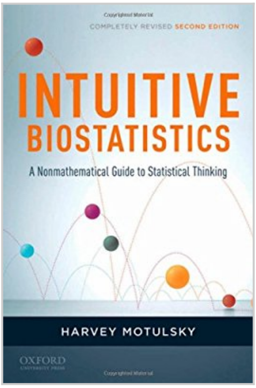

Intuitive Biostatistics: a Nonmathematical Guide to Statistical Thinking, 2nd Revised Edition

By Harvey Motulsky

Intuitive Biostatistics: a Nonmathematical Guide to Statistical Thinking, 2nd Revised Edition By Harvey Motulsky

THIS IS FOR THE 2nd EDITION. THE 3rd EDITION IS NOW AVAILABLE.
Overview
Intuitive Biostatistics is both an introduction and review of statistics. Compared to other books, it has:

- Breadth rather than depth. It is a guidebook, not a cookbook.
- Words rather than math. It has few equations.
- Explanations rather than recipes. This book presents few details of statistical methods and only a few tables required to complete the calculations.

Who is it for?
I wrote Intuitive Biostatistics for three audiences:

- Medical (and other) professionals who want to understand the statistical portions of journals they read. These readers don't need to analyze any data, but need to understand analyses published by others.
- Undergraduate and graduate students, post-docs and researchers who will analyze data. This book explains general principles of data analysis, but it won't teach you how to do statistical calculations or how to use any particular statistical program.
- Scientists who consult with statisticians. Statistics often seems like a foreign language, and this text can serve as a phrase book to bridge the gap between scientists and statisticians.

What's new in the second edition?
Though the spirit of the first edition remains, very few of its words do. It is hard to explain what is new in this edition, since I essentially rewrote the entire book. New and expanded topics in the second edition of Intuitive Biostatistics include:

- Chapter 1 explains how our intuitions can lead us astray in issues of probability and statistics.

- Chapter 11 (and later examples) highlight the fact that lognormal distributions are common.
- Chapter 21 explains the idea of testing for equivalence vs. testing for differences.
- Chapters 22, 23, and 40 discuss the pervasive problem of multiple comparisons.
- Chapters 24 and 25 discuss testing for normality and for outliers.
- Chapter 35 shows how to think about statistical hypothesis testing as comparing the fits of alternative models.
- Chapters 37 and 38 give expanded coverage of the usefulness--and traps--of multiple, logistic, and proportional hazards regression.
- Chapter 43 briefly mentions adaptive study designs where sample size is not chosen in advance.
- Chapter 46 (inspired by, and written with, Bill Greco) reviews many topics in this book and more general issues of how to approach data analysis.

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Editorial Review

Review
I am entranced by the book. Statistics is often difficult for many scientists to fully appreciate. Your writing style and explanation makes the concepts accessible. ----Tim Bushnell, Director of Flow Cytometry, Univ. Rochester Med. Center *(added by author)*

"The second edition of *Intuitive Biostatistics* is a substantial improvement. I am particularly impressed by the chapters on multiple comparisons. This is increasingly important for such molecular trickery as gene expression chips, which produce a very large number of possible comparisons. Individual comparisons and even a Bonferroni correction are often inadequate. Motulsky deals with a newer method, false discovery rate (FDR), in a clear, understandable way. I'll be recommending the new edition with even greater enthusiasm."--James F. Crow, *University of Wisconsin*

"This splendid book meets a major need in public health, medicine, and biomedical research training--a user-friendly biostatistics text for non-mathematicians that clearly explains how to make sense of statistical results and how to avoid being confused by statistical nonsense. You may enjoy statistics for the first time!"--Gilbert S. Omenn, Professor of Medicine, Genetics, Public Health, and Computational Medicine & Bioinformatics, *University of Michigan*

From the Author
View the web page for this book, including errata, at intuitivebiostatistics.com

CONTENTS FOR 2nd EDITION (3rd NOW AVAILABLE)

From the Inside Flap

Excerpt from "Statistics means being uncertain" (chapter 3, page 19)

The whole idea of statistics is to make general conclusions from limited amounts of data. All that statistical calculations can do is quantify probabilities, so every conclusion must include words like "probably," "most likely," or "almost certainly." Be wary if you ever encounter statistical conclusions that seem 100% definitive. The analysis, or your understanding of it, is probably wrong. Be especially wary of the conclusion that a result is statistically significant, because that phrase is often misunderstood.

Excerpt from "Q and A about confidence intervals" (chapter 4, pages 35-36)
Q. What's the difference between a 95% CI and a 99% CI?
A. To be more certain that an interval contains the true population value, you must generate a wider interval. A 99% CI is wider than a 95%CI. See Figure 4.2.

Q. Is it possible to generate a 100% CI?
A. A 100% CI would have to include every possible value, so it would extend from 0.0 to 100.0%. That is always the same, regardless of the data, so it isn't at all useful.

Q. How do CIs change if you increase the sample size?
A. The width of the CI is approximately proportional to the reciprocal of the square root of the sample size. So, if you increase the sample size by a factor of 4, you can expect to cut the length of the CI in half. Figure 4.3 illustrates how the CI gets narrower if the sample size gets larger.

Q. Why isn't the CI symmetrical around the observed proportion?
A. Because a proportion cannot go below 0.0 or above 1.0, the CI will be lopsided when the sample proportion is far from 0.50 or the sample size is small. See Figure 4.4.

Excerpt from "A misconception about P values" (chapter 18, page 136)
Many scientists and students misunderstand the definition of statistical significance (and P values).
Table 18.1 shows the results of many hypothetical statistical analyses, each analyzed to reach a decision to reject or not reject the null hypothesis. The top row tabulates results for experiments where the null hypothesis is really true.

The second row tabulates experiments where the null hypothesis is not true. This kind of table is only useful to understand statistical theory. When you analyze data, you don't know whether the null hypothesis is true, so you could never create this table from an actual series of experiments.

Table 18.2 reviews the definitions of Type I and Type II errors.
The significance level (usually set to 5%) is defined to equal the ratio A/(A + B). The significance level is the answer to these two equivalent questions:

- If the null hypothesis is true, what is the probability of incorrectly rejecting that null hypothesis?
- Of all experiments you could conduct when the null hypothesis is true, in what fraction will you reach a conclusion that the results are statistically significant?

Many people mistakenly think that the significance level is the ratio A/(A + C). This ratio, called the false discovery rate (FDR), is quite different. The FDR, which we'll return to in Chapter 22, answers these two equivalent questions:

- If a result is statistically significant, what is the probability that the null hypothesis is really true?
- Of all experiments that reach a statistically significant conclusion, in what fraction is the null hypothesis true?

Excerpt from "An analogy to understand power" (chapter 20, pages 147-148)
This analogy helps illustrate the concept of statistical power (Hartung, 2005).

You send your child into the basement to find a tool. He comes back and says, "It isn't there." What do you conclude? Is the tool there or not? There is no way to be sure, so the answer must be a probability. The question you really want to answer is, "What is the probability that the tool is in the basement?" But that question can't really be answered without knowing the prior probability and using Bayesian thinking (see Chapter 18). Instead, let's ask a different question: "If the tool really is in the basement, what is the chance your child would have found it?" The answer, of course, is "it depends." To estimate the probability, you'd want to know three things:

- How long did he spend looking? If he looked for a long time, he is more likely to have found the tool. This is analogous to sample size. An experiment with a large sample size has high power to find an effect.
- How big is the tool? It is easier to find a snow shovel than the tiny screw driver used to fix eyeglasses. This is analogous to the size of the effect you are looking for. An experiment has more power to find a big effect than a small one.
- How messy is the basement? If the basement is a real mess, he was less likely to find the tool than if it is carefully organized. This is analogous to experimental scatter. An experiment has more power when the data are very tight (little variation).

If the child spent a long time looking for a large tool in an organized basement, there is a high chance that he would have found the tool if it were there. So you can be quite confident of his conclusion that the tool isn't there. Similarly, an experiment has high power when you have a large sample size, are looking for a large effect, and have data with little scatter (small standard deviation). In this situation, there is a high chance that you would have obtained a statistically significant effect if the effect existed.

If the child spent a short time looking for a small tool in a messy basement, his conclusion that "the tool isn't there" doesn't really mean very much. Even if the tool were there, he probably would have not found it. Similarly, an experiment has little power when you use a small sample size, are looking for a small effect, and the data have lots of scatter. In this situation, there is a high chance of obtaining a conclusion of "statistically significant even if the effect exists.

Users Review

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Edna Pilon:

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Jean Gadson:

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David Manning:

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