J. Biosoc. Sci., (2011) **43**, 761–763, © Cambridge University Press, 2011
doi:10.1017/S0021932011000320 First published online 18 July 2011

Debate

VARIATION OF HUMAN SEX RATIOS AT BIRTH BY THE SEX COMBINATIONS OF THE EXISTING SIBS, AND BY REPRODUCTIVE STOPPING RULES: ANSWER TO COMMENTS BY WILLIAM H. JAMES

MICHEL L. GARENNE

We thank Dr James for his always stimulating comments on variations in the sex ratio at birth. Dr James makes some specific comments and queries about our interpretation of the Lexis variations that we found in data from both Europe and Africa. These Lexis variations (different probability of bearing a boy among couples) were shown primarily by a statistical analysis of the distribution of boys and girls according to the number of males and female already born in the family (Garenne, 2008b, 2009a). In another paper, we showed Poisson variations by age of mother and birth order using the same African data (Garenne, 2008b). We fully agree with Dr James that any systematic Poisson variation will have only a minor effect on the variance of the distribution of boys and girls in families. We have also addressed the issue of behavioural factors in a comment to a study based on American data (Garenne, 2009b).

Statistical evidence for asymmetry

Dr James argues that what we interpreted as Lexis variations could also be interpreted as random or chaotic (non-systematic) Poisson variations (the sex ratio varies among couples for a variety of factors over time and differently for different couples), or by an effect of birth order. His main argument is based on a re-analysis of our regression model linking the sex ratio with the number of boys and girls already born to the couple. This model was:

Logit (sex ratio) = $A + B \times \text{Boys} + C \times \text{Girls}$,

which can also be written as:

Logit (sex ratio) = $A + B' \times (\text{Boys}+\text{Girls}) + C' \times (\text{Boys} - \text{Girls})$,

with $B' = (B+C)/2$ and $C' = (B-C)/2$.

The two models are equivalent. If there is symmetry, then $B \sim -C$, and $(B+C) \sim 0$. If only parity matters and not the family composition, then $(B-C) \sim 0$ and $B+C <> 0$. Otherwise, this means asymmetry and effects other than parity.

This was the case in our analysis of African data. Since our original publication, we added some more data to the database from recent Demographic and Health Surveys (DHS) and found:

$B = +0.001756$ (SD=0.000968)

$C = -0.009676$ (SD=0.000996).

Therefore:

$B' = -0.003960$ (SD=0.000550)

$C' = +0.005716$ (SD=0.000814).

This shows clearly the effect of family composition and the asymmetry of the relationship, with high statistical significance ($p < 2.2 \times 10^{-16}$). The same effect was found in France, when re-analysing the data gathered by E. Malinvaud (Garenne, 2008a).

Rationale for asymmetry

There are many reasons to expect heterogeneity and asymmetry in the sex ratio, because of the complexity of the conception and birth processes, and because the two sexes are involved at various times in the development of the embryo. At time of meiosis and spermatogenesis, the sex ratio (M/F) is assumed to be 1 to 1, although this has been questioned. Just after fertilization and implantation *in utero*, the sex ratio is about 1.6, and this increase is assumed to be primarily coming from the father's side. At birth, the sex ratio is about 1.05, and what happens in between can only be under the control of the mother. Many things could happen between the development of sperm cells and delivery, and a great variety of factors could influence the sex ratio, some coming from the father's side, other from the mother's side. These are likely to be influenced by genetic factors (as exemplified by differences between races or population groups) as well as by a large array of environmental factors including diseases, so one can only expect a large heterogeneity and some asymmetry. We do agree with Dr James that this could be either genetic (pure Lexis variations) or due to variations in the environment (chaotic Poisson variations). However, the strong effect of number of boys (or girls) in unisexual sibships (families with only boys or only girls) indicates that most of the effect seems to be of the Lexis type (couples have either a low or high sex ratio throughout their reproductive period).

Behaviours

We have addressed the issue of the stopping rule in another document (Garenne, 2009b). Of course, the stopping rule (preventing pregnancy after the number of desired males or females is achieved) does not change the sex ratio at birth. By behaviour, we rather meant 'sex selective abortion' or other radical means of controlling the sex ratio before delivery. In the case of the two data sets analysed (France in the 1950s and Africa since 1950), such behaviour simply did not exist, and could not be evoked as a potential explanation. However, in theory, assuming that couples have another attitude, and have differential preferences for boys and girls, so that a large number of couples choose to have mostly boys and another large number choose to have mostly girls, one could find a variance in the distribution of boys and girls similar to that found under the hypothesis of heterogeneity due to biological factors. This hypothesis remains purely speculative, and no population in the real world has been shown with this behaviour.

Conclusion

With our log-gamma fitting, we hope to have provided statisticians with an appropriate tool to include heterogeneity among couples in their calculations and models, whatever the causation. The similarity between France and Africa suggests that these are likely to be global patterns.

References

Garenne, M. (2008a) Heterogeneity in the sex ratio in European populations. *Genus* **LXIV**(3–4), 99–108.

Garenne, M. (2008b) Poisson variations of the sex ratio at birth in African demographic surveys. *Human Biology* **80**(5), 473–482.

Garenne, M. (2009a) Sex ratio at birth and family composition in sub-Saharan Africa: inter-couple variations. *Journal of Biosocial Science* **41**(3), 399–407.

Garenne, M. (2009b) The sex-composition of 2-children families: heterogeneity and selection for the third child. Comment on the paper by Stansfield and Carlton. *Human Biology* **81**(1), 97–100.