MEDICAL STATISTICS from A to Z

MEDICAL STATISTICS from A to Z

A Guide for Clinicians and Medical Students

Third Edition

Brian S. Everitt King's College London



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To the memory of my dear friend and colleague for almost forty years, Professor Graham Dunn

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Preface to the Third Edition

In the third edition of *Medical Statistics from A to Z*, I have added nearly 150 new definitions, many describing topics that have appeared in the medical statistical literature in the last five years or so. I have also updated many references and improved (I hope) some of the definitions in the first and second editions.

Preface to the Second Edition

In the second edition of *Medical Statistics from A to Z*, I have added many new definitions and taken the opportunity to correct and clarify a number of entries. More references are also provided that point readers to more detailed accounts of topics.

Preface to the First Edition

Clinicians, research workers in the health sciences, and even medical students often encounter terms from medical statistics and related areas in their work, particularly when reading medical journals and other relevant literature. The aim of this guide is to provide such people with nontechnical definitions of many such terms. Consequently, no mathematical nomenclature or formulae are used in the definitions. Those readers interested in such material will be able to find it in one of the many standard statistical texts now available and in *The Cambridge Dictionary of Statistics*. In addition, readers seeking more information about a particular topic will hopefully find the references given with the majority of entries of some help; whenever possible, these involve medical rather than statistical journals, and introductory statistical texts rather than those that are more advanced. (References are not given for terms such as mean, variance and critical region for which further details are easily available in most introductory medical statistics texts.)

Several forms of cross-referencing are used. Terms in Courier New appear as a separate headword elsewhere in the dictionary, although this procedure is used in a relatively limited way with headwords defining frequently occurring terms such as random variable, probability and sample not referred to in this way. Some entries simply refer readers to another entry. This may indicate that the terms are

synonymous or that the term is discussed more conveniently under another entry. In the latter case, the term is printed in *italics* in the main entry. Entries are in alphabetical order using the letter-by-letter rather than the word-by-word convention.

Of the many sources of material I have consulted in the preparation of this book, I would like to mention two that have been of particular help, namely the *Encyclopedia of Biostatistics* and the *Dictionary of Epidemiology*.

REFERENCES

Armitage, P. and Colton, T., 1989, *Encyclopedia of Biostatistics*, John Wiley & Sons, Chichester. Everitt, B. S. and Skrondal, A., 2010, *The Cambridge Dictionary of Statistics*, 4th ed., Cambridge University Press, Cambridge.

Last, J. M., 2001, Dictionary of Epidemiology, 4th ed., Oxford University Press, New York.