

THIRD EDITION

Penny Webb | Chris Bain | Andrew Page

# ESSENTIAL Epidemiology

An Introduction for Students and Health Professionals



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Medicine

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and Health Professionals

Third Edition

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University Printing House, Cambridge CB2 8BS, United Kingdom

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[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9781107529151](http://www.cambridge.org/9781107529151)

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First edition published in 2005

Second edition published 2011

Third edition 2017

Printed in Singapore by Markono Print Media Pte Ltd

*A catalogue record for this publication is available from the British Library.*

*Library of Congress Cataloging-in-Publication Data*

Names: Webb, Penny, 1963- , author. | Bain, Chris, 1947- , author. | Page, Andrew, 1974- , author.

Title: Essential epidemiology : an introduction for students and health professionals / Penny Webb, Chris Bain, Andrew Page.

Description: Third edition. | Cambridge ; New York : Cambridge University Press, 2017. | Includes bibliographical references and index.

Identifiers: LCCN 2016007893 | ISBN 9781107529151 (pbk. : alk. paper)

Subjects: | MESH: Epidemiologic Methods | Epidemiology

Classification: LCC RA651 | NLM WA 105 | DDC 614.4-dc23 LC record available at <http://lcn.loc.gov/2016007893>

ISBN 978-1-107-52915-1 Paperback

Additional resources for this publication at [www.cambridge.org/9781107529151](http://www.cambridge.org/9781107529151)

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# Essential Epidemiology

An Introduction for Students and Health Professionals

Third Edition

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I am delighted to write the new foreword for the third edition of *Essential Epidemiology*.

This well known, highly respected and engaging book, aimed at the Masters level in Epidemiology, is a timely evolution from the earlier editions, bringing in new material and educational approaches (fully described in the authors' preface).

As someone who has been heavily involved in my own institution's undergraduate, masters, and doctoral level research and service training over many decades, and been external examiner for many other institutions, I see the value of this book to many international constituencies. The key audience will, of course, be those involved in Masters studies of Epidemiology, Public Health and related disciplines. However I would also recommend this book to those involved in undergraduate teaching of epidemiology, students and teachers, those in post-Master's training or practice, as well as those in the biomedical and social sciences who wish to understand and utilise the perspectives and principles of epidemiology.

The value of the book is that the authors have based it on many years of teaching students on the ground and the latest revision and refreshment ensures that it maintains relevance. Thus this book retains the major content of the earlier versions, with sound grounding in the core principles and practice of epidemiology, as well as incorporating new areas. It is vital that future epidemiological research is relevant to the challenges we face globally. The book continues to provide this wider perspective, as well as the more technical approaches that are used when merged with other fields such as genetics. This new edition also provides on-line further materials (including expanding on some trickier methodological topics) and full teaching materials (more on questions and answers, lecture slides), which allow students to engage in more active learning and teachers to draw on presentations which they can use and adapt.

As is clear I recommend this book strongly to those in relevant training and those involved in their education as an up to date, highly accessible and excellent resource.

Carol Brayne  
Professor of Public Health Medicine  
University of Cambridge

## Preface

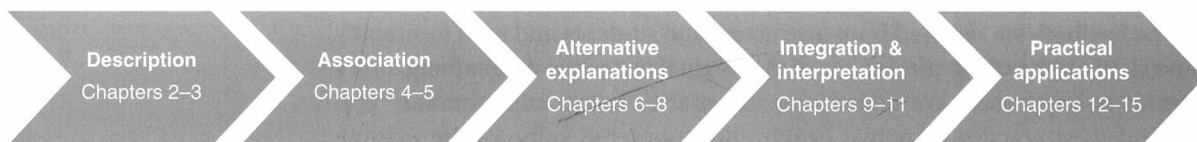
This book grew out of our collective experience of teaching introductory epidemiology both in the classroom and to distance students enrolled in public health and health studies programmes in the School of Public Health (formerly the Department of Social and Preventive Medicine and then School of Population Health), University of Queensland. It began life as a detailed set of course notes that 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 with 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.

The first revision of the text reflected evolution, not revolution. 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 very ‘hands-on’ approach. We added new material to reflect contemporary epidemiological practice in public health and re-ordered some of the existing elements to improve the flow and enhance the continuity between chapters. New and expanded topics included a look at how we measure the burden of disease, greater discussion of issues relevant to ethics and privacy, appendices covering life tables and calculation of confidence intervals for common epidemiological measures, and a glossary.

This, the third edition, reflects further evolution. With our new co-author Professor Andrew Page, and inspired by colleagues at a workshop on methods of teaching modern epidemiology convened by Professors Diana Safarti and John Lynch at the University of Otago, New Zealand in 2014, we have injected some more modern approaches to causal thinking, bias and confounding. These changes are most obvious in Chapter 4 (Study Design), which we have restructured to show more clearly how each design contrasts with the ‘ideal’ (counterfactual) experiment, Chapters 7 (Bias) and 8 (Confounding), and Chapter 10 (Causation). A series of constructive reviews from teachers using the book helped us to identify and correct some faults, convinced us to retain the infectious disease elements of the text but in a more focussed and practical

form, and led us to add recommendations for ‘further reading’ for those who want deeper insights into some of the issues discussed. We have also refined the final chapter, which now builds on the experience of the earlier material to consider the role and value of epidemiology in translational research. Another major enhancement is the greatly expanded website, which provides the reader with access to additional examples and useful links, many of the references cited in the book (subject to copyright), additional questions with comprehensive worked answers and a ‘Test Yourself’ set of interactive multiple choice questions (and answers) for each of the main content chapters. For lecturers there are also more detailed sets of teaching slides for each chapter.

Our overall aims are, however, unchanged. Firstly, to give students a good understanding of the fundamental principles common to all areas of epidemiology, 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.



As previously, 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 next chapters are divided into five separate sections. The first covers the basic principles and underlying theory of epidemiology in a very ‘hands-on’ way. We start by looking at how we can measure disease and, new to this edition, the overall burden of disease in a population (Chapter 2), followed by a look at the role of descriptive epidemiology in describing health patterns (Chapter 3). We move on to look at the types of study that we use to identify potential causes of disease, including an expanded discussion of the potential of record linkage (Chapter 4) and how we quantify the associations between cause and outcome (Chapter 5). In the next 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 third 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 in to a single review to make practical judgements regarding 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 impact of different preventive interventions on the health of a population (Chapter 14) and screening (Chapter 15). The greatly revised Chapter 16 then concludes by reviewing core concepts of the earlier material to address some of the challenges that face a modern epidemiologist who desires to improve health through ‘translation’ of research into practice.

## Symbols

Throughout the book we have used **bold** typeface to indicate terms included in the glossary and the following symbols are used to define key elements within the text.

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. Because we also know how frustrating it is to have to search for answers, 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 full 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 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.)

We have deliberately tried to keep the main text free of unnecessary detail and equations, but have included some 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.







New to this third edition, we have identified areas where additional material is available online; [www.cambridge.org/9781107529151](http://www.cambridge.org/9781107529151). This material includes additional reading, links to the papers that we have cited and additional questions and answers.

## 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* (Lillienfeld and Lilienfeld, 1980), and *Epidemiology* (Gordis, 1996). We would also like to thank our colleagues and friends, especially the Fellows from the then School of Population Health, University of Queensland, and the 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, who has since moved on to a rewarding new career post-epidemiology; we remain grateful for her prior contributions. Also to Adrian Sleight (Australian National University) who wrote the original chapters on Outbreak Investigation and Surveillance and to Martyn Kirk (Australian National University) who extensively revised these chapters for this 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 consideration of the 'Burden of Disease' for the second edition, and to Chalapati Rao (Australian National University) whose constructive feedback helped us to update Chapters 2 and 3 for this edition. The excellent critiques and suggestions we received from Michael O'Brien and Kate Van Dooren regarding the first edition helped 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, University of Queensland, which provided the intellectual environment that led to us writing this book in the first place, the team from Otago University in New Zealand who provided very helpful feedback on the first edition, and the many users of the first two editions who provided the critical feedback that has directly led to this new and hopefully improved third edition.

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# Epidemiology is ...

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## Box 1.1 Epidemiology is ...

'The science of epidemics' (*Concise Oxford Dictionary*, 1964)

'The science of the occurrence of illness' (Miettinen, 1978)

'The study of the **distribution** and **determinants** of disease in humans'  
(MacMahon and Pugh, 1970)

'The study of the distribution and determinants of **health-related states or events** in specified populations, and the **application of this study to control of health problems**' (Porta, 2008)

'The study of the occurrence and distribution of health-related events, states and processes in specified populations, including the study of the determinants influencing such processes, and the application of this knowledge to control relevant health problems' (Porta, 2014)

So what is epidemiology anyway? As shown in Box 1.1, the *Concise Oxford Dictionary* (1964) defined it accurately, but not very helpfully, as 'the science of epidemics'. In 1970, MacMahon and Pugh came up with something a bit more concrete: 'the study of the *distribution* and *determinants* of disease'. Their definition succinctly identifies the two core strands of traditional epidemiology: *who* is developing disease (and *where* and *when*), and *why* are they developing it? The next definition, from the 2008 edition of the *Dictionary of Epidemiology* (Porta, 2008), takes things two steps further by broadening the scope to include health in general, not just disease, as well as highlighting the essential role of epidemiology in translating research findings into health policy and medical practice to control disease. The most recent definition (Porta, 2014) elaborates further still but, in doing so, loses some of the elegance of the earlier versions.

Epidemiology, therefore, is about measuring disease or other aspects of health, identifying the causes of ill-health and intervening to improve health; but what do we mean by 'health'? Back in 1948, the World Health Organization (WHO, 1948) defined it as '... a state of physical, mental and social well-being'. In practice, what we usually measure is physical health, and this focus is reflected in the content of most routine reports of health data and in many of the health measures that we will consider here. However, methods that attempt to capture the more elusive components of mental and social well-being are now emerging. Instead of simply measuring 'life expectancy', WHO introduced the concepts of 'health-adjusted life expectancy' (HALE) and subsequently 'disability-adjusted life years' (DALYs) to allow better international comparisons of the effectiveness of health systems. In doing so, they recognised that it is not longevity per se that we seek, but a long and healthy life. We will discuss these and other measures in more detail in Chapter 2.

Perhaps epidemiology's most fundamental role is to provide a logic and structure for the analysis of health problems both large and small or, as described by Wade Hampton Frost, epidemiology involves the 'orderly arrangement of [established facts] into chains of inference which extend more or less beyond the bounds of direct observation' (Frost, 1927). It emphasises the sound use of numbers – we have to count and we have to think. We have to think about what is worth counting and how best to count it, about what is practical and, importantly, about how well we (or others) finally measured whatever it was we set out to measure, and what it all means. Accurate measurement of health is clearly the cornerstone of the discipline, but we believe the special value of epidemiology flows from a way of thought that is open, alert to the potential for error, willing to consider alternative explanations and, finally, constructively critical and pragmatic.

We offer this book as an aid to such thought. It does not aim to turn you into a practising epidemiologist overnight, but will give clear directions if that is where you decide to go. Its primary goal is to help you interpret the mass of

**Table 1.1** Numbers of people who became ill after eating various foods at a youth camp.

Food	People who ate the food		People who didn't eat the food	
	Total	Number ill	Total	Number ill
Friday dinner:				
Hot chicken	343	156	231	74
Peas	390	175	184	55
Potato fries	422	184	152	46
Saturday lunch:				
Cold chicken	202	155	372	75
Salad	385	171	189	59
Saturday dinner:				
Fruit salad	324	146	250	84

(Adapted from Hook *et al.*, 1996, with permission from John Wiley and Sons. © 1996 The Public Health Association of Australia Inc.)

epidemiological literature and the various types of health data that you may come across. We hope that you will see, by reading and by doing, that the fundamental concepts and tools of epidemiology are relatively simple, although the tasks of integrating, synthesising and interpreting health information are more challenging. But before we go any further, let us do some public health epidemiology.

### A case of food poisoning

Epidemiology is a bit like detective work in that we try to find out why and how disease occurs. Our first example illustrates this. After an outbreak of food poisoning at a youth camp, the local public health unit was called in to identify the cause (Hook *et al.*, 1996). They first asked everyone at the camp what they had eaten prior to the outbreak and some results of this investigation are shown in Table 1.1.

Looking at the numbers in Table 1.1, it is difficult to see which of the foods might have been responsible for the outbreak. (Note that everyone is recorded as either having eaten or not eaten each food; and that most people will have eaten more than one of the foods.) More people became ill after eating potato fries than after eating cold chicken (184 versus 155) – but then more people ate the fries (422 versus 202). How then can we best compare the two foods? One simple way to do this is to calculate the *percentage* of people who became ill among those who ate (or did not eat) each type of food. For example, 156 out of 343 people who ate hot chicken became ill and

$$156 \div 343 = 0.45 = 45\%$$