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LETTER TO THE EDITOR

Response to Fellman

We appreciate being able to comment on Professor Fellman's letter regarding our article [1]. Dr. Fellman is certainly correct that, in linear regression, errors in the independent variable produce biased estimates of the slope coefficient. However, his letter deals with the general conceptual problem which, as we understand it, has only an indirect and inconsequential bearing on our application of regression analysis. In this correspondence we derive regression estimates by a method nearly free of the bias Dr. Fellman refers to and attempt to explain why our method is almost immune to that bias.

Tangentially to the main question, Dr. Fellman states that we used ordinary least squares regression. Although we formulated our model in terms of rates of the various kinds of twins per 1,000 births, the total numbers of births were available to us. We used them by applying weighted least squares regression, as stated in our article.

Dr. Fellman appears to attribute error in the opposite-sex twinning rate (OSR) to sampling. Since we dealt with births in entire national populations, it is not clear that we need to concern ourselves with sampling. The national censuses represent the complete experience for the times and locations covered, and in that sense there is no sampling error.

Even if we do regard our observations as samples in time, or from some larger, hypothetical experience, the numbers of births in the analysis are very large, and consequently any random error and the resultant bias would be small. The Table compares our estimates with those obtained by Bartlett's three-group method [2], which, although statistically inefficient, has been suggested to deal with the bias due to error in the independent variable. The age groups were arranged by magnitude of the OSR. Births in age groups with the lowest OSR (15-19, 20-24) and births in age groups with the highest OSR (30-34, 35-39) were separately totaled to give twinning rates at low and high OSR, respectively. Each OSR was taken as an X-coordinate and each same-sex rate (SSR) was taken as a Y-coordinate, thus

defining two points on the OSR scale (see [1], Fig. 2). These points determine the slope of the estimated regression line. A point was also obtained from the mean OSR and SSR in the total data. A line passing through the last point, with slope given by the first two, then intercepts the Y-axis to yield an estimate of the constant MZ rate. These calculations were performed four times to give the four points in the right-hand column of the table.

Table - Estimates of the MZ twinning rate if it is constant, obtained by weighted least squares regression analysis and by Bartlett's three-group method.

Category of births	MZ rate by weighted least squares	MZ rate by Bartlett's method
White	3.02	3.01
Black	2.64	2.75
White male	2.99	2.93
White female	3.06	3.08

The largest correction resulting from Bartlett's method is for black births, where the small numbers could best produce random error. However, in the comparison between races, the method reduces the difference in MZ twinning by only a third, and in the comparison between sexes the method increases the difference. The bias alleged by Fellman therefore does not explain the differences.

If we subdivided the material into smaller groups (eg, by age *and* birth order), sampling errors and the resulting bias would become larger, but it would still have little bearing on our conclusion. Our argument is based not on the absolute values of the intercepts, but on their relative values. The bias due to error in the independent variable is always a reduction in b and hence an increase in a, and it will be similar for most groups in the comparison. Therefore the differences between groups will persist, ruling out a constant MZ rate.

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