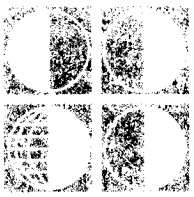
Sex Ratio at Birth, Polygyny, and Fertility: A Cross-National Study



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ABSTRACT: **The sex ratio at birth may reflect frequency of intercourse that affects the timing of conception. If so, cross-national variation in polygyny and fertility might account for country differences in secondary sex ratios. Consistent with the timing of intercourse hypothesis, the birth sex ratios of 148 countries declined with total fertility rates and polygyny intensity, and increased with contraception use in correlational analysis. Regression analysis confirmed that polygyny was a negative predictor of the sex ratio (and contraception was a positive predictor), with level of economic development and mother's age controlled, but the effects disappeared with total fertility added to the equation. The sex ratio evidently declines with increases in fertility because more children are born at a later birth order when frequency of intercourse is lower.**

INTRODUCTION

Sex ratios at birth vary considerably among human populations, and even between entire countries. Possible explanations for such variation include genetics, circulating hormones, nutrition, dominance and social status, war, birth order, seasonality, marriage system, single motherhood, length of marriage, and paternal age, among others (James, 1987; Sieff, 1990; Singh and Zambarano, 1997). At present there are many interesting hypotheses about how any or all of these factors could favor the fertilization of ova by X-bearing or Y-bearing sperm but the precise mechanisms have not been established. Despite this, there is good evidence that the timing of insemination is important, with more female conceptions resulting from intercourse around the time of ovulation and more males resulting from insemination outside the periovulatory period (consisting of the day before to the day after the day of ovulation) (Guerrero, 1974; Harlap, 1979; James, 1971, 1980; Whiting, 1993; but see Gray, Simpson, and Bitto, 1998 for a failure to replicate). If this interpretation is correct, then more frequent intercourse would increase the probability of male conceptions (James, 1971, 1987).

The research reported in this paper used cross-national data for 148 countries to investigate predictions drawn from the timing-of-insemination hypothesis proposed by James (1971).

If the timing of insemination is important, then the sex ratio at birth should vary with the marriage system because frequency of intercourse is likely to be reduced for women who share a husband. Anthropological data confirms that polygynously married mothers produce more daughters than monogamously married ones in the same society. Of most direct relevance here is a study by Whiting (1993) for seven different polygynous tribes in Kenya. Polygynous mothers produced more daughters than monogamous mothers for each of these peoples, although the differences were not always statistically significant. The average sex ratio for all of the polygynous mothers

was low at 93 males (per 100 females) compared to the higher value of 107 for monogamous mothers. This difference was highly significant.

The decline in sex ratios with birth order is another phenomenon that may be related to frequency of coition because couples have sex less often later in the marriage than they do earlier, as established by Kinsey's surveys of Americans (Kinsey, Pomeroy, and Martin, 1948; Kinsey, Pomeroy, Martin, and Gebhard, 1953). Martin's (1994) Havasupai data suggest that birth order, rather than the age of the parents, is what matters because the sex ratios of first births to women in second marriages were also high. Needless to say, birth order is inevitably confounded with the length of a marriage and age of the parents. Birth order is difficult to analyze in the data of all but a handful of developed countries but its influence on the sex ratio of a country can be investigated indirectly by looking at total fertility rates. The more children a woman produces, on average, in a country, the higher the average birth order and the lower the sex ratio should be.

Predictions tested by cross-national data for 148 countries included the following:

1. The sex ratio at birth will decline with polygyny, consistent with previous research for a limited number of societies, an effect that might also be mediated by frequency and timing of intercourse.

2. The secondary sex ratio will decline as total fertility increases due to the birth order effect, which could be mediated by reduced frequency of intercourse.

3. The sex ratio should be higher in countries where contraception is widely practiced because total fertility would be lower and average birth order would consequently be lower.

METHOD

The sample was derived from previous research investigating the relationship between economic development and social variables, which called for coding of polygyny intensity (Barber, 2002a) and comprised all the countries for which information could be obtained on demographic variables and economic development. The 148 countries in the sample had an arithmetic average GNP of $5,775 (95 percent confidence interval $4,223–$7,327) compared to $5,180 for the 201 countries described in the World Population Data Sheet (Population Reference Bureau, 1998), so that they did not differ from the larger sample in economic productivity. Demographically, the sample had similar total fertility, Mdn = 2.95, compared to a population-weighted world average of 2.90 (Population Reference Bureau, 1998).

Dependent Variable

The dependent variable was the sex ratio at birth (CIA, 2000) where an equal number of males and females was represented by 100 (rather than 1.00).

Independent Variables

Independent variables intended to tap cross-national differences in parental investment included total fertility rate (or expected number of children produced by the average woman in her reproductive career) (Population Reference Bureau, 1998), and the proportion of women using any form of contraception (Population Reference Bureau, 1998). Polygyny was coded based on the predominant ethnic group within a country (see Barber, 2002a for more details). Codings were based on encyclopedia descriptions of countries and ethnic groups. Polygyny

was defined as men having multiple wives simultaneously. Countries were coded as 1 = monogamous, 2 = polygyny permitted but rare, or 3 = polygyny permitted and commonly practiced. Interobserver reliability of coding was 0.91.

Control Variables

Level of economic development was controlled using gross national product (GNP) per capita, which includes the value of all domestic and foreign output (Population Reference Bureau, 1998). Due to the great range in this variable, it was log transformed. Given that polygyny is a feature of economically less developed countries, it is important to assess the effects of marriage system with level of economic development statistically controlled.

The hypotheses deal in various ways with the effects of birth order. Obviously, as birth order increases, so does the age of mothers and fathers; therefore, age might have a biological effect on the secondary sex ratio. It is thus desirable to control for the age of the mother. Data used were modes estimated as the center point of the five-year age block with the highest fertility in a country (United Nations, 2002).

Statistical Analyses

Preliminary analysis consisted of producing a correlation matrix for independent and dependent variables (Table 1). Note that the polygyny intensity variable was on an ordinal scale. Although some researchers prefer to use nonparametric statistics with ordinal variables, this is not strictly necessary, given that identical results are produced with parametic and nonparametric tests (Zimmerman and Zumbo, 1989). Variables entered into the regression model predicting the sex ratio at birth included mother's age, GNP per capita, polygyny, contraception and total fertility rate. Two models were produced, one with the three independent variables with mother's age controlled and the other with total fertility omitted and GNP controlled. This was done on account of the substantial negative correlation between fertility and GNP (Table 1), which would have introduced multicollinearity problems. All variables were entered, resulting in some nonsigniticant slopes. Both models reported were free of multicollinearity error (see Results).

RESULTS

A correlation matrix of sex ratio at birth and independent variables is presented in Table 1. From the first column of the Table, it can be seen that the sex ratio at birth was negatively related to polygyny and total fertility, and positively correlated with contraception use and log GNP per capita and mother's age. All of the variables were highly correlated with each other and the largest correlation was between total fertility and log GNP, $r(146) = -0.73$, $p < 0.001$. Correlations were not large enough to threaten the validity of the regression analyses (Table 2) due to multicollinearity biases, however. Variance inflation factors (VIF) were calculated based on multiple correlations of each predictor variable with all of the others (Fox, 1991). All of the VIF square roots were well below the 2.00 cutoff that Fox (1991) sees as indicative of multicollinearity problems.

Results of the regression analyses are shown in Table 2. From model A, it can be seen that the sex ratio increases significantly with the mother's age and declines with increases in fertility. Neither contraception nor polygyny reached

TABLE 1

CORRELATIONS AMONGST PREDICTOR VARIABLES AND TEEN BIRTH RATIO

	SEX RATIO	CONTRACEPTION	POLYGYNY	TOTAL FERTILITY	LOG GNP	MOTHER AGE
Contraception	0.42*	-				
Polygyny	-0.41*	-0.51*	-			
Total fertility	-0.60*	-0.62*	0.64*	-		
Log GNP	0.45*	0.60*	-0.60*	-0.73*	-	
Mother age	0.45*	0.31*	-0.25*	-0.45*	0.67*	-
Mean (± SD)	104.90	42.76	1.70	3.47	3.23	24.08
	(1.57)	(20.57)	(.87)	(1.20)	(0.68)	3.04
Range	102–109	2–92	1–3	1.1–7.3	2.00–4.64	22–32

* $p < 0.01$.

TABLE 2

REGRESSION ANALYSIS OF THE RELATIONSHIP BETWEEN SEX RATIO AT BIRTH AND INDEPENDENT VARIABLES WITH LOG GNP CONTROLLED (STANDARDIZED REGRESSION COEFFICIENTS IN PARENTHESES)

PREDICTOR	B		SE B	t
		Model A		
Contraception	0.0053	(0.07)	0.0050	1.06
Polygyny	-0.11	(0.06)	0.12	0.92
Total fertility	-0.34	(0.26)	0.055	6.19**
Mother's age	0.12	(0.23)	0.034	3.53**
Constant	103.80		0.89	-
		Model B		
Contraception	0.017	(0.22)	0.0051	3.27**
Polygyny	-0.45	(0.25)	0.12	3.75**
Log GNP	-0.18	(0.08)	0.16	1.13
Mother's age	0.19	(0.37)	0.035	5.43**
Constant	100.84		1.05	-

* $p < 0.05$ ** $p < 0.01$

NOTE: Numbers in parentheses are standardized regression coefficients. The first model accounted for 40 percent of the variance in sex ratios at birth, F 3,143 = 23.38, $p < 0.001$. The second model accounted for 33 percent of the variance, F 3,143 = 17.56, $p < 0.001$.

significance in this model. Model B shows that with log GNP entered in the equation, instead of fertility, each of the other variables reaches statistical significance. The sex ratio at birth is inversely related to polygyny intensity and positively related to contraception and mother's age.

DISCUSSION

Data supported the three predictions drawn from the hypothesis that frequency and timing of intercourse affect the sex ratio at birth. Specifically, the sex ratio at birth of countries declined with polygyny intensity and total fertility and increased with frequency of contraception use. These effects were independent of mother's age and level of economic development. Results thus confirm earlier research on the influence of the marriage system on secondary sex ratios (Whiting, 1993).

Perhaps the most striking result was that effects of polygyny and contracep-

tion were eliminated in a regression analysis that included total fertility (Table 2, Model A). This indicates that there is a decline in sex ratios with polygyny because polygynous societies have much higher fertility. By implication, this means that a greater proportion of births are at a higher birth order. Previous data shows that sex ratios are lower for late-born children and there is good reason to believe that this is partly mediated by declining frequency of intercourse later in a marriage, which increases the probability of producing daughters via a timing mechanism (James, 1987, 1996; Martin, 1994; Whiting, 1993).

Similarly, the result for contraception is evidently mediated by reduced fertility and its implications for birth order. Societies in which more mothers use contraception have lower fertility and, thus, a higher proportion of early-born children (i.e., those with a low birth order) which are more likely to be male. In general the data thus provide some compelling cross-cultural support for the frequency-of-intercourse hypothesis, at least if the underlying mechanisms resemble those that have been assumed. This evidence is indirect, of course, and it was not possible to quantify the frequency of intercourse in this study.

A strong positive effect of mother's age on the sex ratio was revealed such that countries with older mothers have a higher sex ratio at birth. Comparing the two regressions it can be inferred that the effect of mother's age was reduced by controlling for total fertility. This might be because women give birth at a later age in countries with lower fertility, a pattern that is particularly common in developed countries where women delay childbirth by up to a decade to develop careers (Goldin, 1995). Controlling for mother's age also removed the effect of log GNP, presumably because mothers are older in economically developed countries than in less developed ones. It is interesting that the effect of mother's age in the cross-national data is the opposite of what would be predicted from individual data (e.g., Martin, 1994) where sex ratios tend to decline with mother's age.

It is useful to ask whether there are any other possible explanations for the pattern of results reported here apart from frequency or timing of intercourse associations between the secondary sex ratio and polygyny/fertility. At least some possibilities can be imagined, although none seems compelling. Thus, it is theoretically possible that there is no functional relationship between fertility and the sex ratio, if both are determined by a third variable. One possible third variable is climate, which could affect both marriage system and fertility as well as the sex ratio. That climate influences human fertility is suggested by a strong effect for fertility to increase at low latitudes (Barber, 2002b) even with level of economic development and other potential confounding influences statistically controlled. It is also possible that the human sex ratio is affected by temperature, although this phenomenon is more characteristic of reptiles and is believed to have disappeared for mammals. Further controlling for geographic latitude did not alter the outcome of the regression analyses in any material way, suggesting that climate, which varies quite predictably with latitude, is not the third variable of interest.

Another possible third variable is country variation in reproductive hormones in either sex. James (2000) provided evidence that sex ratios increase with parental testosterone and estrogen

and decline with progesterone and gonadotrophin and argued that this was a causal relationship. This mechanism could allow geographic variation in sex ratios to occur via natural selection. Thus, it has been suggested that low sex ratios evolve in populations where it is particularly difficult to support the greater energetic cost of raising males (Mace, Jordan, and Holden, 2003). Whether country variation in sex hormones could explain national variation in secondary sex ratios is difficult to know.

Another variable of potential importance is national differences in sexual practices. Thus, unusually high sex ratios among Orthodox Jews may reflect ritual control over the timing of intercourse (Guttentag and Secord, 1983).

A reviewer of this paper suggested that a gender preference by parents might influence the birth sex ratio, as implied by a theoretical model developed by Yamaguchi (1989) demonstrating that male-preferring stopping rules generate a declining probability of male births at higher parities, a counter-intuitive result that can be thought of as due to the "extra" females being produced as parents work towards a desired male offspring. Bongaarts and Potter (1983) also concluded that parity progression is linked to satisfying the desire for a child of a particular sex. While such effects may be real, there is little empirical evidence concerning their practical importance. One way of evaluating these ideas would be to ask whether the gender preferences within a society affect the sex ratio at birth in the way that Yamaguchi's (1989) model predicts.

Most societies express a distinct preference for male children (Cronk, 1991), which would tend to reduce the sex ratio of birth, according to Yasmaguchi (1989). Still, more males than females are born in most countries. The few societies in which daughters are strongly preferred do not have unusually high sex ratios at birth, either, as Yamaguchi's model would predict. Among Herero herders, who strongly prefer daughters, for example, the sex ratio at birth is 105. By the age of 4 years, this falls to 94, probably due to better nutrition going to daughters who have 40 percent more subcutaneous fat than sons, according to skinfold measurements (Cronk, 1991). (The low sex ratio at age four is not relevant to the birth sex ratio, of course, but it does verify daughter preference among the Herrero). A similar pattern is seen among the Mukogodo herders of Kenya where more sons than daughters are born but the sex ratio for children aged 0–4 years is just 67, indicating substantial discrimination against males. Although Yamaguchi's theoretical model thus predicts a pattern of reduced sex ratios based on fertility stopping rules in these societies, there is little empirical evidence of any such phenomenon.

Moreover, in those countries in Asia (e.g., India, China) where male-favoring sex selection is most assiduously practiced, there is an elevation of the sex ratio rather than a decline (Mangla, 1991). In such countries, amniocentesis, or high resolution sonography, are used to facilitate sex-selective abortions, which increases the sex ratio at birth. To summarize, there is no compelling empirical evidence that gender preference affects the birth sex ratio in systematic and substantial ways that could provide a compelling alternative explanation for the present results.

In conclusion, it appears that the sex ratio at birth declines with polygyny and with high national fertility, and that these

phenomena could be due to more children being born at a high parity in polygynous societies and in countries where fertility is high. Similarly, contraception may elevate the sex ratio by removing offspring at higher parities.

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