

LETTERS TO THE EDITOR

Public health surveys in Singapore

EDITOR.—In their article, Hughes *et al*¹ used analysis of covariance to compile tables 2 and 3. In another study Hughes and Ong² again used analysis of covariance in table 2. The trouble with the analysis of covariance is that it assumes the means of the normal populations whose means are being compared have equal variances, though unknown. As unknown variances do not have to be equal, the analysis of covariance is not generally applicable to comparing the means of normal populations with unknown variances. The standard deviations in the present case are not equal, giving no reason to believe that the variances are equal. This has already been pointed out by Tsakok.³

Hughes *et al*¹ also used the Z test. This approximates the unknown variances to the standard deviations. As there is no reason why unknown variance should be more accurately determined from the sample than their population means given the same sample size, this approximation is a source of error in the Z test.

The problem of comparing the means of normal populations with unknown variances at exact significance levels is the well known Behrens-Fisher problem, and this has been solved by Tsakok,⁴ and reprinted with further implications for the non-parametric case.⁵ Using the software GSP to implement the Tsakok method,⁵ it is found that, at significance level 0.02 (to 2 dp) from the information given in table 2 by Hughes *et al*,¹ there are significant differences in the mean serum LDL cholesterol concentrations between Indian men and Malay men, in the mean fasting serum triglyceride concentrations between

Indian and Chinese men, and between Malay and Chinese men. Plasma prothrombinF1 + 1 levels between Malay and Chinese men are significant, at 0.02 significance level. It is also found that fasting triglyceride concentrations between Malay and Chinese women are significant, at 0.02 significance level, as well as their serum apolipoprotein B values, and the serum apolipoprotein B values between Indian and Chinese women.

Using the data in table 2 by Hughes and Ong,² it is found at significance level 0.02 that there are significant differences in the plasma vitamin A values between Indian and Malay women, the serum selenium concentrations between Malay and Chinese women, and the plasma vitamin E values between Indian and Malay men.

The above results are only some of the more notable refutations of Hughes *et al*¹ and Hughes and Ong.² They are provisional because the data given in the tables seem to have been incorrectly "age adjusted by analysis of covariance". The raw data should be re-analysed.

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- 1 Hughes K, Aw TC, Kuperan P, *et al*. Central obesity insulin resistance, syndrome X, lipoprotein (a) and cardiovascular risk in Indians, Malay, and Chinese in Singapore. *J Epidemiol Community Health* 1997;51:394-9.
- 2 Hughes K, Ong CN. Vitamins, selenium, iron and coronary heart disease risk in Indians, Malays and Chinese in Singapore. *J Epidemiol Community Health* 1998;53:181-5.
- 3 Tsakok AD. Comment on physical activity. *J Clin Epidemiol* 1997;50:631.
- 4 Tsakok AD. A solution to the generalized Behrens-Fisher problem. *Metron* 1978;36:79-91.
- 5 Tsakok AD. *Statistics and the unified field*. London: AD Tsakok Mathematical Centre, 1987.

Reply

AD Tsakok points out that analysis of covariance should only be used for comparing means of populations with equal

variances. Accordingly, he says that ageadjustment by analysis of covariance is inappropriate in the papers on cardiovascular risk factors in Indians, Malays and Chinese in Singapore,^{1,2} and suggests that the raw data should be analysed.

I would like to point out that the age distributions in the populations concerned were very similar. The means (SD) in years were: Indian men 46.8 (12.2), Malay men 46.7 (11.7), Chinese men 46.9 (12.0), Indian women 45.8 (10.0), Malay women 46.1 (10.4), Chinese women 46.7 (10.4).

Accordingly, analysing the raw and age adjusted data gives very similar results. For example, for mean serum LDL cholesterol the unadjusted and age adjusted concentrations in mmol/l were: Indian men (4.02 and 4.01), Malay men (4.07 and 4.07), Chinese men (3.88 and 3.86), Indian women (4.03 and 4.04), Malay women (4.10 and 4.11), and Chinese women (3.94 and 3.94).

I was not aware of A D Tsakok solving the Behrens-Fisher problem, but I find his analyses difficult to accept. For example, it is difficult to believe that the very small difference in mean serum LDL cholesterol between Indian men and Malay men (see above) can be significant at 0.02. A problem may be that in the papers the data are given to only one decimal point and it is on these that A D Tsakok has done his analyses of statistical significance, whereas for our analyses of statistical significance seven decimal points were used though they were not given in the papers.

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- 1 Hughes K, Aw TC, Kuperan P, *et al*. Central obesity insulin resistance, syndrome X, lipoprotein (a) and cardiovascular risk in Indians, Malay, and Chinese in Singapore. *J Epidemiol Community Health* 1997;51:394-9.
- 2 Hughes K, Ong CN. Vitamins, selenium, iron and coronary heart disease risk in Indians, Malays and Chinese in Singapore. *J Epidemiol Community Health* 1998;52:181-5.