 and 13). We have also made a number of changes to improve clarity, in response to feedback from reviewers of the previous edition. The main changes, however, relate to the greatly expanded resources available with this edition, through the enhanced eBook. In addition to the core text, the eBook includes extra material to supplement the text, links to the papers we cite in the book, additional questions and answers, information about free analytic software and methodological guidelines, and other useful material.

Our overall aims for the book, however, have remained constant. First, to give students a good understanding of the fundamental principles that are common to all areas of epidemiology in a very ‘hands-on’ way, including the study of both infectious and chronic diseases as well as public health and clinical epidemiology, and to show the essential role of epidemiology in a broad range of health monitoring and research activities. Secondly, and perhaps more importantly, we have endeavoured to do this in a way that is both approachable and engaging, that minimises mathematical jargon and complex language without sacrificing accuracy, and that encourages study and stimulates epidemiological thought.



Chapter 1 is a general introduction that both answers the question ‘what is epidemiology and what can it do?’ and presents the main concepts that are the focus of the rest of the book. The following chapters are divided into five separate sections. The first of these looks at how we can measure disease and the overall burden of disease in a population (Chapter 2), followed by a look at the role of descriptive epidemiology in describing health patterns and making a community diagnosis (Chapter 3). We then look at the types of study that we use to identify potential causes of disease, including a discussion of the potential of record linkage (Chapter 4) and how we quantify the associations between cause and outcome (Chapter 5). In the third section, we look at the role of chance in epidemiology (Chapter 6), consider the thorny issues of error and bias (Chapter 7) and give a practical overview of the problem of confounding (Chapter 8). This leads to the fourth section, where we integrate this information in a practical look at how we read and interpret epidemiological reports (Chapter 9), think about assessing causation (Chapter 10) and finally synthesise a mass of information into a single review to make practical judgements about the likelihood that a relation is causal (Chapter 11). In the final section we look at some specific applications of epidemiology, including its role in surveillance (Chapter 12), outbreak control (Chapter 13), prevention – including a discussion of how we can assess the effects of different preventive interventions on the health of a population (Chapter 14) – and screening (Chapter 15). Chapter 16 concludes by reviewing core concepts of the earlier material to address some of the challenges that face an epidemiologist who desires to improve health through ‘translation’ of research into practice. It also hints at some of the newer methods that epidemiologists are adopting from other disciplines, such as systems science, to help answer complex questions in the real world.

About the authors

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Andrew Page, BA(Psych) Hons (Newcastle), PhD (Sydney), is Professor of Epidemiology in the School of Medicine at Western Sydney University, Australia. He has been teaching basic and intermediate epidemiology and population health courses to health sciences students for 13 years, and has published more than 180 research articles and reports across a diverse range of population health topics. He has been a research associate at the University of Bristol in the United Kingdom and has also worked at the University of Queensland and University of Sydney.

Contributors

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Acknowledgements

If we were to name everyone who had contributed in some way to this book, the list would be endless. We would, however, like to acknowledge some of the great teachers (and their books) from whom we have learned most of what we know, and the books we have relied on heavily for our teaching. These include Brian MacMahon (*Epidemiology: Principles and Methods*, MacMahon and Pugh, 1970); Olli Miettinen; Charlie Hennekens (*Epidemiology in Medicine*, Hennekens and Buring, 1987); Ken Rothman (*Modern Epidemiology*, 1986); *Foundations of Epidemiology* (Lilienfeld and Lilienfeld, 1980); and *Epidemiology* (Gordis, 1996). We would also like to thank our colleagues and friends, especially the Fellows from the former School of Population Health at the University of Queensland, and staff and students from the then Cancer and Population Studies Group at the QIMR Berghofer Medical Research Institute, whose constructive feedback helped shape the first edition back in 1995.

Particular thanks go to our former colleague and co-author of the first edition, Sandi Pirozzo; to Adrian Sleight (Australian National University), who wrote the original chapters on outbreak investigation and surveillance; and Martyn Kirk (Australian National University), who extensively revised these chapters for the third edition. We are grateful to members of the former Burden of Disease group at the School of Public Health, University of Queensland, especially Theo Vos, Stephen Begg and Alan Lopez for their suggestions regarding our discussion of the burden of disease for the second edition, and to Chalapati Rao (Australian National University), whose constructive feedback helped us to further update chapters 2 and 3 for editions three and four. The excellent critiques and suggestions we received from Michael O'Brien and Kate Van Dooren on the first edition helped to improve the cohesion and internal 'sign-posting' of the book. We also thank Susan Jordan, Kate Van Dooren and Keren Papier, who helped pull everything together for the first, second and third editions, respectively. Finally, we would like to acknowledge the School of Public Health at the University of Queensland, which provided the intellectual environment that led to us to writing this book in the first place; the many users of the previous editions, particularly the team from Otago University in New Zealand, who have provided critical and constructive feedback; and the thoughtful reviewers of our submitted draft of this edition.

How to use this book

This book includes a number of features to enhance learning. These include questions embedded within the text and at the end of each chapter (with full answers provided), text boxes that provide additional information about topics of interest, examples of clinical epidemiology and more advanced material for those who want this, and a range of other interactive features in the eBook. There is also a comprehensive glossary at the end of the book, and we have used a **bold** typeface the first time we use terms that are included in this.

We strongly believe that the best way to learn anything is by actually doing it, and so have included questions within the text for those who like to test their understanding as they go. These questions will appear in the text as:

 Calculate the attack rates for the other foods. Which food has the highest attack rate?

Because we also know how frustrating it is to have to search for answers when you are reading, we have provided these immediately following the questions, for those in a hurry to proceed. The questions at the end of the chapters also have fully worked answers at the end of the book.

We have used numerous real-life examples from all around the world to illustrate the key points and to provide additional insights in some areas. Extra examples that provide added interest and complement the main message in the text are given in boxes featuring this symbol:



Many books present clinical epidemiology as a separate discipline from public health epidemiology – a distinction that is strengthened by the fact that clinical epidemiologists have developed their own names for many standard epidemiological terms. In practice, all epidemiology is based on the same underlying principles, so we have integrated the two approaches throughout the book, but we have also highlighted specific examples more relevant to the clinical situation. (Please note that this book does not offer a comprehensive coverage of clinical epidemiology; rather, we aim to show the similarity of the two areas where they overlap.) Information about clinical epidemiology appears in boxes with this symbol:



We have deliberately tried to keep the main text free of unnecessary detail and equations, but have included some optional epidemiological ‘extras’. This material is not essential to the continuity of the core text but provides some additional information for those who like to see where

things have come from or want a more detailed perspective. More advanced material is presented in the book in boxes featuring this symbol.



Further extensions of core material, as well as links to additional resources, the papers that we cite in the book, useful websites and epidemiological resources, are provided in the enhanced eBook. See How to use your VitalSource eBook for further details.

To help reinforce the core concepts introduced in the book, there are several sets of questions for all chapters, other than the first and last. In addition to the questions within the text, there are *revision questions* at the end of the chapters (answers are at the end of the book) and, in the enhanced eBook, there are further *multiple-choice questions* and *additional questions* (all with full answers). Additional material, including a series of exercises that ask the reader to critique published papers and full sets of slides for lecturers, are available online at www.cambridge.edu.au/academic/essentialepidemiology.

How to use your VitalSource eBook

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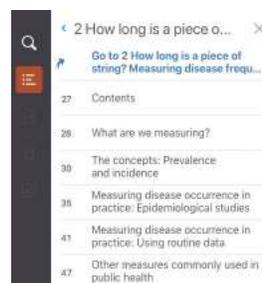
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This icon is used throughout the textbook to indicate the presence of an interactive component in the eBook. A descriptor below indicates the type of content available.

Navigation and search

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Highlight

Highlight text with one click in your choice of colours. Add notes to highlighted passages.

Links

Explore relevant hyperlinked web and video content to extend your knowledge on the topics presented in the book.

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Where available, links to items in the reference lists are included.

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Further detail on some topics is found within the VitalSource eBook. The icon descriptor indicates the topic available.

More about Disability Adjusted Life Years (DALYs)

The concept of a DALY was developed to facilitate attempts to quantify the global burden of disease, and the metric has undergone a number of iterations in terms of scope and methodology in the context of the Global Burden of Disease (GBD) initiative (www.healthdata.org/gbd; www.who.int/healthinfo/global_burden_disease/about/en/).

The GBD project is a systematic, scientific effort to quantify the comparative magnitude of health loss due to diseases, injuries and risk factors by age,

Questions

Q1: For each of the following scenarios, calculate a measure of the incidence of disease and identify the type of measure:

a. One thousand healthy women were followed for 8 years, and 15 developed high blood pressure.

Incidence proportion = 15 cases
 Incidence proportion = 15 cases ÷ 1000 women = 1.5% in 8 years.

b. A large group of elderly men was followed for a total of 5000 person-years, and 75 of the men had a stroke during the duration of the study.

Questions

Respond to the questions at the end of each chapter and use the guided solutions to assess your responses. Note that the solution pop-ups can be moved about the page.

Additional questions

There are hundreds more questions available within the VitalSource eBook. Respond to the questions and use the guided solutions to assess your responses. Note that the solution pop-ups can be moved about the page.

Additional questions

Q1: What effect would the following have on (i) the incidence, (ii) the prevalence and (iii) the duration of disease, and why?

a. The introduction of a new drug that cures a previously incurable but non-fatal disease

(i) The incidence would not change because the new drug would not affect how quickly people developed the disease; the DURATION of the disease would decrease because the new drug would mean that people would have the disease for a shorter time and, as a result, the PREVALENCE would decrease.

Multiple-choice questions

Q1: In a study of 500 patients with coronary heart disease, 100 already had diabetes when the study started on 1 January 2018. Over the next year, 50 more developed diabetes. (Assume the diabetes is permanent and there are no losses or entries to the group of patients with heart disease.) Which of the following statements are correct (select all that apply)?

A – The prevalence of diabetes at the start of 2018 was 30% and the incidence proportion was 10% in 1 year.

B – The prevalence of diabetes at the start of 2018 was 30% and the incidence proportion was 12.5% in 1 year.

C – The prevalence of diabetes at the end of 2018 was 30% and the incidence proportion was 10% in 1 year.

D – The prevalence of diabetes at the start of 2018 was 30% and the incidence proportion was 12.5% in 1 year.

E – The prevalence of diabetes at the start of 2018 was 20% and the incidence proportion was 12.5% in 1 year.

Check answer

Multiple-choice questions

Open the multiple-choice questions pop-up box, select your choice of correct answer(s) and click 'Check answer' to assess your response against the guided answer. Note that this box can be moved about the page for you to read text while choosing your responses.

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Throughout the book there are useful documents available to download from your eBook to your device. Click the icon to download the PDF.

Downloadable 13.1: More about investigating outbreaks