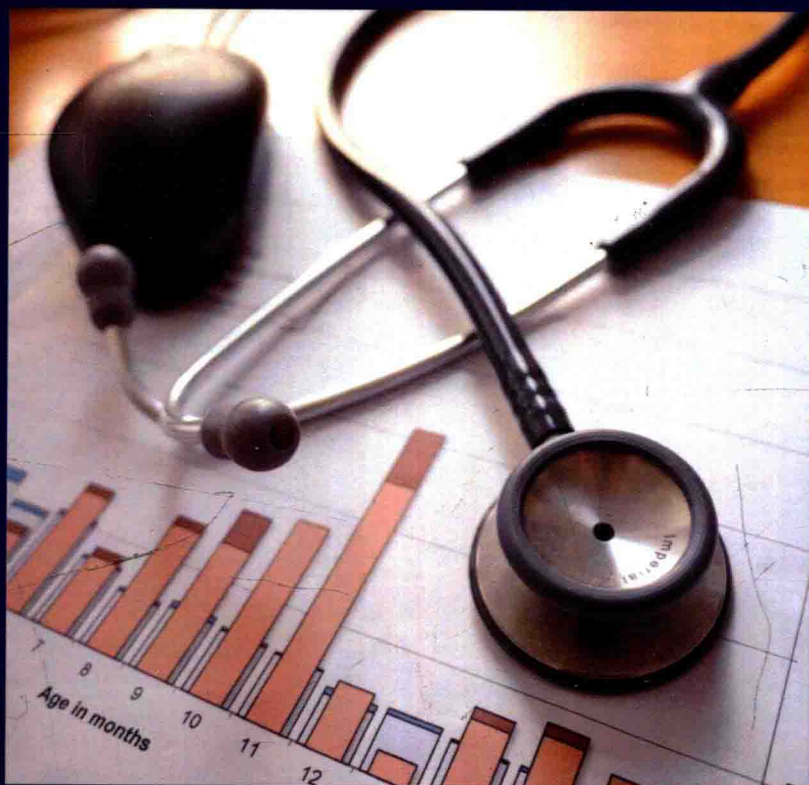


Chapman & Hall/CRC Biostatistics Series

Statistical Methods for Healthcare Performance Monitoring



Alex Bottle
Paul Aylin



CRC Press
Taylor & Francis Group

A CHAPMAN & HALL BOOK

Chapman & Hall/CRC Biostatistics Series

Statistical Methods for Healthcare Performance Monitoring

Alex Bottle

Imperial College London, United Kingdom

Paul Aylin

Imperial College London, United Kingdom



CRC Press

Taylor & Francis Group

Boca Raton London New York

CRC Press is an imprint of the
Taylor & Francis Group, an **Informa** business

A CHAPMAN & HALL BOOK

CRC Press
Taylor & Francis Group
6000 Broken Sound Parkway NW, Suite 300
Boca Raton, FL 33487-2742

© 2017 by Taylor & Francis Group, LLC
CRC Press is an imprint of Taylor & Francis Group, an Informa business

No claim to original U.S. Government works

Printed on acid-free paper
Version Date: 20160510

International Standard Book Number-13: 978-1-4822-4609-4 (Hardback)

This book contains information obtained from authentic and highly regarded sources. Reasonable efforts have been made to publish reliable data and information, but the author and publisher cannot assume responsibility for the validity of all materials or the consequences of their use. The authors and publishers have attempted to trace the copyright holders of all material reproduced in this publication and apologize to copyright holders if permission to publish in this form has not been obtained. If any copyright material has not been acknowledged please write and let us know so we may rectify in any future reprint.

Except as permitted under U.S. Copyright Law, no part of this book may be reprinted, reproduced, transmitted, or utilized in any form by any electronic, mechanical, or other means, now known or hereafter invented, including photocopying, microfilming, and recording, or in any information storage or retrieval system, without written permission from the publishers.

For permission to photocopy or use material electronically from this work, please access www.copyright.com (<http://www.copyright.com/>) or contact the Copyright Clearance Center, Inc. (CCC), 222 Rosewood Drive, Danvers, MA 01923, 978-750-8400. CCC is a not-for-profit organization that provides licenses and registration for a variety of users. For organizations that have been granted a photocopy license by the CCC, a separate system of payment has been arranged.

Trademark Notice: Product or corporate names may be trademarks or registered trademarks, and are used only for identification and explanation without intent to infringe.

Library of Congress Cataloging-in-Publication Data

Names: Bottle, Alex, author. | Aylin, Paul, author.
Title: Statistical methods for healthcare performance monitoring / Alex Bottle and Paul Aylin.
Description: Boca Raton : Taylor & Francis, 2017. | Series: Chapman & Hall/CRC biostatistics series ; 92 | "A CRC title, part of the Taylor & Francis imprint, a member of the Taylor & Francis Group, the academic division of T&F Informa plc." | Includes bibliographical references and index.
Identifiers: LCCN 2016006496 | ISBN 9781482246094 (alk. paper)
Subjects: LCSH: Medical care--Evaluation. | Medical statistics. | Medical care--Quality control. | Medical care--Safety measures.
Classification: LCC RA399.A1 B68 2016 | DDC 362.1072/7--dc23
LC record available at <https://lcn.loc.gov/2016006496>

Visit the Taylor & Francis Web site at
<http://www.taylorandfrancis.com>

and the CRC Press Web site at
<http://www.crcpress.com>

Statistical Methods for Healthcare Performance Monitoring

Chapman & Hall/CRC Biostatistics Series

Editor-in-Chief

Shein-Chung Chow, Ph.D., Professor, Department of Biostatistics and Bioinformatics,
Duke University School of Medicine, Durham, North Carolina

Series Editors

Byron Jones, Biometrical Fellow, Statistical Methodology, Integrated Information Sciences,
Novartis Pharma AG, Basel, Switzerland

Jen-pei Liu, Professor, Division of Biometry, Department of Agronomy,
National Taiwan University, Taipei, Taiwan

Karl E. Peace, Georgia Cancer Coalition, Distinguished Cancer Scholar, Senior Research Scientist
and Professor of Biostatistics, Jiann-Ping Hsu College of Public Health,
Georgia Southern University, Statesboro, Georgia

Bruce W. Turnbull, Professor, School of Operations Research and Industrial Engineering,
Cornell University, Ithaca, New York

Published Titles

Adaptive Design Methods in Clinical Trials, Second Edition

Shein-Chung Chow and Mark Chang

Adaptive Designs for Sequential Treatment Allocation

Alessandro Baldi Antognini
and Alessandra Giovagnoli

Adaptive Design Theory and Implementation Using SAS and R, Second Edition

Mark Chang

Advanced Bayesian Methods for Medical Test Accuracy

Lyle D. Broemeling

Applied Biclustering Methods for Big and High-Dimensional Data Using R

Adetayo Kasim, Ziv Shkedy,
Sebastian Kaiser, Sepp Hochreiter,
and Willem Talloen

Applied Meta-Analysis with R

Ding-Geng (Din) Chen and Karl E. Peace

Basic Statistics and Pharmaceutical Statistical Applications, Second Edition

James E. De Muth

Bayesian Adaptive Methods for Clinical Trials

Scott M. Berry, Bradley P. Carlin,
J. Jack Lee, and Peter Muller

Bayesian Analysis Made Simple: An Excel GUI for WinBUGS

Phil Woodward

Bayesian Designs for Phase I-II Clinical Trials

Ying Yuan, Hoang Q. Nguyen,
and Peter F. Thall

Bayesian Methods for Measures of Agreement

Lyle D. Broemeling

Bayesian Methods for Repeated Measures

Lyle D. Broemeling

Bayesian Methods in Epidemiology

Lyle D. Broemeling

Bayesian Methods in Health Economics

Gianluca Baio

Bayesian Missing Data Problems: EM, Data Augmentation and Noniterative Computation

Ming T. Tan, Guo-Liang Tian,
and Kai Wang Ng

Bayesian Modeling in Bioinformatics

Dipak K. Dey, Samiran Ghosh,
and Bani K. Mallick

Benefit-Risk Assessment in Pharmaceutical Research and Development

Andreas Sashegyi, James Felli,
and Rebecca Noel

Benefit-Risk Assessment Methods in Medical Product Development: Bridging Qualitative and Quantitative Assessments

Qi Jiang and Weili He

Biosimilars: Design and Analysis of Follow-on Biologics

Shein-Chung Chow

Biostatistics: A Computing Approach

Stewart J. Anderson

Cancer Clinical Trials: Current and Controversial Issues in Design and Analysis

Stephen L. George, Xiaofei Wang, and Herbert Pang

Causal Analysis in Biomedicine and Epidemiology: Based on Minimal Sufficient Causation

Mikel Aickin

Clinical and Statistical Considerations in Personalized Medicine

Claudio Carini, Sandeep Menon, and Mark Chang

Clinical Trial Data Analysis using R

Ding-Geng (Din) Chen and Karl E. Peace

Clinical Trial Methodology

Karl E. Peace and Ding-Geng (Din) Chen

Computational Methods in Biomedical Research

Ravindra Khattree and Dayanand N. Naik

Computational Pharmacokinetics

Anders Källén

Confidence Intervals for Proportions and Related Measures of Effect Size

Robert G. Newcombe

Controversial Statistical Issues in Clinical Trials

Shein-Chung Chow

Data Analysis with Competing Risks and Intermediate States

Ronald B. Geskus

Data and Safety Monitoring Committees in Clinical Trials

Jay Herson

Design and Analysis of Animal Studies in Pharmaceutical Development

Shein-Chung Chow and Jen-pei Liu

Design and Analysis of Bioavailability and Bioequivalence Studies, Third Edition

Shein-Chung Chow and Jen-pei Liu

Design and Analysis of Bridging Studies

Jen-pei Liu, Shein-Chung Chow, and Chin-Fu Hsiao

Design & Analysis of Clinical Trials for Economic Evaluation & Reimbursement: An Applied Approach Using SAS & STATA

Iftekhar Khan

Design and Analysis of Clinical Trials for Predictive Medicine

Shigeyuki Matsui, Marc Buyse, and Richard Simon

Design and Analysis of Clinical Trials with Time-to-Event Endpoints

Karl E. Peace

Design and Analysis of Non-Inferiority Trials

Mark D. Rothmann, Brian L. Wiens, and Ivan S. F. Chan

Difference Equations with Public Health Applications

Lemuel A. Moyé and Asha Seth Kapadia

DNA Methylation Microarrays: Experimental Design and Statistical Analysis

Sun-Chong Wang and Arturas Petronis

DNA Microarrays and Related Genomics Techniques: Design, Analysis, and Interpretation of Experiments

David B. Allison, Grier P. Page, T. Mark Beasley, and Jode W. Edwards

Dose Finding by the Continual Reassessment Method

Ying Kuen Cheung

Dynamical Biostatistical Models

Daniel Commenges and Hélène Jacqmin-Gadda

Elementary Bayesian Biostatistics

Lemuel A. Moyé

Empirical Likelihood Method in Survival Analysis

Mai Zhou

Exposure-Response Modeling: Methods and Practical Implementation

Jixian Wang

Published Titles

Frailty Models in Survival Analysis

Andreas Wienke

Fundamental Concepts for New Clinical Trialists

Scott Evans and Naitee Ting

Generalized Linear Models: A Bayesian Perspective

Dipak K. Dey, Sujit K. Ghosh, and
Bani K. Mallick

Handbook of Regression and Modeling: Applications for the Clinical and Pharmaceutical Industries

Daryl S. Paulson

Inference Principles for Biostatisticians

Ian C. Marschner

Interval-Censored Time-to-Event Data: Methods and Applications

Ding-Geng (Din) Chen, Jianguo Sun,
and Karl E. Peace

Introductory Adaptive Trial Designs: A Practical Guide with R

Mark Chang

Joint Models for Longitudinal and Time-to-Event Data: With Applications in R

Dimitris Rizopoulos

Measures of Interobserver Agreement and Reliability, Second Edition

Mohamed M. Shoukri

Medical Biostatistics, Third Edition

A. Indrayan

Meta-Analysis in Medicine and Health Policy

Dalene Stangl and Donald A. Berry

Mixed Effects Models for the Population Approach: Models, Tasks, Methods and Tools

Marc Lavielle

Modeling to Inform Infectious Disease Control

Niels G. Becker

Modern Adaptive Randomized Clinical Trials: Statistical and Practical Aspects

Oleksandr Sverdlov

Monte Carlo Simulation for the Pharmaceutical Industry: Concepts, Algorithms, and Case Studies

Mark Chang

Multiregional Clinical Trials for Simultaneous Global New Drug Development

Joshua Chen and Hui Quan

Multiple Testing Problems in Pharmaceutical Statistics

Alex Dmitrienko, Ajit C. Tamhane,
and Frank Bretz

Noninferiority Testing in Clinical Trials: Issues and Challenges

Tie-Hua Ng

Optimal Design for Nonlinear Response Models

Valerii V. Fedorov and Sergei L. Leonov

Patient-Reported Outcomes: Measurement, Implementation and Interpretation

Joseph C. Cappelleri, Kelly H. Zou,
Andrew G. Bushmakina, Jose Ma. J. Alvir,
Demissie Alemayehu, and Tara Symonds

Quantitative Evaluation of Safety in Drug Development: Design, Analysis and Reporting

Qi Jiang and H. Amy Xia

Quantitative Methods for Traditional Chinese Medicine Development

Shein-Chung Chow

Randomized Clinical Trials of Nonpharmacological Treatments

Isabelle Boutron, Philippe Ravaud,
and David Moher

Randomized Phase II Cancer Clinical Trials

Sin-Ho Jung

Sample Size Calculations for Clustered and Longitudinal Outcomes in Clinical Research

Chul Ahn, Moonseong Heo,
and Song Zhang

Published Titles

Sample Size Calculations in Clinical Research, Second Edition

Shein-Chung Chow, Jun Shao,
and Hansheng Wang

Statistical Analysis of Human Growth and Development

Yin Bun Cheung

Statistical Design and Analysis of Clinical Trials: Principles and Methods

Weichung Joe Shih and Joseph Aisner

Statistical Design and Analysis of Stability Studies

Shein-Chung Chow

Statistical Evaluation of Diagnostic Performance: Topics in ROC Analysis

Kelly H. Zou, Aiyi Liu, Andriy Bandos,
Lucila Ohno-Machado, and Howard Rockette

Statistical Methods for Clinical Trials

Mark X. Norleans

Statistical Methods for Drug Safety

Robert D. Gibbons and Anup K. Amatya

Statistical Methods for Healthcare Performance Monitoring

Alex Bottle and Paul Aylin

Statistical Methods for Immunogenicity Assessment

Harry Yang, Jianchun Zhang, Binbing Yu,
and Wei Zhao

Statistical Methods in Drug Combination Studies

Wei Zhao and Harry Yang

Statistical Testing Strategies in the Health Sciences

Albert Vexler, Alan D. Hutson,
and Xiwei Chen

Statistics in Drug Research: Methodologies and Recent Developments

Shein-Chung Chow and Jun Shao

Statistics in the Pharmaceutical Industry, Third Edition

Ralph Buncher and Jia-Yeong Tsay

Survival Analysis in Medicine and Genetics

Jialiang Li and Shuangge Ma

Theory of Drug Development

Eric B. Holmgren

Translational Medicine: Strategies and Statistical Methods

Dennis Cosmatos and Shein-Chung Chow

List of Illustrations

Figure 6.1	Comparison of percentage of AVSD operations by age at operation (in months) between Bristol (UBHT) and elsewhere in England 1991/1992–1994/1995.	97
Figure 9.1	An example of a run chart showing a run of eight data points below the median.	158
Figure 9.2	An example of a Shewhart chart of the data from the run chart of Figure 9.1, with upper and lower control limits with 3 SD on either side of the mean.	159
Figure 9.3	An example of a funnel plot: inner lines represent 95% and outer lines 99.8% control limits.	160
Figure 11.1	Traffic light display of fictitious data on multiple indicators by unit.	190
Figure 11.2	Spider plot of an imaginary unit's fictitious data.	192
Figure 11.3	Benchmarked performance for NHS West Essex CCG's commissioned elective knee surgery.	200
Figure 11.4	Example scatter plot from Public Health England's commissioning tool "Fingertips" showing CCG-level deprivation and adult inactivity.	201
Figure 11.5	Screenshot from NHS Choices.	203
Figure 11.6	Illustrative Hospital Compare results for three Seattle hospitals for readmissions and deaths in patients with COPD.	205
Figure 11.7	COPD readmission rates for three Seattle hospitals displayed as bar charts by Hospital Compare.	205
Figure 12.1	Time segments pre- and post-intervention in an interrupted time series design.	211

--- *List of Tables* ---

Table 3.1	Main Methodological Issues When Considering the Unit of Analysis	29
Table 4.1	Structure, Process and Outcome Indicators Compared	40
Table 4.2	Ways of Combining Quality and Cost Measures in a 2014 National Quality Forum White Paper	56
Table 4.3	Attributes of Ideal Quality Indicators	60
Table 5.1	Comparison of Key Features of Clinical and Administrative Databases	83
Table 6.1	Issues Associated with Common Patient Factors in Risk Models	107
Table 7.1	Summary of the Main Types of <i>Standardised Mortality Ratio</i> Derived from Logistic Regression or Standardisation with the National Average as the Benchmark Unless Specified Otherwise	133
Table 8.1	Main Steps in Composite Indicator Construction	137
Table 8.2	Common Options for Weighting and Combining Component Indicators in a Composite	141
Table 8.3	Main Pros and Cons of Healthcare Composite Measures	148
Table 9.1	Common Ways to Compare Units	155
Table 9.2	Common Definitions of Outlying Performance	162
Table 10.1	Main Challenges for Maintaining an International Database for Benchmarking Outcomes	181
Table 11.1	Fictitious Data for Average Appointment Waiting Times by Unit with Categories and Star Rating	190
Table 11.2	Selected Public-Facing Websites for Obtaining Comparative Healthcare Unit Performance	203
Table 13.1	Trade-Offs in Healthcare Performance Monitoring	226

Preface

Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it.

H. James Harrington

Healthcare is important to everyone. A high standard of healthcare is even more important, yet large variations in quality have been well documented both between and within many countries. As populations grow older and medical care becomes more complex, expenditures continue to rise. It is therefore more crucial than ever to know how well the healthcare system and all its components are performing. This requires data, which inevitably differ in form and quality, and it requires statistical methods. Whether those methods are simple or complicated, their output has to be made understandable to whoever needs it, be it the patient choosing a doctor, the healthcare professional improving their own performance, the manager overseeing their unit, or the regulator assessing the whole system. This book covers measuring quality, types of data, risk adjustment, defining good and bad performance, statistical monitoring, presenting the results to different audiences, and evaluating the monitoring system itself. It thereby brings all the issues and perspectives together in a largely non-technical format for clinicians, managers and methodologists.

Both authors moved from environmental epidemiology to health services research in 2002, following our involvement with the public inquiries into two big UK scandals: (1) paediatric cardiac surgery at the Bristol Royal Infirmary and (2) general practice by Harold Shipman, the country's most prolific serial killer and family doctor. Applying what we had learned from our work to those public inquiries, Alex Bottle devised the details of our national hospital monitoring system that helped uncover a third scandal: the high death rate at Mid Staffordshire NHS Hospital Trust. Our unit's research focuses on developing indicators of quality and safety and care and understanding performance variations in primary care and between surgeons and hospitals in a range of specialties. We are also involved in quality improvement projects and work with psychologists to understand how clinical staff and managers use (or ignore) performance information. Alex conceived this book as a way to bring together all the elements of performance monitoring, with examples from around the world. We were also

keen for the algebra content to be as close to zero as possible, which it never is in statistics guides, not because writing formulae is fiddly, but because many statistical issues need to be understood by everyone interested in performance.

Alex Bottle

Paul Aylin

*Imperial College London
United Kingdom*

Authors

Alex Bottle is a senior lecturer in medical statistics in the School of Public Health at Imperial College London and methodological lead at the Dr. Foster Unit there. His background is in statistics and epidemiology, and he researches the use of large databases to measure and monitor the quality and safety of healthcare, with particular interests in risk adjustment, statistical process control and modelling multiple health service contacts in patients with chronic diseases. His fruitful collaborations with a wide range of clinicians, from anaesthetists to urologists, as well as with quality improvement scientists and the media, led him to conceive and write this book to bring all these worlds together.

Paul Aylin is a professor of epidemiology and public health at the School of Public Health at Imperial College London and leads the Dr. Foster Unit. After his medical training, he specialised in public health medicine and then spent three years at the Office for National Statistics in London before joining Imperial College in 1997. He became a Fellow of the Faculty of Public Health Medicine in 2001. He is a non-executive director at West London Mental Health NHS Trust. His research explores variations in indicators of quality and safety using routinely collected administrative data, including out-of-hours hospital mortality, the August (or July) effect, cancer care and indicators for late diagnosis. He has been an expert witness for both the Bristol Royal Infirmary and the Shipman public inquiries in the United Kingdom.

Contents

List of Illustrations	xv
List of Tables	xvii
Preface.....	xix
Authors	xxi
1. Introduction	1
1.1 The Need for Performance Monitoring	1
1.2 Measuring and Monitoring Quality.....	2
1.3 The Need for This Book	2
1.4 Who Is This Book For and How Should It Be Used?	3
Common Abbreviations Used in the Book.....	4
Acknowledgment.....	6
2. Origins and Examples of Monitoring Systems	7
Aims of This Chapter	7
2.1 Origins	7
2.2 Healthcare Scandals	8
2.2.1 Responses to the Scandals	12
2.3 Examples of Monitoring Schemes	14
2.4 Goals of Monitoring.....	15
2.4.1 Accountability	15
2.4.2 Regulation and Accreditation	16
2.4.3 Patient Choice	19
2.4.4 Openness and Transparency.....	21
2.4.5 Quality Improvement.....	21
2.4.6 Prevent Harm and Unsafe Care.....	22
2.4.7 Professionalism	23
2.4.8 Informed Consent.....	23
3. Choosing the Unit of Analysis and Reporting.....	25
Aims of This Chapter	25
3.1 Issues Principally Concerning the Analysis	26
3.1.1 Clustering (*).....	26
3.1.2 Episode Treatment Groups.....	32
3.2 Issues More Relevant to Reporting: Attributing Performance to a Given Unit in a System.....	34

4. What to Measure: Choosing and Defining Indicators	37
Aims of This Chapter	37
4.1 How Can We Define Quality?	38
4.2 Common Indicator Taxonomies	38
4.3 Particular Challenges of Measuring Patient Safety	42
4.4 Particular Challenges of Multimorbidity	45
4.5 Measuring the Health of the Population and Quality of the Whole Healthcare System	47
4.5.1 The WHO Annual World Health Statistics Report	50
4.6 Efficiency and Value	53
4.6.1 Data Envelopment Analysis and Stochastic Frontier Analysis (*)	57
4.7 Features of an Ideal Indicator	59
4.8 Steps in Construction and Common Issues in Definition	59
4.9 Validation of Indicators	62
4.10 Some Strategies for Choosing among Candidates	63
4.11 Time to Go: When to Withdraw Indicators	64
4.12 Conclusion	65
5. Sources of Data	67
Aims of This Chapter	67
5.1 How to Assess Data Quality	67
5.2 Administrative Data	69
5.2.1 Coding Systems for Administrative Data	71
5.2.2 Use of Administrative Databases to Flag Patient Safety Events	74
5.3 Clinical Registry Data	75
5.4 Accuracy of Administrative and Clinical Databases Compared	77
5.5 Incident Reports and Other Ways to Capture Safety Events	84
5.6 Surveys	87
5.7 Other Sources	89
5.8 Other Issues Concerning Data Sources	90
5.9 Conclusion	91
6. Risk-Adjustment Principles and Methods	93
Aims of This Chapter	93
6.1 Risk Adjustment and Risk Prediction	94
6.2 When and Why Should We Adjust for Risk?	95
6.3 Alternatives to Risk Adjustment	96
6.4 What Factors Should We Adjust For?	96
6.4.1 Factors Not under the Control of the Provider	96
6.4.2 Proxies Such as Age and Socioeconomic Status	98
6.4.3 Comorbidity	98
6.4.4 Disease Severity	100

6.5	Selecting an Initial Set of Candidate Variables.....	101
6.6	Dealing with Missing and Extreme Values.....	102
6.7	Timing of the Risk Factor Measurement	104
6.8	Building the Model	108
6.8.1	Choosing the Final Set of Variables from the Initial Set of Candidates.....	108
6.8.2	Decide How Each Variable Should Be Entered into the Model	111
6.8.3	Decide on the Statistical Method for Modelling (*)	111
6.8.4	Assess the Fit of the Model (*).....	114
6.8.4.1	Adjusted R^2	115
6.8.4.2	Area under the Receiver Operating Characteristic Curve: c Statistic.....	115
6.8.4.3	The Hosmer–Lemeshow Statistic for Calibration.....	116
6.8.5	Which Is More Important, Discrimination or Calibration?.....	117
6.8.6	What Can Be Done If the Model Fit or Performance Is Unacceptable?.....	117
6.8.7	Convert Regression Coefficients into a Risk Score If Desired.....	118
7.	Output the Observed and Model-Predicted Outcomes (*).....	121
	Aims of This Chapter	121
7.1	Ratios versus Differences.....	122
7.2	Deriving SMRs from Standardisation and Logistic Regression.....	123
7.3	Other Fixed Effects Approaches to Generate an SMR.....	126
7.4	Random Effects–Based SMRs (*).....	126
7.5	Marginal versus Multilevel Models (*)	129
7.6	Which Is the “Best” Modelling Approach Overall? (*).....	130
7.7	Further Reading on Producing Risk-Adjusted Outcomes by Unit	134
8.	Composite Measures.....	135
	Aims of This Chapter	135
8.1	Some Examples.....	136
8.2	Steps in the Construction.....	137
8.2.1	Specify the Scope and Purpose	138
8.2.2	Choose the Unit.....	138
8.2.3	Select the Data and Deal with Missing Values.....	138
8.2.4	Choose the Indicators and Run Descriptive Analyses.....	138
8.2.5	Normalise the Metrics.....	140
8.2.6	Assign Weights and Aggregate the Component Indicators.....	140
8.2.7	Run Sensitivity Analyses.....	144
8.2.8	Present the Results.....	145

8.3	Some Real Examples	146
8.3.1	AHRQ's Patient Safety Indicator Composite	146
8.3.2	Leapfrog Group Patient Safety Composite	147
8.4	Pros and Cons of Composites.....	148
8.5	Alternatives to the Use of Composites.....	149
9.	Setting Performance Thresholds and Defining Outliers.....	151
	Aims of This Chapter	151
9.1	Defining Acceptable Performance.....	152
9.1.1	Targets	152
9.1.2	Historical Benchmarks.....	153
9.1.3	Referring to Inter-Unit Variation	153
9.2	Bayesian Methods for Comparing Providers.....	155
9.3	Statistical Process Control and Funnel Plots.....	157
9.4	Multiple Testing (*).....	163
9.4.1	Multivariate Statistical Process Control Methods (*).....	165
9.4.2	Further Reading on SPC	166
9.5	Ways of Assessing Variation between Units.....	166
9.6	How Much Variation Is "Acceptable"?.....	167
9.7	Impact on Outlier Status of Using Fixed versus Random Effects to Derive SMRs	171
9.8	How Reliably Can We Detect Poor Performance?.....	172
9.9	Some Resources for Quality Improvement Methods	174
10.	Making Comparisons across National Borders	177
	Aims of This Chapter	177
10.1	Examples of Multinational Patient-Level Databases.....	178
10.2	Challenges.....	180
10.2.1	Worked Example of Combining Administrative Databases from Multiple Countries: Stroke Mortality.....	181
10.2.2	Clustering within Countries	184
10.2.3	Countries with Unusual Data or Apparent Performance	184
10.3	Interpreting Apparent Differences in Performance between Countries	185
10.4	Conclusion.....	186
11.	Presenting the Results to Stakeholders	189
	Aims of This Chapter	189
11.1	The Main Ways of Presenting Comparative Performance Data....	189
11.2	Effect on Behaviour of the Choice of Format When Providing Performance Data.....	192
11.3	The Importance of the Method of Presentation.....	195
11.3.1	Presenting Performance Data to Managers and Clinicians.....	195
11.3.2	Presenting Results to the Public	197