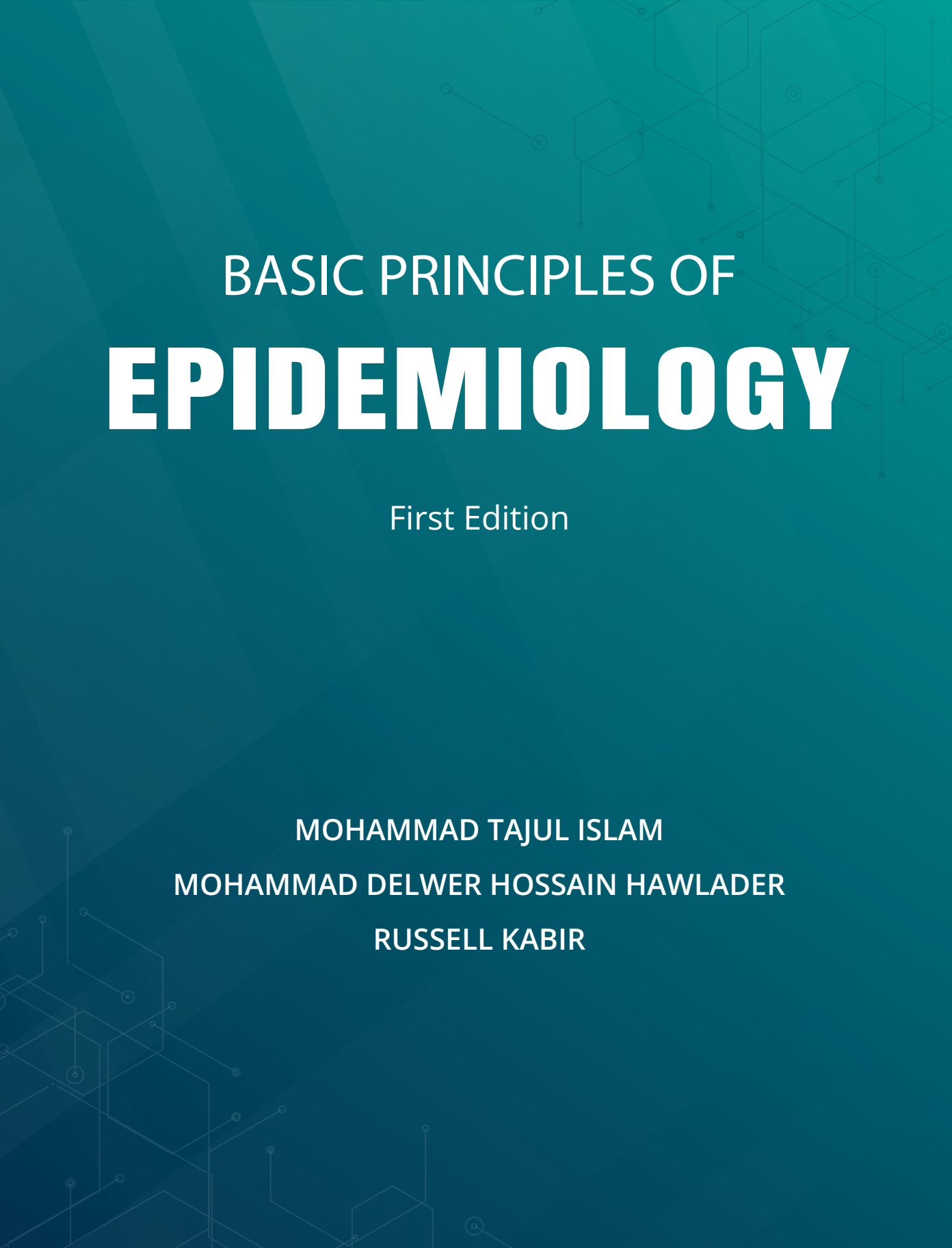




BASIC PRINCIPLES OF **EPIDEMIOLOGY**

First Edition

MOHAMMAD TAJUL ISLAM
MOHAMMAD DELWER HOSSAIN HAWLADER
RUSSELL KABIR

Basic Principles of Epidemiology

First Edition

Mohammad Tajul Islam

MBBS, DTM&H, MSc (CTM), MPH

Professor (Adjunct), Department of Public Health

North South University and State University of Bangladesh

Mohammad Delwer Hossain Hawlader

MBBS, MPH, PhD

Associate Professor and Chairman, Department of Public Health

North South University, Bangladesh

Russell Kabir

BDS, MPH, MSc, PhD

Associate Professor in Public Health and Biostatistics

Course Leader, MSc Public Health and Community Wellbeing

School of Allied Health, Faculty of Health, Medicine and Social Care

Anglia Ruskin University, Chelmsford, Essex, UK

Edited by

Mohammad Tajul Islam

ASA Publications

Dhaka, Bangladesh

ISBN 978-984-35-4720-0

Copyright © 2023 by Authors

First published September 2023

All rights are reserved. No part of this book may be reproduced or transcribed by any means—print, photocopy, or otherwise—without prior written permission from the first author. Its contents may, however, be used and incorporated into other materials with proper acknowledgements and citations.

Publisher

ASA Publications

Dhaka, Bangladesh

Email: asapublications7@gmail.com

Distributor

Altaf Medical Book Center

Shop: 121 & 128; Lane: 3; Islamia Market, Nilkhet, Dhaka 1205

Cell: +880-1711-985991; +880-1611-985991; +880-1511-985991

Production credits

Composition and Cover Design: Zariath Al-Mamun Badhon

Production Director: Md Altaf Hossain

Printing: ASA Publications

Binding: Rahim Bindings

Suggested Citation

Islam MT, Hawlader MDH, Kabir R. Basic Principles of Epidemiology. Dhaka, Bangladesh: ASA Publications; September 2023.

Printed in Bangladesh

To all our family members, students, and promising researchers in
health and social sciences

Preface

Encouraged by our students and very favorable responses to our books on data analysis, we decided to write this book. An easy and user-friendly book is always in demand. The purpose of this book is to present the basic concepts and methods of epidemiology as they are applied to disease or health-related problem investigation and intervention designs in an understandable manner. This book has been designed for the introductory courses in epidemiology offered in the undergraduate and graduate programs. It is difficult to decide how much detail is needed for a chapter. We tried to keep the presentations shorter while giving the basic information. Those who wish to know more detail about a particular topic are directed to the resources provided in references.

This book can be used at universities or schools offering courses in public health and allied sciences like medicine, dentistry, veterinary medicine, environmental sciences, and other disciplines. The health professionals and social scientists involved in public health and research should be familiar with epidemiological principles and methods and will find this book useful. This book can also be of value to students (MPH, MSc, MS, MD, FCPS, MPhil, and PhD), teachers, public health practitioners, and researchers.

The world is rapidly changing with the emergence of new diseases and the reemergence of old ones. As a result, there is a great need for epidemiologists in the fields of public health, preventive medicine, and research. We hope that this book will serve, at least to some extent, the needs of students and public health professionals in getting the basic concepts and stepping up into more advanced studies in epidemiology. Since data analysis is done using computers, we recommend our books on data analysis (Learning SPSS without Pain, ASA Publications, 2021; and Data Analysis with Stata, ASA Publications, 2022), which readers may find useful.

If you have any comments or suggestions about this book, feel free to write to the e-mail address below.

M. Tajul Islam
abc.taj@gmail.com

Foreword

It was a pleasure writing a foreword to this book. As a medical student, when I was learning epidemiology nearly 35 years ago, there were limited suitable reference books to guide junior doctors and public health researchers like me. That all began to change since then, and we had a plethora of books and guidance or journal papers to consider when deciding on something to recommend to the students at every level, from beginners to advanced postgraduates.

The authors of the current book have given much thought to create a user-friendly reference book that guides readers throughout their journey in the epidemiology world. They are long-standing experts in health service and social science research methods - the reader is in good hands. It is worth having a look at some of their published books and academic papers utilizing population-level data to understand and improve public health provision globally; all of these research outputs have been established based on their strong knowledge and skills in epidemiology.

The aim of the book is to make understanding of epidemiology easy and explicit. I am sure this book would be a handy companion reference to students and early-career researchers in population health. One of the distinctive features of this book from all the others could be the clarity of the concepts and approaches introduced to the essential aspects of practical epidemiology. It explains the fundamental concepts in a simple, digestible format with an example. Therefore, this is instrumental for further epidemiology practice by public health practitioners, junior health services researchers, and university students using the latest statistical packages to analyze data and properly interpret them.

It had been a privilege to receive and read the book. I personally know their works and have a high regard for the authors of the chapters. This textbook guides us through properly selected population health analysis and interpretations, reducing room for error while helping to build confidence through practice. The book has a logical framework and structure, proceeding from sections on concepts and methods and statistical methods to applications and fields of current research. I enjoyed reading these accounts, and I am confident that many others will do so too.

As an academic who has taught population health subjects including epidemiology modules (basic and advanced) over the last 25 years, very often I observed that some students were able to run the statistical analysis using software packages (e.g., SPSS)

but struggled to properly absorb the results or do the basic analysis manually. I am confident that this book sits next to the most preferred key textbooks that students and researchers enjoy returning to it whenever they struggle to understand statistical analysis outputs or if they want to check the interpretations suggesting decisions or policies at the population health level themselves.

Finally, I am obliged to mention that the authors have accomplished this book as an unpaid task, and it has taken significant time for them to compile this book. All selling profits will be donated to their chosen good causes via charities. I am sure you will also appreciate their intention and would recommend reading the book.

Dr. Ali Davod Parsa
MD(GP), PhD (Health Economist), PGDip (HSR), PGCE, PGCBA
FRSPH, FHEA, FIHM, FCMI, M-SSM, M-EUPHA
Associate Professor of Health Economics, Policy, and Management
Public Health Course and Modules Leader
Former Advisor, Deputy Cabinet Minister of Health in Medical Education, Iran
Faculty of Health, Medicine, and Social Care
Anglia Ruskin University, Cambridge, UK

Acknowledgements

We are grateful to Mr. Md. Golam Kibria, who reviewed this book and provided his critical views and constructive suggestions. We are indebted to Mr. Zunayed Al Azdi for preparing the index for this book. We are particularly thankful to Dr. Ali Davod Parsa for his careful review and for writing the foreword for this book.

We would like to acknowledge and thank our well-wishers, Dr. Divya Vinnakota and Mrs. Madhini Sivasubramanian of University of Sunderland, London, UK; Dr. Haniya Zehra Syed and Dr. Richard Hayhoe of Anglia Ruskin University, UK; Dr. Masoud Mohammadnezhad and Dr. Marcus Chilaka of University of Bradford, UK Prof. Hafiz T. A. Khan of University of West London, UK; Dr. S. M. Yasir Arafat of Enam Medical College & Hospital, Dhaka, Bangladesh; Dr. Fahima Nasrin Eva of North South University, Bangladesh; Dr. Mosharraf Sarker of Liverpool John Moores University, Liverpool, UK; and Dr. Rajeeb Kumar Sah of University of Huddersfield, Huddersfield, UK, for their continued support and valuable suggestions.

Many of our students and academicians, who continually pushed and encouraged us to write this book, deserve a share of the credit, including Dr. Shakil Ahmed and Dr. Al-Afroza Sultana. We, the authors, accept full responsibility for any deficiencies or errors that the book may have. Finally, we express our sincerest thanks to ASA Publications for publishing this book.

Contents

Chapter 1	Introduction	1
1.1	Definition of epidemiology	1
1.2	Uses of epidemiology	4
1.3	Epidemiological approaches	4
1.4	Scope of epidemiology	4
1.5	Role of epidemiology in public health	6
1.6	History of epidemiology	6
 Chapter 2	 Concepts of Disease Causation and Transmission of Communicable Diseases	 11
2.1	Concepts of disease causation	11
2.1.1	Epidemiologic triad	11
2.1.2	Web of causation	12
2.1.3	Multifactorial causation	12
2.1.4	Causal pie	13
2.1.5	Sufficient-component cause model	13
2.2	Transmission of communicable diseases	14
2.3	Iceberg of disease	20
2.4	Commonly used definitions	21
 Chapter 3	 Measures of Morbidity and Mortality	 27
3.1	Basic tools of epidemiology: count, rate, ratio, and proportion	28
3.2	Measures of morbidities and mortalities: prevalence and incidence	31
3.3	Prevalence	31
3.3.1	Point prevalence	31
3.3.2	Period prevalence	32
3.4	Incidence	33
3.4.1	Cumulative incidence based on persons at risk	33
3.4.2	Cumulative incidence when there is no loss to follow-up	34
3.4.3	Cumulative incidence when there are losses to follow-up	35
3.4.4	Cumulative incidence: Classic life table approach	36
3.4.5	Cumulative incidence: Kaplan-Meier approach	39
3.5	Incidence rate: incidence based on person-time units at risk	41

3.6	Relationship between cumulative incidence and incidence rate	46
3.7	Frequently used measures of morbidities and mortalities	47
Chapter 4	Epidemiological Study Designs: An Overview	51
4.1	Types of epidemiological studies	51
4.1.1	Descriptive studies	51
4.1.2	Analytic studies	52
4.1.3	Observational studies	53
4.1.4	Experimental studies	53
4.2	Descriptive study designs	54
4.2.1	Case report	54
4.2.2	Case series	54
4.2.3	Ecological studies	54
4.2.4	Cross-sectional studies	55
4.3	Analytic study designs	56
4.3.1	Case-control studies	56
4.3.2	Cohort studies	58
4.3.3	Experimental studies	59
4.4	Hierarchy of study designs	62
4.5	Choice of study designs	63
Chapter 5	Descriptive Studies	65
5.1	Descriptive studies	65
5.2	Types of descriptive studies	71
5.2.1	Case report and case series	71
5.2.2	Ecological studies	72
Chapter 6	Cross-sectional Studies	79
6.1	Types of cross-sectional studies	80
6.2	Conduct	80
6.3	Data analysis	81
6.4	Advantages and limitations	84
6.5	Potential biases in cross-sectional studies	85
Chapter 7	Case-control Studies	89
7.1	Design	89

7.2	Types of case-control studies	90
7.3	Definition of cases and controls	91
7.4	Selection of cases and controls	92
7.5	Number of control groups and number of controls per case	94
7.6	Ascertainment of exposure	95
7.7	Matched case-control design	95
7.8	Data analysis of case-control studies	97
7.8.1	Data analysis of an unmatched case-control design	97
7.8.2	Interpretation of odds ratio	99
7.8.3	Data analysis of a matched case-control design	101
7.9	Relationship between OR and RR	104
7.10	Potential sources of bias	105
Chapter 8	Cohort Studies	109
8.1	Design	109
8.1.1	Types of cohort studies	110
8.2	Selection of study subjects	111
8.3	Information on exposure and outcome	113
8.4	Follow-up of study subjects	114
8.5	Data analysis	115
8.5.1	Interpretation of relative risk	116
8.6	Calculation of risk when the measurement of observation is person-time	118
8.7	Attributable risk	120
8.7.1	Attributable risk or risk difference	120
8.7.2	Proportional or percent attributable risk	121
8.7.3	Population attributable risk	121
8.8	Potential biases in cohort studies	123
Chapter 9	Clinical Trials	125
9.1	Clinical trials	125
9.2	Clinical trial phases	126
9.3	Study protocol	127
9.4	Trial designs	127
9.4.1	Parallel group design	129
9.4.2	Crossover design	129

9.4.3	Factorial design	130
9.5	Blinding	130
9.6	Selection of subjects	131
9.7	Control group	131
9.7.1	Historical controls	132
9.7.2	Concurrent nonrandomized controls	132
9.7.3	Concurrent randomized controls	133
9.8	Treatment allocation: randomization	133
9.9	Treatment schedule and compliance	135
9.10	Protocol deviation	137
9.11	Patient evaluation	137
9.12	Sample size	138
9.13	Plan for statistical analyses	138
Chapter 10	Survival Analysis	141
10.1	Survival time	142
10.2	Comparison of survival experiences	143
10.2.1	Median survival time	144
10.2.2	Survival probability for two groups	146
10.2.3	Log rank test	147
10.2.4	Survival curve	148
Chapter 11	Evaluation of a Diagnostic Test and Screening in Health	151
11.1	Evaluation of diagnostic and screening tests	151
11.2	Precision	152
11.3	Validity	153
11.3.1	Sensitivity and specificity	153
11.4	Predictive values	154
11.5	Efficiency	155
11.6	Likelihood ratios	156
11.7	Trade-offs between sensitivity and specificity	158
11.8	ROC curve	159
11.9	Relationship between prevalence and predictive values	160
11.10	Screening in health	162
11.11	Concept of screening	162
11.12	Benefits and risks of screening	162

11.13	Objectives of screening	163
11.14	Strategies for screening	163
11.15	Selecting a test for screening	164
11.16	Use of multiple tests in screening	165
11.17	Diseases suitable for screening	166
11.18	Criteria for screening programs	168
11.19	Potential sources of bias in the evaluation of a screening program	169
Chapter 12	Investigation of an Epidemic	173
12.1	Epidemic investigation	173
12.2	Understanding the epidemic landscape	174
12.3	Steps of epidemic investigation	175
12.4	Historical evidence of epidemic investigation	179
Chapter 13	Public Health Surveillance	183
13.1	Uses of public health surveillance	184
13.2	Components of surveillance	184
13.3	Different types of surveillance	185
13.4	Steps of public health surveillance	187
13.5	Ways to improve surveillance	188
Chapter 14	Bias, Confounding, and Interaction in Epidemiological Studies	191
14.1	Selection bias	192
14.2	Information bias	195
14.3	Confounding	196
14.3.1	What is confounding?	197
14.3.2	Types of confounding effects	198
14.3.3	Control of confounding factors	199
14.3.4	Residual confounding	201
14.4	Effect modification and interaction	201
14.4.1	Effect modification	202
14.4.2	Interaction	204
14.4.3	Additive interaction model	204
14.4.4	Multiplicative interaction model	206

14.5	How to identify if confounding or effect modification is present	207
Chapter 15	Causality in Epidemiology	211
15.1	Chance or random error	212
15.2	Bias and confounding	213
15.3	Hill's criteria of causality	213
Chapter 16	Sample Size Estimation for Epidemiological Studies	217
16.1	Sample size for cross-sectional studies	217
16.2	Sample size for hypothesis testing	222
16.3	Sample size for case-control studies	230
16.4	Sample size for cohort studies	234
16.5	Sample size for clinical trials	235
Chapter 17	Ethical Considerations in Epidemiological Research with Human Subjects	241
17.1	Ethical considerations in epidemiological studies	241
17.2	Ethics and law	242
17.3	Historical background of human subject research	242
17.4	Rules and regulations of human subject research	244
17.5	Research on human subjects	245
17.6	Research ethical committee	249
17.7	Common research misconducts	251