Adjustment of bias in the comparison of means

SIR,—The objective of many research investigations is to assess the effect of a stimulus on some quantitative response. This often entails comparing the mean value of the response variable between groups of subjects exposed to contrasting stimuli. Thus an occupational health study might be undertaken to compare the mean pulmonary function—for example, FEV₁/FVC ratio between firefighters and police officers. Comparing the crude means between two or more groups, however, may give rise to a misleading impression about the effect of stimulus (chemicals inhaled during firefighting) and the response variable (FEV₁/FVC), since such a comparison is potentially biased by confounding variables such as smoking and age. Similarly, a clinical trial might be carried out to compare the mean reduction of blood pressure in hypertensive subjects given either a new or established antihypertensive drug. Again, comparing the crude mean reduction is potentially biased by differences in baseline blood pressure in the two groups.¹

Analysis of covariance (ANCOVA), a statistical technique for comparing means with adjustment for confounding bias, is usually the method of choice for adjusting the crude mean values.²⁻⁴ It must be noted, however, that ANCOVA is a parametric statistical method based on a mathematical model. Any mathematical model which attempts to represent reality necessarily stipulates conditions about the data. Some of the conditions stipulated by the ANCOVA model are that the relation between the covariate and the response is linear and equal in each comparison group, and that the error terms in the model are independent, normally distributed, and have the same variance.² Hence, unless the data meet all the model assumptions (to within statistical limits), the ensuing statistical results obtained by ANCOVA may be uninformative and misleading.

An alternative statistical procedure to ANCOVA for the comparison of means with adjustment for confounding bias is the Z-score method.^{3,5} The main appeal of this essentially non-parametric method is that it stipulates only one condition about the data: the relation between the covariate and the response is the same in each comparison group—that is, there is no interaction. When the data show interaction, neither ANCOVA nor the Z-score method is applicable to analysis.³ One drawback of the Z-score method is that it accomplishes adjustment by stratification (analogous to the standardisation procedure for the comparison of rates). Consequently, the method is generally not feasible for adjustment of more than one or two confounders. In our view the Z-score method should be used when ANCOVA is clearly inappropriate for a given set of data.

We have written a computer procedure to perform the Z-score method in SAS⁶ for the mainframe computer as well as in dBase III* for the microcomputer. The programme listing, including a worked example, is available on request.

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*dBase III is a trademark of Ashton-Tate.

Book reviews

Environmental health criteria 59: principles for evaluating health risks from chemicals during infancy and early childhood: the need for a special approach. (Pp 7+Sw fr 9.) Geneva: World Health Organisation, 1986.

This short monograph is designed to draw attention to the special problems of evaluating possible risks to children and infants from environmental chemicals. Some of the more important areas examined are differences in feeding patterns of young and adult, the relatively greater surface area of the infant, and the consequences resulting from the structural and functional immaturity of target organs and differences in the handling of the toxicant. The biological principles at work are explained and the book is well laced with examples of the special problems associated with the young. Many of the examples came from heavy metal or pesticide intoxication.

In these days when returning to work shortly after the birth of a child is commonplace risks to children may arise from the mother's exposure in the workplace to industrial chemicals, and may include trans-