namely, *Physical Activity and Health: A Report of the Surgeon General* (2). Other well-established books provide different perspectives on the same topic (3–10). Some of the latter extend more comprehensively such topics as diet, weight control, and obesity (11–13), which currently hold much interest in the quest to relate exercise and diet to health, disease, and longevity. Perhaps *Physical Activity Epidemiology* does not emphasize sufficiently the influence of interactions among physical activity, diet, and weight control for health during all ages, especially for children. The same could be said about the metabolic syndrome and about genetics and molecular biology. Missing, for example, are data on tai chi, an increasingly popular sport, and its value in promoting proper balance and in preventing falls and fractures. The choice of learned sayings to introduce each chapter is appropriate; however, the photographs definitely are unneeded and inappropriate. Furthermore, one might claim the book to be too repetitive, which can be excused by the book's format.

In its 8½″ × 11¼″ format, and more than 1½″ thick, *Physical Activity Epidemiology* in hardcover form is no pocketbook. Yet, it is well illustrated with tables and figures and with sidebars that contain key messages and featured points. The authors have done a good job. Read the book and keep it handy for reference.

In sum, *Physical Activity Epidemiology* is a wide-ranging, absolutely current, and commonsense guide to health in terms of physical exercise, as viewed from population-based studies. From prelude to postlude, the book is comprehensive and detailed, yet it is pleasurable to read, to contemplate over, and to reread as a reference text. Well done.

References

1. Dishman RK, Heath GW, Washburn R. Physical activity epidemiology. Champaign, IL: Human Kinetics, 2004.
2. US Department of Health and Human Services. Physical activity and health: a report of the Surgeon General. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, 1996.
3. Cooper KH. Aerobics. New York, NY: Evans and Co, 1968.
4. Morris JN. Uses of epidemiology. 3rd ed. Edinburgh, United Kingdom: Churchill Livingstone, 1975.
5. Fixx JF. Jim Fixx's second book of running. New York, NY: Random House, 1980.
6. Eaton SB, Shostak M, Konner M. The Paleolithic prescription: a program of diet and exercise and a design for living. New York, NY: Harper and Row, 1988.
7. Berryman JW. Out of many, one: a history of the American College of Sports Medicine. Champaign, IL: Human Kinetics, 1995.
8. Paffenbarger RS Jr, Olsen E. LifeFit. Champaign, IL: Human Kinetics, 1996.
9. Noakes T. Lore of running. 4th ed. Oxford, United Kingdom: Oxford University Press, 2001.
10. Kolata G. Ultimate fitness: the quest for truth about exercise and health. New York, NY: Farrar, Straus and Giroux, 2003.
11. Bennett WB, Gurin J. The dieter's dilemma: eating less and weighing more. New York, NY: Basic Books, 1982.
12. Willett WC. Eat, drink, and be healthy. New York, NY: Simon and Schuster, 2001.
13. Brownell KD, Horgen TB. Food fight. New York, NY: Contemporary Books, 2004.

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Measurement Error and Misclassification in Statistics and Epidemiology: Impacts and Bayesian Adjustments

By Paul Gustafson

ISBN 1-58488-335-9, Chapman and Hall/CRC Press, Boca Raton, Florida (Telephone: 800-272-7737, Fax: 800-374-3401, Website: http://www.crcpress.com), 2003, 200 pp., $79.95 (hardcover)

Epidemiologic studies that attempt to characterize associations between exposures and disease occurrence often rely on exposure assessments that are subject to *mismeasurement* (a term used in this book for either measurement error in a quantitative variable or misclassification in a categorical variable). The large body of existing literature on this subject deals mostly with the impact of mismeasurement on indicators of estimated exposure-disease associations. The literature is relatively scanty and unwieldy with regard to methods of adjustment for such mismeasurement. In most of the existing literature, measurement error in quantitative variables is considered separately from misclassification in categorical variables, with relatively few attempts having been made to consider these problems from a unified approach.

In this relatively small (approximately 200 pages) but ambitious volume (1), Professor Paul Gustafson takes a unified approach to 1) characterizing the consequences of ignoring mismeasurement on resulting indicators of exposure-disease association and 2) demonstrating the use of Bayesian statistical methods, enhanced by recently developed computational tools such as Markov chain Monte Carlo simulation, to adjust for mismeasurement. His formulation models the relation between a dependent variable, Y, that is not subject to mismeasurement and an explanatory variable, X, that is not directly observable. However, an observable variable X^*, distributed with mean equal to X and variance σ^2, can be used as a surrogate for the unobservable variable X. Thus, instead of a relation between Y and X, the resulting study measures the relation between Y and X^*. Using an example in epidemiology, the variable Y may indicate the presence or absence of disease; X may be an unobservable exposure variable, such as the total body burden of a pollutant; and X^* may represent the measured blood level of some metabolite of the pollutant. This scenario is that of a typical analytical epidemiologic investigation, where the target is the relation between the exposure, X, and the disease, Y, but the study substitutes the surrogate X^* for the immeasurable exposure X.

The book is organized into six chapters and an appendix. This includes an introduction (chapter 1), followed by two chapters on the impact of mismeasurement (chapter 2 for the scenario in which the mismeasured variable X^* is quantitative and subject to measurement error and chapter 3 for the scenario in which X^* is a categorical variable subject to misclassification error). These three chapters take up approximately 25 percent of the book, with the bulk of the remainder being devoted to methods of adjusting for mismeasurement (chapter 4 to developing methods of adjustment for measurement error in quantitative explanatory variables and chapter 5 to methods of adjustment for misclassification in categorical variables). Chapter 6 consists of more specialized topics, such as the situation where the mismeasured variable has been constructed by dichotomizing a quantitative variable. It also discusses additional effects caused by misspecification in the original model relating the disease variable Y to the unobservable exposure variable X. Finally, in the Appendix, the author develops the Bayes-Markov chain Monte Carlo adjustment methodology.

Most analytical epidemiologists are aware that mismeasurement in an exposure variable generally results in attenuation of the estimated regression coefficients or odds ratios characterizing the exposure-disease relation, or, as it is usually stated in the Discussion section of a paper, a "conservative bias toward the null." However, in chapter 2, the author presents the much less well known result that if another variable, Z, having no mismeasurement but correlated with the mismeasured exposure variable X^*, is in the regression equation, the estimated exposure-disease regression coefficients or odds ratios can undergo further attenuation (much further if the correlation is large). Even less well known is the fact that error in the exposure variable can distort the estimated regression coefficients for all variables in the regression equation, even those that are not subject to mismeasurement. If there is more than one mismeasured exposure variable in the regression equation, the estimates of the exposure-disease relation are biased but not necessarily attenuated toward the null hypothesis. In other words, they can be biased in either direction.

The discussion of possible consequences of mismeasurement in chapter 2 for quantitative exposure variables subject to measurement error is repeated in chapter 3 for categorical variables subject to misclassification, and findings are analogous to those for quantitative variables. These two chapters, taken together, present a strong case for the use of estimation techniques that adjust for mismeasurement. This topic is addressed in chapter 4 for quantitative variables and in chapter 5 for categorical variables, with these two chapters comprising approximately 50 percent of the book. To briefly summarize the complex material in these two chapters: The adjustment for mismeasurement is made by assuming a prior distribution for the surrogate variable X^* and setting up estimating equations based on the Bayesian paradigm. The parameters of interest (e.g., exposure-disease relations) are then estimated by use of the recently developed Markov chain Monte Carlo techniques; a "primer" detailing these techniques is included in the Appendix.

In his preface, Professor Gustafson states that he intended this book to be of interest to the "(bio)statistics community, and at least the more quantitative subset of the epidemiology community" (1, p. x). The book is certainly accessible to statisticians/biostatisticians, especially those trained within the last decade, during which the type of modeling developed in this book entered the mainstream of statistical analysis. Despite the author's obvious interest and involvement in epidemiologic issues and his efforts to include examples from analytical epidemiology (e.g., discussion of the relation between smoking and bladder cancer and the discussion of the Framingham Study in chapter 4), the Bayesian concepts and computational adjuncts, especially in chapter 4 and later chapters, would probably be foreign to all but the most quantitatively trained and inclined epidemiologists. This may not be true in the near future as use of these methods becomes more widespread in epidemiologic studies and as user-friendly, off-the-shelf software enters the market. This happened in the mid- to late 1990s for generalized estimating equations and mixed-effects modeling, and we will doubtless see it for the methods described in this book.

In summary, the author has written a careful, well-organized book on an important topic that has widespread consequences for interpretation of findings from epidemiologic studies. While it was not written as a polemic, the book presents a strong case that the effects of mismeasurement can be overwhelming and that methods of adjustment for mismeasurement should be given strong consideration.

Reference

1. Gustafson P. Measurement error and misclassification in statistics and epidemiology: impacts and Bayesian adjustments. Boca Ration, FL: CRC Press, 2003.

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