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Polygyny, Family Structure, and Child Mortality

A Prospective Study among the Dogon of Mali

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The lyrics of Oumou Sangâre, Mali's leading pop-vocalist and feminist, and the witticisms of George Bernard Shaw neatly capture two opposing schools of thought on polygyny. Sangare, the daughter of a third wife, sings about the emotional cost of polygyny for women. Shaw, on the other hand, quipped that: "The maternal instinct leads a woman to prefer a tenth share in a first-rate man to the exclusive possession of a third-rate one." Shaw's view was formalized by the economist Gary Becker (1981), who attempted a mathematical demonstration of the argument that women tend to benefit from polygyny. According to Becker, polygynous men give a smaller fraction of their resources to each wife, but each wife gets more resources than a monogamous man could provide. Becker's approach echoes the polygyny threshold model, originally developed for passerine birds (Verner and Willson 1966; Orians 1969) and subsequently extended to humans (Borgerhoff Mulder 1988, 1990; Josephson 1993). Under the polygyny threshold model, polygyny is driven by female choice of mates who command more resources. However, females might be better off controlling resources themselves, or from a more equitable distribution of resources among males, in which case the emphasis on "female choice" is misleading (Hrdy 1996). Females may exert choice, but only within a restricted array of options.

An alternative to the female-choice model predicts conflicts of interest between members of the two sexes over the optimum mating system (Chisholm and Burbank 1991; Davies 1989; Downhower and Armitage 1971; Hrdy 1996; Irons 1983; Smuts 1995; Smuts and Smuts 1993). This conflict is expected because males may benefit reproductively from concurrent mates, even if the result is lower average fitness for each. Contra Becker, men might attempt to marry two wives even if they offer less than twice as much paternal investment (e.g., resources, time) as monogamous men. Thus, to the extent that male strategies prevail over female strategies in any given society, women who marry polygynously may incur a fitness cost. Females may experience the cost of polygyny through a reduction in fertility or an increase in child mortality.

Demographers have extensively probed the possibility of reduced fertility, but owing to methodological problems, their findings have been inconclusive (e.g. Dorjahn 1958; for review see Wood 1995). The hypothesis that child mortality is higher under polygyny has attracted comparatively little attention, despite its relevance for public health. Both sets of studies are limited by the use of retrospective data and the absence of controls for confounding risk factors (fertility: Pebley and Mbugua 1989; Wood 1994; mortality: Borgerhoff Mulder 1989, 1990; Chisholm and Burbank 1991; Chojnacka 1980; Isaac and Feinberg 1982; Roth and Kurup 1988).

In a study of polygyny and female fitness among the Dogon of Mali, West Africa, I attempted to overcome the methodological problems of previous studies by measuring female fecundability and child mortality prospectively. I measured female fecundability from two years of data on menstrual hut attendance, as corroborated by hormonal profiles (Strassmann and Warner 1998). Significant covariates of fecundability were controlled, including: wife's age, husband's age, marital duration, gravidity, and breast-feeding status. According to both discrete and continuous time survival analyses, there was no association between a woman's marital status and her fecundability (Strassmann and Warner, 1998). I measured child mortality from eight years of data on child survivorship, analyzed by logistic regression (Hosmer and Lemeshow 1989). The results indicated that the odds of death were 7 to 11 times higher under polygyny even in the presence of controls for confounding risk factors (such as age, sex, wealth, and family size) (Strassmann 1997). Here I present two additional logistic regression models that further implicate polygyny as a predictor of mortality.

ETHNOGRAPHIC BACKGROUND

In the fifteenth or sixteenth century, the Dogon established villages in easily defended sites along the Bandiagara Escarpment, a sandstone cliff (260 km long by ca. 500 m high) in Mali, West Africa (Pern 1982). After the French colonial government put an end to raids on Dogon villages by nearby pastoralists, Dogon settlements expanded to include much of the plateau on top of the escarpment as well as the Seno and Gondo plains below. This study took place in Sangui, a plateau-top village with a population of 460 individuals in January 1988, situated at 14° 29′ N, 3° 19′ W. The major subsistence crop in Sangui is millet and other cereals (rice, sorghum, and fonio). Onions are a cash crop that helps make up for deficits in the millet harvest.

The incidence of polygyny varies among villages, but in January 1988, 54% of the married men in Sangui had one wife, 35% had two wives, and 11% had three wives. Dogon polygyny is strictly nonsororal, and related women, such as first cousins, are not allowed to marry into the same patrilineage. Thus the Dogon illustrate the tendency for male kin in patrilineal societies to form powerful coalitions that thwart alliances among female kin (Smuts 1995; Hrdy 1997). First wives have the minor honor of sleeping in the room to the right of the husband's, but are not otherwise in a position of power or privilege. To maintain family harmony, the husband is expected to sleep with his wives on alternate nights. He owes them equal quantities of *yu buburu* (low quality millet) to store in their granaries; the good millet (*yu anran* or male millet) he stores in his own granaries. In dividing the millet, the first wife cuts the pile and the second wife chooses. Parents arrange their son's or daughter's first marriage, but ideally, the new couple does not co-reside until the birth of two children (who will be raised by the wife's parents). Bride-price is absent among the Dogon, but a fiancé shows respect to his parents-in-law by helping in their fields and through small gifts of cash, firewood, cowries, chickens, and grain.

In a strongly male-dominated society, husbands are more likely to be able to subordinate the reproductive interests of their wives in the pursuit of their own reproductive interests. Thus, polygyny is more likely to adversely affect female fitness when females have low status. The inferior status of Dogon women is particularly clear as they get older. An elderly widow is no longer considered useful to her husband's family and must return to her natal village to grow her own food. Elderly men usually enjoy a lighter workload in old age, but according to behavioral scan data, the workload of women does not abate. Across all ages, men spent 29% more time resting than women ($t = 7.71$, df = 127; $p < 0.0001$), and women spent 21% more time working than men ($t = -5.10$, df = 127, $p < 0.0001$) (Strassmann 1996). Women assume the energetic demands of lactation and heavy physical labor but are prohibited from the places where meat is consumed: hangars in the market place and religious shrines.

The indigenous religion is a vehicle through which Dogon males attempt to exert control over female sexuality (Strassmann 1992, 1996). For example, supernatural beliefs regarding menstrual pollution are a tactic for obligating menstruating women to spend the night at a menstrual hut. When a woman obeys the menstrual taboos it is evident that she is no longer in postpartum amenorrhea and that she will soon be ready to conceive. Although all female informants ($N = 113$) disliked the menstrual taboos, hormonal data indicate that menstrual hut visitation was an honest signal of menstruation. By enforcing the taboos, husbands and patrilineages gain precise knowledge of the timing of menstruation, information they consider useful for detecting and preventing cuckoldry (details in Strassmann 1992, 1996). The women of Sangui are also clitoridectomized. Informants had multiple interpretations of clitoridectomy, including the belief that genital surgery promotes paternity certainty through the reduction of sexual pleasure.

The greatest adversity faced by Dogon women is child mortality. The mean number of live births for postreproductive women was 8.6 ± 0.03, but 20% of children died in their first 12 months, and 46% died by age five ($N = 388$) (Strassmann 1992). From a human and primate comparative perspective, this mortality rate is very high (Lancaster and Lancaster 1983). Malaria, measles, and diarrhea caused the most fatalities (Fabre-Test 1985).

METHODS

This study monitored child survivorship longitudinally from 1986 to 1994. The study population included all children ($N = 205$), age ≤ 10 years, who were resident in the village of Sangui between May 1986 and August 1988. Children who were born during this interval were added to the study population. I resided in the village during this initial two-and-a-half-year period and therefore was able to ensure that the census for this period was complete. I recensused the village in 1994, at which time 20 children had left the village and were lost to follow-up. Nine children lived with widowed grandmothers in domestic units that did not include any married adults. I excluded these 29 children and compared the effect of polygyny versus monogamy on mortality among the remaining children ($N =$ 176, 86% of the initial population). The dependent variable was coded 1 for each child who died and 0 for each child who survived to the time of the 1994 census. Since the dependent variable was dichotomous, and data on age at death were unavailable, I analyzed the data using logistic regression. These regressions were carried out in the statistical program SPSS 6.1 (SPSS 1994).

Polygyny, the independent variable of key interest, was defined first by the mother's marital status: first, second, third, or sole wife. This definition excluded from the analysis 46 children whose mothers were widowed, engaged, divorced, or deceased, reducing the sample size to 130. Second, I computed polygyny as the ratio of married women to married men in the child's work-eat group, defined as the people who cultivated the same millet fields and assembled in one compound to eat together. For example, if a work-eat group had two men with two wives and one man with one wife, the polygyny index for that group would be the ratio of 5 women to 3 men, or 1.67. The significance of a work-eat group is twofold: *(a)* members depend on one another economically, and *(b)* they defer to the same family head. Married women cultivated millet alongside the other members of their work-eat group (both male and female) and did not plant their own individual millet fields. Thus, the economic status of women depended on the economic status of their work-eat groups. The sample size for polygyny of the work-eat group was 176 children and the mean ($\pm$ s.d.) work-eat group size was 15.60 ($\pm$ 10.64) persons with a range from 3 to 41. Work-eat groups did not correspond to households: if a work-eat group contained several married men, their families slept in different compounds. Co-wives and their children also sometimes had separate compounds. Adolescent boys slept in small compounds with their age mates.

The final models include all variables that improved model fit based on the likelihood ratio test (Hosmer and Lemeshow 1989). To test whether the logit had a quadratic rather than a linear relationship with any of the continuous variables, I added squared terms. If a squared term did not improve model fit based on the likelihood ratio test it was omitted. The values for the independent variables in this analysis were obtained from a combination of direct observation (e.g., child's sex), private interviews (e.g., parent's education), and quantitative measurement (e.g., economic rank). To compare the economic resources (land, grain, onions, and livestock) of all families, the 540 cereal fields and 422 onion fields belonging to the people of Sangui were measured with a compass and meter tape, baskets of grain and onions were counted and weighed, and livestock were tallied by species, maturity (juvenile versus adult), and sex, as described elsewhere (Strassmann and Warner 1998). Year-to-year fluctuations in the wealth of the village from 1986 to 1994 occurred in response to changes in rainfall and market forces but had a negligible impact on the relative wealth of the families, which I expressed as a rank from 1 to 59. After the exclusion of 9 children who lived with widowed grandmothers (see above), no children lived in a family that had a wealth rank below 15.

To compare the standard of living of different work-eat groups, I computed the daily energy requirement of each group from the number of individual members, adjusted for age and sex, using the guidelines of the FAO and WHO (1973). I standardized the wealth of each group by its daily energy requirement. To find out whether children in polygynous families were less well nourished, I used cross-sectional anthropometric data on 77 children age six or younger in 1988. In particular, I compared their observed and expected values for weight/height.

To assess the effect of polygyny on aspects of paternal behavior that were both quantifiable and observable, I compared observations of direct childcare performed by polygynously and monogamously married men. The following behaviors were defined as "direct childcare:" carrying, holding, washing, wiping, feeding, minding (baby-sitting), or otherwise assisting a child. Observations of childcare were obtained via behavioral scan sampling in the agricultural fields and village from December 1987 to May 1988. I divided the number of childcare observations for a given person by the total number of observations for that person, to obtain an approximation of the time that person allocated to direct childcare as opposed to other activities.

RESULTS

Univariate Analyses

As shown in Table 3.1, the chi-square test revealed a nonrandom relationship between mother's marital status and child mortality. More children of first wives died than expected, and fewer children of sole wives died than expected. In a univariate logistic regression, the polygyny index (ratio of married women to married men in a child's work-eat group) was a significant predictor of mortality (odds ratio = 3.14, 95% confidence interval = 1.45–6.78, n = 176). Strikingly, only 3 of 58 children died in the groups with an index of <1.5, while 37 of 118 children died

Table 3.1. Child survivorship (died or lived) by wife type (first, second/third, or sole wife).

	Children	
Wife Type	*Died*	*Lived*
First		
Observed	16	27
Expected	10	33
Second/Third		
Observed	11	32
Expected	10	33
Sole		
Observed	4	40
Expected	11	34

$\chi^2 = 9.57$, df = 2, $p = 0.008$, $n = 130$

in the groups with an index of ≥1.5 ($\chi^2 = 15.18$, df = 1, $p = 0.0001$) (Strassmann 1997).

Multivariate Analyses

In previous multivariate analyses, I coded polygyny as a dichotomous categorical variable, with a work-eat group defined as monogamous if the polygyny index was <1.5, and polygynous if the index was ≥1.5 married women to married men (Strassmann 1997). This approach was based on empirical evidence that the relationship between polygyny and mortality was a step function. After controlling for other predictors of mortality (child's age, child's sex, number of children in family, and economic rank) the odds of death were more than 7 times higher in the polygynous work-eat groups than in the monogamous groups (95% confidence interval = 1.8–29.4, $p = 0.0005$). It should be emphasized that this effect size was based on an empirically derived cutoff point.

Here I employ an alternative approach. Rather than model work-eat group polygyny as a dichotomous variable, I treat it as a continuous variable with values ranging from 1.00 to 3.00. The two best-fitting final models are shown in Table 3.2. They differ from each other in that model 1 includes the number of children (age ≤ 10 years) in the family, whereas model 2 includes the ratio of children (age ≤ 10 years) to married adults. In model 1, the relationship between polygyny and mortality is best modeled as a quadratic function; at $\alpha = 0.05$, polygyny was significant ($p < 0.03$), as was polygyny squared ($p = 0.05$). In this model, the effect of a one- unit increase in the polygyny index was not constant across all values of the index, so the relationship between the predicted probability of death and the polygyny index is best shown graphically (Figure 3.1). In model 2, polygyny

Table 3.2. Predictors of child mortality from 1986 to 1994, with polygyny as a continuous variable (N = 176 children).

	Model 1			*Model 2*		
Predictor	*Coefficient*	*Odds Ratio*	*95% Confidence Interval*	*Coefficient*	*Odds Ratio*	*95% Confidence Interval*
Polygyny index of the work-eat group (1.00–3.00)	8.293**	—	—	1.526†	4.60	1.61–13.11
Polygyny index squared	−2.064*	—	—	—	—	—
Age of child (0–10)	−0.398‡	0.67	0.55–0.81	0.399‡	0.67	0.56–0.81
Sex of child (0 = female, 1 = male)	0.864	2.37	0.96–5.87	0.743	2.10	0.88–5.01
Number of children in family (1–13)	0.235†	1.26	1.08–1.49	—	—	—
Ratio of children to married adults (0.33–2.33)	—	—	—	1.237†	3.44	1.46–8.15
Economic rank (14–59)	−0.087**	0.42	0.2–0.85	−0.0006	0.99	0.68–1.45
Constant	−6.611*	—	—	−4.82†	—	—

* $p \leq 0.05$; ** $p < 0.03$; † $p < 0.005$; ‡ $p < 0.00005$.

Odds ratios are for a one-unit increase in the predictor variable, except the odds ratio for economic rank is for an increase of 10 ranks. In model 1, the relationship between polygyny and mortality is a quadratic function and therefore cannot be represented by just a single odds ratio (see Fig. 3.3).

−2 Log likelihood = 138.0 (model 1) and 143.0 (model 2). Goodness-of-fit statistic: 176.4 (model 1) and 158.8 (model 2). Percentage of outcomes (lived or died) correctly predicted by the model: 81.3% (model 1) and 79.2% (model 2).

squared was not significant so it was preferable to model the relationship between polygyny and the logit as linear. In model 2, as the ratio of married women to married men increased by 1.00, the odds of death increased 4.6-fold ($p < 0.005$). In summary, regardless of whether work-eat group polygyny was modeled as a dichotomous or a continuous variable, the odds of death for Dogon children were significantly lower under monogamy.

Work-eat group polygyny was more predictive of mortality than mother's marital status. For example, after controlling for the other predictors of mortality in model 2, the odds of death were higher for the children of first wives (odds ratio = 3.7, $p = 0.07$, $n = 130$) and for the children of second wives (odds ratio = 1.8, $p = 0.41$, $n = 130$) than for the children of sole wives, but these results were not significant at $\alpha = 0.05$. In this analysis, the sample size was reduced from 176 to 130 because only 130 children had mothers who were married and living in the village. The loss of significance, however, was not merely due to sample size. When work-

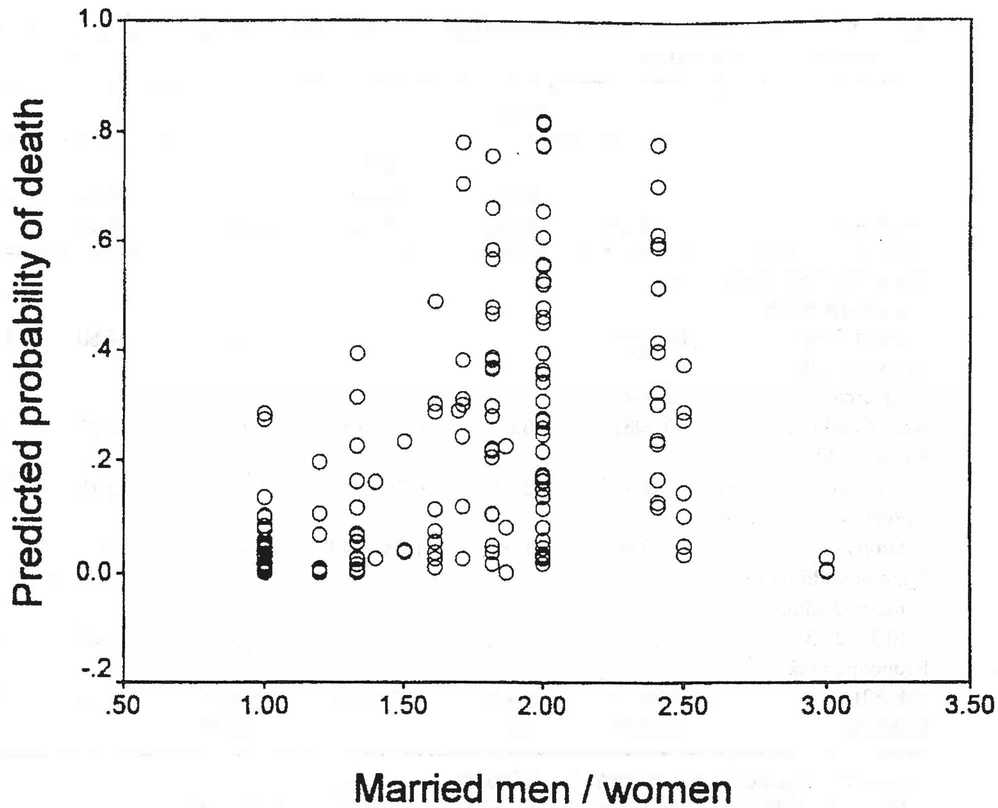

Figure 3.1. The predicted probability of death for each child ($n = 176$) plotted against the polygyny index of the work-eat group. Unlike a simple plot of the percentage of children who died at each level of the index, these predicted probabilities reflect each child's particular values for all the covariates in model 1. Thus, predictors of mortality other than polygyny are controlled.

eat group polygyny (as a continuous variable) was substituted for mother's marital status in the same sample ($n = 130$), the odds of death were 5.1 times higher under polygyny ($p = 0.006$).

Other variables, beyond mother's marital status, that were not significant predictors of mortality are listed in Table 3.3. For example, after controlling for the variables in Table 3.2, no interactions were significant. According to the likelihood ratio test, Sex × Age was marginally significant when polygyny was modeled as a dichotomous variable (Strassmann 1997), but was nonsignificant when polygyny was modeled as a continuous variable (model 1: $p = 0.07$, model 2: $p = 0.16$).

The wealth rank of the work-eat group was positively correlated with the ratio of married females to married males ($r^2 = 0.28$, $n = 45$, $p = 0.0001$) (Figure 3.2). Work-eat groups in which this ratio was ≥1.5 farmed more land ($p = 0.001$), and produced more grain ($p = 0.009$) and onions ($p = 0.002$) than did families in

Table 3.3. Independent variables that did not predict mortality ($p >> 0.05$ after controlling for variables in table 3.1; $N = 176$ children).

Father's age
Mother's age
Number of married women in work-eat group
Number of married men in work-eat group
Whether father resident in village
Whether mother resident in village
Father's education[1]
Whether father had worked in city
Polygyny × Sex
Polygyny × Economic rank
Polygyny × Number of children in family
Polygyny × Ratio of children to adults
Economic rank × Number of children in family
Economic rank × Ratio of children to adults

[1]Although some of the fathers had been to primary school for a few years, none of the mothers had any formal schooling.

which this ratio was <1.5 (Strassmann 1997). When work-eat group wealth was standardized by energy requirements, the polygynous groups were still slightly wealthier than the monogamous groups ($r^2 = 0.09$, $n = 45$, $p = 0.03$) (Figure 3.3) because they had more revenue from onions ($p = 0.01$) (Strassmann 1997). On other measures of wealth, polygynous and monogamous families were comparable (Strassmann 1997).

The dependency ratio provides another estimate of the parental resources (e.g., wealth, time) available to children. As this variable increased by one additional child, the odds of death increased by a factor of 2.9 ($p = 0.02$). However, as shown by model 2, mortality was much higher under polygyny even after controlling for the dependency ratio.

The expected weight/height for each girl or boy was obtained from quadratic regressions of weight/height against age. These equations are as follows: weight/height (Dogon girls) = 9.17 + Age(1.53) + Age^2 (0.10) ($r^2 = 0.74$, $n = 34$, $p < 0.0001$); and weight/height (Dogon boys) = 9.47 + Age(1.98) + Age^2(–0.16) ($r^2 = 0.71$, $n = 43$, $p < 0.0001$). If the children in the polygynous families were leaner than those in the monogamous families, then they should have tended toward negative residuals (observed weight/height < expected weight/height) while the children in monogamous families should have tended toward positive residuals (observed weight/height > expected weight/height). As shown in Figure 3.4, there was a very weak tendency in the predicted direction that was not quite significant ($r^2 = 0.04$, $n = 74$, $p = 0.07$). Controlling for this weak relationship had no effect on the coefficient for polygyny in the subset of observations ($n = 74$) for which weight-for-height measurements were available.

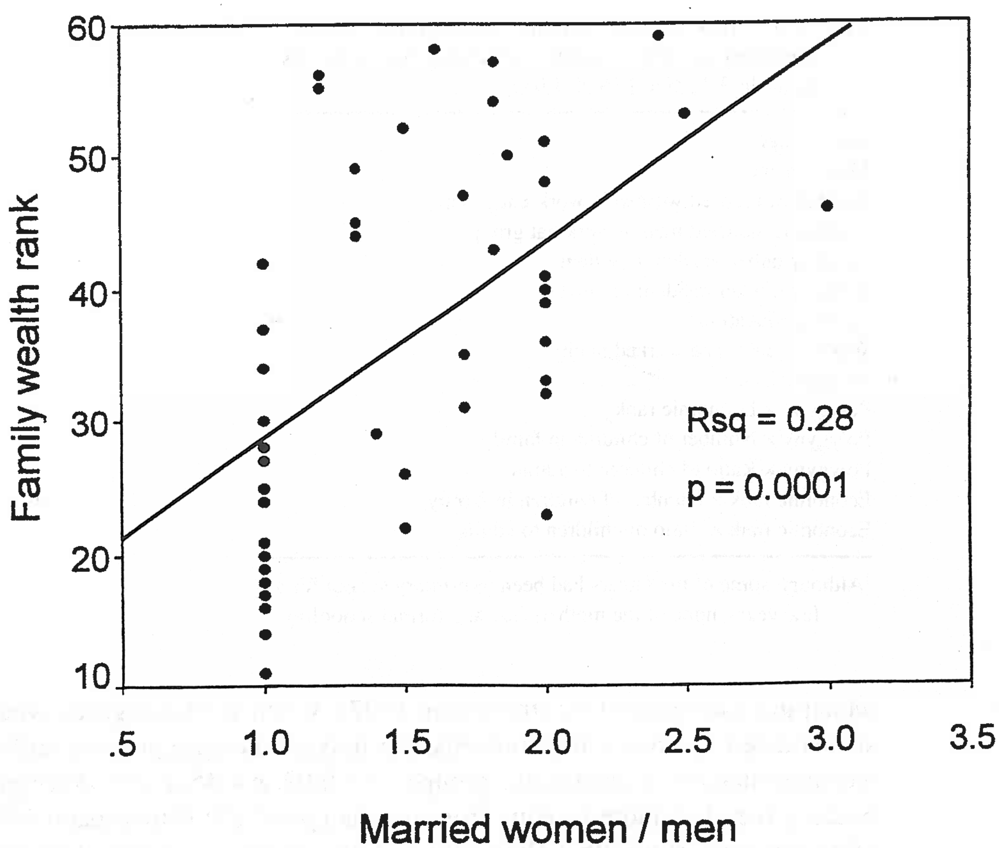

Figure 3.2. Regression of the wealth rank of the work-eat group on the polygyny index (number of married women / number of married men) of the work-eat group ($n = 44$). Groups in which an elderly widow or widower worked alone or with a grandchild are excluded.

The behavioral scan data indicated that the participation of adult males in direct childcare was negligible, regardless of whether a man was monogamously or polygynously married. The difference in the amount of childcare performed by males and females was highly significant ($\chi^2 = 111.7$, df = 1, $p < 0.000001$).

DISCUSSION

A vast, though inconclusive, literature is devoted to the effect of polygyny on fertility, but only a few studies tested the hypothesis that child mortality is higher under polygyny. A limitation of these studies is that they use retrospective data on child survivorship over a woman's reproductive career. Such data may be prone to recall and reporting bias. Another problem is absence of controls for confounding variables: two studies were strictly univariate (Chisholm and Burbank 1991;

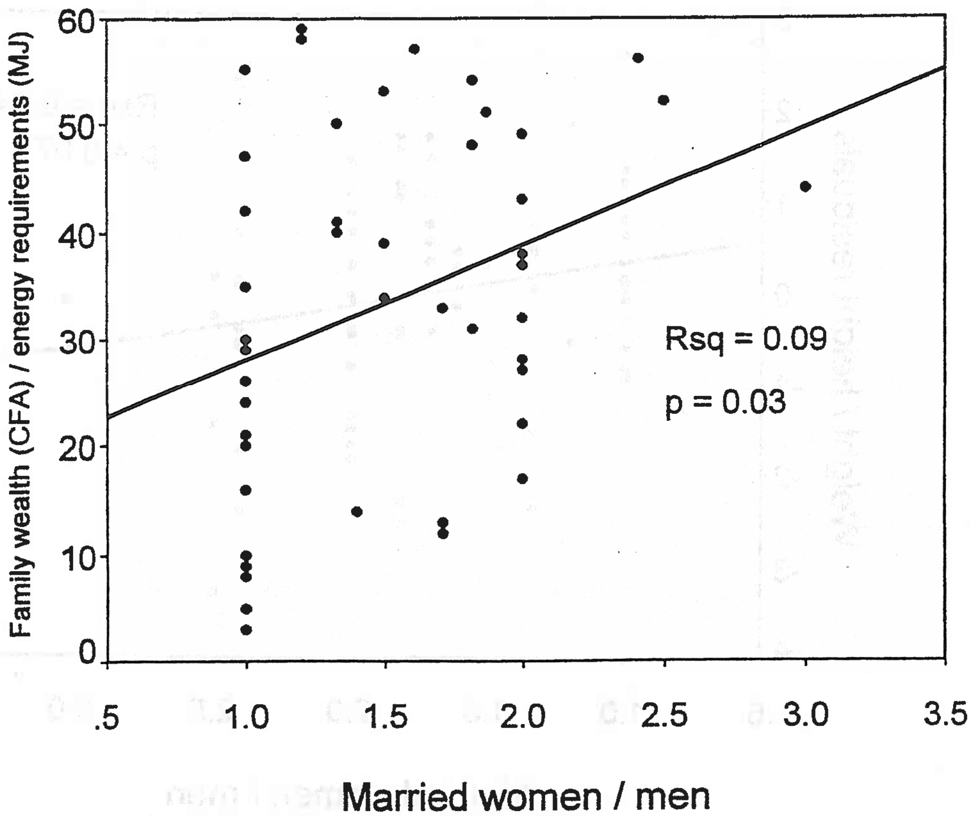

Figure 3.3. Regression of work-eat group wealth (CFA) per work-eat group energy requirements (MJ) on the polygyny index ($n = 45$).

Chojnacka 1980) and two others controlled only for the age of the mother (Isaac and Feinberg 1982; Roth and Kurup 1988). Borgerhoff Mulder (1990) and Chisholm and Burbank (1991) focused on the number of surviving offspring, but in these analyses fertility and mortality are confounded. By contrast with previous studies, the data presented here provide a prospective, longitudinal test of the polygyny-mortality hypothesis. Through logistic regression analysis, other risk factors for mortality were systematically identified and controlled, including age, sex, number of children in the family, ratio of children to married adults, and economic rank.

Before the effect of polygyny on mortality is discussed, it will be helpful to consider these other risk factors. The odds of death decreased by a factor of 0.67 with each additional year of age, and although one might expect the age effect to level off, age-squared was not significant. Consistent with the public health literature, an increase in economic rank was also associated with lower mortality.

The odds of death increased by a factor of 1.26 as family size increased by one additional child (age 0 to 10 years). This result may reflect competition among

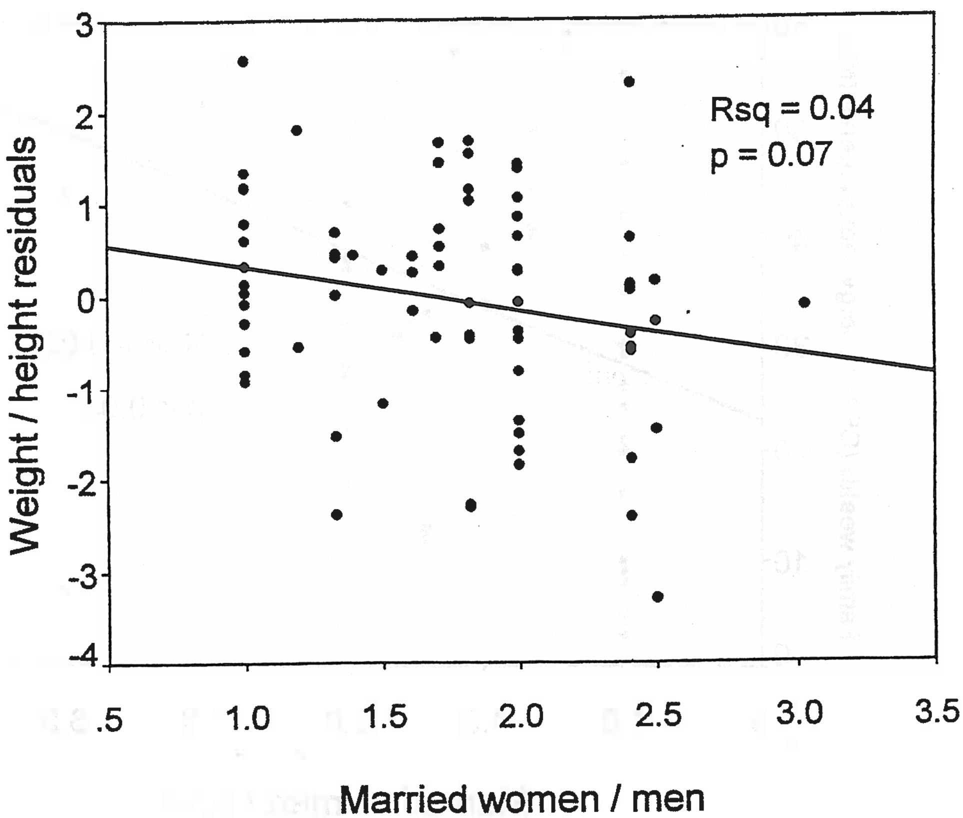

Figure 3.4. Regression of weight for height residuals on the polygyny index of the work-eat group ($n = 74$).

children or increased exposure to infectious diseases such as measles and gastroenteritis (the "daycare effect") (Aaby et al. 1984; Desai 1995). The odds of death increased by a factor of 3.4 as the ratio of children (age ≤ 10 years) to married adults increased by one child. This result could be caused by a decrease in the ratio of net consumers to net producers (Hames 1996). However, resources did not appear to be diluted in the polygynous compared with the monogamous families. Another possibility is that when the ratio of children to adults was higher, each child received less adult supervision.

When polygyny was modeled as a dichotomous variable, the odds of death were 2.5-fold higher for males than for females ($p < 0.05$) (Strassmann 1997). When polygyny was modeled as a continuous variable, the odds of death remained more than twofold higher for males, but this result was not quite significant (model 1: $p = 0.06$, model 2: $p = 0.09$). Nonetheless, the skewed confidence interval for the odds ratio (0.96 to 5.87) (Table 3.2: model 1) suggests that this result is unlikely to be due entirely to chance (see Hosmer and Lemeshow 1989:105).

In the behavioral scans, boys were the recipients of direct childcare significantly more often than girls (correcting for the total number of observations of each sex) ($\chi^2 = 20.9$, df = 1, $p < 0.00001$, $n = 90$ children age ≤ 3 years, $n = 743$ observations). This comparison is restricted to children under 3 years of age because they were the primary targets for direct childcare; they also experienced the greatest level of both overall mortality and sex-biased mortality. The finding that boys received more direct childcare, and ethnographic observations from long-term residence in the village, contradict any suggestion that female-biased parental investment caused boys to have higher mortality.

The Trivers and Willard (1973) effect predicts that wealthy, polygynous families should favor sons more than poor, monogamous families. However, when the children in families above and below the mean wealth rank were analyzed separately, the higher mortality of boys was significant only in the wealthier group (model 1: odds ratio = 3.6, $p < 0.05$, $n = 92$, economic rank > 41). Thus, the higher mortality of boys cannot be explained by the Trivers-Willard hypothesis and remains enigmatic.

After controlling for other risk factors for mortality, the odds of death were significantly higher in polygynous than in monogamous work-eat groups. This was true regardless of whether polygyny was modeled as a dichotomous (see Strassmann 1997) or a continuous (Table 3.2) variable. In the multivariate analyses, mother's marital status was substantially less useful for predicting mortality than the polygyny index for the work-eat group as a whole, a result that underlines the importance of family structure. When members of a patrilineal extended family are economically interdependent, children are affected by the polygyny status of their paternal relatives, not just that of their own parents.

Although these results provide the strongest evidence to date that polygyny is a risk factor for mortality, they leave the underlying mechanism unidentified. Prior to the fieldwork, I expected wealth to be diluted in polygynous compared with monogamous families. The economic and the anthropometric data, however, did not support this hypothesis. Polygynous families were at least as wealthy as monogamous families even after correcting for family size. Weight-for-height residuals declined slightly with the ratio of married women to married men, but even after controlling for this weak effect, polygyny remained highly predictive of mortality. Thus, the relationship between polygyny and mortality in this study appears to be caused by a mechanism other than resource dilution.

The indigenous Dogon explanation is that in their competition to outreproduce each other, co-wives sometimes poisoned each other's children. Boys were said to be more at risk than girls. This belief took expression most forcefully at masked dance rituals in which the men obliged all of the women of the village to assemble for collective chastisement. Future offenders were threatened with death. Malian court cases provide compelling documentation of confessions and convictions for poisoning the offspring of a co-wife. Such cases can be compared with records of child abuse in the United States. Children have about 100 times the risk of death from child abuse if they live with a stepparent rather than with two genetic parents (Daly and Wilson 1988:89), but the baseline rate is still very low. The incidence of poisonings among the Dogon is unknown, but it might be premature to dismiss all such accusations as fictive sorcery. Even if poisonings are rare or absent, fear of mother's co-wife must be a source of stress. Residence with a step-father and half siblings can affect childhood cortisol levels and lead to immuno-suppression and illness (Flinn and England 1995). Regardless of whether female-female competition results in outright poisoning, immuno-suppression, or simple neglect, the focus on co-wives alone is too narrow. Work-eat group polygyny was a better predictor of survivorship than mother's marital status, implying that if female-female competition results in child mortality, it may not stop with co-wives. Instead it may extend to women married to a set of brothers.

An alternative hypothesis is that polygynous men provide less paternal care to each of their offspring (see Hewlett 1988; Strassmann 1981). Monogamous fathers have fewer children, so each child is a larger component of a father's life-time reproductive success. Monogamous fathers also tend to be poorer, and are less likely to have future mating opportunities. In their behavior toward their children, they may act as if more is at stake. Polygynous fathers eventually produce a greater number of offspring, so each child represents a smaller fraction of the father's total lifetime reproductive success. Controlling for age, polygynists (aged 24 to 69) had on average two more living offspring for each additional wife ($r^2 = 0.25$, $n = 70$, $p = 0.0001$).

Children whose fathers had more offspring did not have higher odds of death. Thus it does not appear that polygynous men simply spread their investment among a greater number of existing children. Instead they might have diverted resources from paternal effort to mating effort, and gained increased prospects for producing future offspring. If their resources were diverted to somatic effort (buying meat or beer in the marketplace), then polygynous males did not pursue an optimum fitness strategy. Clearly, a great deal more needs to be learned about the allocation of effort on the part of polygynous and monogamous men.

What might polygynous men have withheld from their children that was important for survivorship? Both polygynous and monogamous men left most of the direct childcare to women (see Draper 1989; Hewlett 1991), so it is doubtful that there was a critical deficit in time spent with children. Another possibility is that polygynous men were less willing to pay for costly medical care. Given the prevalence of parasitic and infectious diseases, differential access to medical care could have a dramatic impact on mortality. This hypothesis should be tested after controlling for any differences in morbidity under monogamy and polygyny.

A shortcoming of the paternal care hypothesis is that it does not explain why work-eat group polygyny was a better predictor of child survivorship than parent's marital status. One solution is to broaden the paternal investment hypothesis to include the nepotistic investment of relatives other than fathers. Men in polygynous work-eat groups may have been less inclined to pay for medicines and other treatments for childhood illnesses. The father himself was not necessarily the one who withheld investment. Instead it might have been the child's uncle, particularly if he was the work-eat group boss. The Dogon described the relationship between a boy and his paternal cousins as one of competition and distrust, whereas his relationship with his maternal cousins (with whom he was not in competition for resources) tended to be amicable and relaxed. Conflicts of interest between paternal relatives often became sufficiently intense that the entire work-eat group fissioned along lines of genetic relatedness (see Chagnon 1981). In future research, it would be useful to explore these conflicts of interest further, and to determine how they might influence nepotistic investment in children (see also Castle 1993). This line of inquiry appears promising because, after controlling for the covariates in model 2, the odds of death were 74% lower for children whose father or grandfather was work-eat group boss rather than the child's uncle (odds ratio = 0.26, 95% confidence interval = 0.09–0.77).

Given the high mortality of children in polygynous work-eat groups, it appears likely that, when all else was equal, Dogon women achieved higher fitness under monogamy. To test this proposition, it would be useful to compare the number of surviving grandchildren for women in polygynous and monogamous groups (Josephson 1993). However, although it is easy to make such a comparison, it is difficult to make it well. A woman's marital status at the time she is censused cannot simply be compared to her number of grandchildren because her marital status may have changed. Instead one needs to track marital status and work-eat group polygyny retrospectively over the course of a woman's marital life. Any changes make it difficult to determine the polygyny or marital status relevant to a particular grandchild. One approach is to restrict the sample to women who had been in no more than one marriage. But child mortality can be a cause of divorce, so these women are likely to be those whose children survived. In such a biased sample, it may be difficult to detect any effect of polygyny. Another problem in retrospective studies is the difficulty of controlling for confounding variables such as age, family size, and wealth. To make matters worse, these variables change over time. To date, no retrospective study has fully surmounted these difficulties (see Borgerhoff Mulder 1988, 1996; Josephson 1993).

The problem of time-varying covariates is less severe in a prospective analysis such as this one because changes in the independent variables can be more easily monitored and taken into account. These changes are also likely to be smaller because of the shorter time span involved. Whereas retrospective studies of postmenopausal women span several decades, this study spanned only eight years. Nonetheless, to find out if the changes that did occur might alter my conclusions, I constructed alternative models that used either the value of the variable at the beginning of the study or the value at the end. For example, I compared the ratio of married women to married men at the beginning and end of the study and found that the results were essentially the same. A better approach is to use survival analysis with time-varying covariates, but this method will not work with a dichotomous dependent variable (lived or died). Future studies of child mortality should gather data on age at death so that survival analysis can be employed.

In view of the high mortality of children in polygynous families, why are women willing to become junior co-wives? Prior to the fieldwork, I predicted that women who entered marriage as a second or third wife were of lower mate value. However, contrary to this prediction, the monthly probability of conception was not associated with marital status. Junior co-wives were just as fecundable as senior wives and monogamously married women (Strassmann and Warner 1998). Nor was there a relationship between a woman's marital status and her nutritional status based on standard anthropometric indices such as weight for height and sum of skinfolds (Strassmann, unpublished data). Moreover, contrary to expectation, the decrease in survivorship was greatest for the offspring of first wives, not second or third wives (Figure 3.1). Because of the prospective study design, this result cannot be attributed to a tendency for husbands to marry a second wife if many children by the first wife died. In sum, the hypothesis that women of lower fitness were relegated to polygynous marriages was not supported.

Instead, it appears that many young, well-nourished, fecund women were forced into polygynous situations simply because there were too few monogamous opportunities available. The shortage of monogamous opportunities was caused by the excess of women relative to men on the marriage market. Dogon wives were on average eight years younger than their husbands. This difference in age at marriage, in conjunction with the pyramidal age-structure for the population, ensures that the cohort of women looking for husbands is larger than the cohort of men looking for wives. Many women are thereby forced into polygyny (Chisholm and Burbank 1991; Dorjahn 1959; Pison 1985). The tendencies for men to marry at a later age and to die at a younger age generate a surplus of widows relative to widowers. Among the Dogon, these widows generally remarried even after menopause, which also produces a surplus of women on the marriage market (Pison 1985), regardless of the age-structure of the population. Last, Dogon polygyny is promoted by a female-biased operational sex ratio (Dorjahn 1959). In this study, the skew was caused by higher male mortality and urban migration.

Even girls who succeed at entering monogamous marriages and work-eat groups have no guarantee that monogamy will prevail. The Malian government has acknowledged their predicament by passing a law that requires all men who contract civil marriages to commit themselves, on paper at least, to either monogamy or potential polygyny. Not surprisingly, few men choose to limit their options. If a woman seeks to avoid polygyny, her most effective tactic is divorce, or the threat of divorce. Both men ($n = 71$) and women ($n = 113$) interviewed in Sangui emphasized that divorce was primarily female-initiated (Strassmann 1997). In a sample of 88 divorces, the wife said that she had been the initiator in 95% of divorces, and the four most frequently cited reasons were: (1) husband pursuing wage labor in the city (25%), (2) dislike of husband (18%), (3) dislike of co-wife (10%), and (4) too many children died in that marriage (6%). Forty-one percent of divorces were attributed to miscellaneous other reasons, each of which was less commonly cited than the above. Although women may resist polygyny through divorce, few escape it entirely. In preparation, young girls are taught to sing, "I'm not afraid of my husband's other wife."

SUMMARY

1. This study tested the effect of the polygyny index on child survivorship from 1986 to 1994. The polygyny index was defined as the ratio of married women to married men in the family, and ranged from 1.0 to 3.0. As this ratio increased by one, the odds of death for Dogon children ($n = 176$) increased approximately 4.6-fold.

2. By contrast with previous analyses, this study employed a prospective design and controlled for other predictors of mortality, including age of the child, sex of the child, number of children in the family, the dependency ratio of the family, and economic status.

3. Mother's marital status (first, second, third, or sole wife) predicted child mortality in univariate analyses. In multivariate analyses, however, only the polygyny index for the family as a whole was critical. This result suggests that when members of a patrilineal extended family depend on one another economically, child survivorship is influenced by the polygyny status of paternal relatives. Family structure, not simply the marital status of parents, needs to be taken into account.

4. Hypotheses regarding the mechanism through which polygyny adversely affects child survivorship need to consider the roles of resource dilution, co-wife competition, paternal investment, and nepotistic investment. The data did not support resource dilution, but it is premature to exclude any of the remaining possibilities.

5. Becker's economic model and the polygyny threshold model view polygyny as the outcome of female choice. However, the eight-year difference in the age of spouses generates a surplus of Dogon females on the marriage market, obliging many wives to accept polygyny. Dogon men who achieve polygyny gain reproductively while their wives lose (at least in the offspring generation), implying that male preference is more likely to be the driving force behind this marriage system.

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