Maternal Stature, Fertility and Infant Mortality

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ABSTRACT

The relationship between maternal stature, parity, offspring mortality and number of surviving children was investigated in 380 malnourished Guatemalan Indian women. Maternal stature averaged 142 cm, maternal age 28 years, and parity and number of surviving children 4.4 and 3.0 respectively. Shorter women tended to have greater parities but fewer surviving children; these relationships were not statistically significant ($p > .05$). However, after adjusting for age, and/or parity, the association between maternal stature and number of surviving children became statistically significant ($p < .05$). Mortality rates were higher for children of shorter mothers and this finding was unchanged by adjustments for maternal age and parity ($p < .001$). Specifically the infant mortality rate (deaths per 1000 live born) for the children of the shortest third of the mothers was 209, for the middle group the rate was 148 and for the tallest third it was 99. One explanation for the findings is that shorter women compensate for the greater mortality of their children by having more children but not to the extent of having more surviving children.

Human biologists as well as public health professionals have been quite interested in the relationship between maternal body size, fertility, and offspring survival. Human biologists have concentrated on describing fertility differentials associated with variations in body size and shape and have attempted to assess the evolutionary implications of these relationships. Those more interested in public health have instead focused on determining whether the prevalence of low birth weight (<2.5 kg) and infant mortality rates are associated with maternal anthropometric characteristics in order to develop simple ways of identifying high risk cases.

This paper uses data on poor and malnourished Guatemalan Indian women to address questions of interest to both human biologists and public health professionals. Using maternal stature as a general indicator of maternal body size, the analyses are guided by three questions: (1) Is there a relationship between maternal size and parity? (2) Are mortality rates in children associated with maternal size? (3) Is the number of children who survive a function of maternal size?

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Materials and Methods

The data used come from studies carried out in collaboration with the Institute of Nutrition of Central America and Panama (INCAP). The study subjects were Indian families working and living in coffee plantations of the Pacific lowlands of Guatemala. Surveys by INCAP showed that there were high prevalences of severe and moderate malnutrition and of infectious diseases, particularly among infants and young children. Corn was the dietary staple and an analysis of dietary data indicated energy was more limiting than protein in this area (Martorell et al. 1979). There was much uniformity in socioeconomic conditions due to the fact that all heads of household were agricultural laborers who received the minimum wage decreed by law. As residents of plantations, families were provided with a hut, some corn, and little else. With the arrival of INCAP, an ongoing program of curative and preventive services became available.

The key subjects are the 380 women of parity 1 or more who participated in a study of nutrition and fetal development during the 18-month period from October 1977 to March 1979.[3] Maternal stature and reproductive histories were collected as part of the battery of tests given to pregnant women. Births and deaths were verified against records in over 80 percent of cases.

Ranges, means and standard deviations for key variables are shown in Table 1. The mothers of this study were very short, averaging 142 cm or 4 feet 8 inches. Average age was 28 years, average parity was 4.4 children per woman and the average number of surviving children per woman was 3. Parity, the number of dead and surviving children, and mortality figures, it should be pointed out, reflect the status at the time of the interview and hence do not include the outcome of the pregnancy for which these women were being studied by INCAP. The absolute number of children who died by 1, 2, and 5 years of age as well as the corresponding mortality rates are also shown in Table 1. As all children born to the study women could have lived to 1 year of age by the time of the interview, infant mortality figures are accurate. On the other hand, mortality figures for 2 years and 5 years are underestimates because, at the time of the interview, some of the children were younger than 2 years of age and even more were younger than 5 years of age. Infant mortality is therefore the key mortality variable of this paper.

[3]The population is more precisely defined as that of women of parity 1 or more who gave birth to a live baby from October 1977 to March 1979 and whose pregnancy could have been monitored from the fifth to the ninth month of pregnancy during the same 18-month period.

Table 1

Means and Standard Deviations for Key Variables (n = 380)

Variable	Range		Mean	Standard Deviation
	Minimum	Maximum		
Stature (cm)	126.3	158.6	142.4	5.3
Head circumference (cm)	47.8	55.7	51.5	1.2
Age (years)	15	47	28.4	6.8
Parity	1	12	4.36	2.64
Number surviving children	0	10	3.00	2.00
Number dead by 1 year	0	5	0.71	0.97
Number dead by 2 years	0	8	1.01	1.24
Number dead by 5 years	0	8	1.23	1.37
Infant mortality[a]	0	1000	152	216
Mortality by 2 years[a]	0	1000	215	261
Mortality by 5 years[a]	0	1000	255	271

[a] Mortality rates are expressed per 1000 live born.

Results

Standardized regression coefficients, or beta weights, for regressions of family size and mortality variables (dependent variables) on maternal stature (independent variable) and age and parity (confounding variables) are shown in Table 2. As additional background material the intercorrelation matrix for all variables is shown in Table 3. The unadjusted beta weights, shown in the first column of numbers in Table 2, are numerically equal to the simple correlations between maternal stature and the dependent variables which appear in Table 3. These unadjusted beta weights or simple correlations indicate that maternal stature is not related to parity or to the number of surviving children. On the other hand, the taller the mother the lower are the childhood mortality rates. Adjusting for age and parity in multiple regressions, as shown in the last three columns of numbers in Table 2, only changes the relationship with one variable, number of surviving children. After controlling for either age or parity, taller women do seem to have a greater number of surviving children. Finally, the relationship between maternal stature and the mortality variables is not affected by age and parity.[4]

[4]Similar analyses as for stature were carried out for maternal head circumference. The unadjusted beta weights suggested that women with larger head circumferences had slightly higher parities and more surviving children. These associations, however disappeared after

Table 2

Regression of Family Size Variables and Mortality on Maternal Stature, Adjusted for Age and Parity (n = 380)

	Standardized Regression Coefficients (Beta Weights)[a]			
Dependent Variable	Unadjusted	Adjusted for Age	Adjusted for Parity	Adjusted for Age and Parity
Parity	−.07	−.03	n.a.	n.a.
Number surviving children (NSC)	.05	.09[b]	.11[c]	.11[c]
Number dead by 1 year (ND1)	−.24[c]	−.23[c]	−.21[c]	−.21[c]
Number dead by 2 years (ND2)	−.23[c]	−.21[c]	−.19[c]	−.19[c]
Number dead by 5 years (ND5)	−.24[c]	−.22[c]	−.19[c]	−.19[c]
Infant mortality (IM)	−.19[c]	−.20[c]	−.19[c]	−.19[c]
Mortality by 2 years (M2)	−.21[c]	−.22[c]	−.21[c]	−.20[c]
Mortality by 5 years (M5)	−.24[c]	−.24[c]	−.23[c]	−.23[c]

[a] The relationship between beta weights and unstandardized regression coefficients is given by:

$$B_{yx} = b_{yx}\left(\frac{S_x}{S_y}\right)$$

Where B_{yx} is the beta weight, b_{yx} the unstandardized regression coefficient, S_x the standard deviation of X, and S_y the standard deviation of Y. Standard deviations for all variables are given in Table 1.

[b] $p < .05$.

[c] $p < .01$.

n.a. = not applicable.

The distribution of maternal stature was divided into terciles as shown in Table 4. As shown at the bottom of Table 4, the percent of children surviving 1 year of age was 77 for the lower tercile but 89 for the upper tercile. Similarly, the percent of children still alive at the time of the interview was 62 for the lower tercile but 74 for the upper tercile. The probability of survival for individual children is clearly greater for children of taller mothers.

The question whether parity, the number of previous deliveries, differs by maternal stature is addressed in Table 5. Parity values were 4.75

controlling for age and/or parity. Finally, though there was clearly a tendency for a negative association between head circumference and mortality variables, the relationships were weak and unimpressive in comparison to the ones observed for maternal stature in Table 2. This suggests that maternal stature is a far more important obstetric risk indicator than maternal head circumference.

Table 3

Matrix of Intercorrelations[a]

	Stature	Age	Parity	NSC	ND1	ND2	ND5	IM	M2	M5
Stature	—									
Age	−.05	—								
Parity	−.07	.80	—							
NSC	.05	.71	.83	—						
ND1	−.24	.30	.47	.08	—					
ND2	−.23	.37	.55	.09	.85	—				
ND5	−.24	.45	.64	.16	.79	.93	—			
IM	−.19	−.05	.08	−.23	.76	.59	.51	—		
M2	−.21	−.04	.10	−.28	.63	.72	.63	.82	—	
M5	−.24	.02	.17	−.25	.60	.69	.71	.76	.93	—

[a] See Table 2 for definition of variable codes. As the sample size is 380, all correlations greater than .10 are statistically significant at the 5% level.

Table 4

Terciles of Maternal Stature: Definition and Sample Sizes

	Terciles of Height		
	Lower	Middle	Upper
Stature (cm)			
Mean	136.7	142.0	148.2
Range	126.3-140.2	140.3-144.7	144.8-158.6
Age (years)[a]			
Mean	29.0	27.9	28.2
Range	15–42	17–44	17–47
Number of mothers	127	124	129
Total number of children born to each group	603	509	545
Total number dead by 1 year of age	137	75	58
Total number dead after 1 year of age	91	71	84
Total number alive at time of interview	375	363	403
Percent of children surviving 1 year of age[b]	77	85	89
Percent of children alive at time of interview[c]	62	71	74

[a] Differences between groups not statistically significant ($F = 0.5$, $p > .05$).
[b] (Total number dead by 1 year/total number of children born) × 100.
[c] (Total number alive at time of interview/total number of children born) × 100.

Table 5

Parity, Number of Surviving Children, and Mortality Rates by Maternal Stature Tercile

	Terciles of Stature			Analysis of Variance: Main Effects	
	Lower (n = 127)	Middle (n = 124)	Upper (n = 129)	F	p
Parity					
Unadjusted	4.75	4.10	4.22	2.1	.12
Adjusted for age[a]	4.56	4.24	4.27	1.6	.20
Number surviving children					
Unadjusted	2.95	2.92	3.12	0.4	.70
Adjusted for age[a]	2.83	3.02	3.15	1.7	.18
Adjusted for age and parity[a]	2.71	3.09	3.20	7.2	.001
Infant mortality					
Unadjusted	209	148	99	8.7	<.001
Adjusted for age and parity[a]	205	150	101	7.9	<.001
Mortality by 2 years					
Unadjusted	284	208	153	8.4	<.001
Adjusted for age and parity[a]	278	211	156	7.6	<.001
Mortality by 5 years					
Unadjusted	332	249	184	10.0	<.001
Adjusted for age and parity[a]	322	255	188	8.8	<.001

[a] Means adjusted for the specified metric covariates using the SPSS multiple classification analysis (MCA) program.

for the lower tercile, 4.10 for the middle tercile, and 4.22 for the upper tercile. Adjusting for age (see footnote to Table 5) reduces the differences between groups to a considerable extent. It should be noted that the relationship between maternal stature and parity is not statistically significant either before or after controlling for age.

Table 5 also answers the question whether the number of surviving children per woman, the most meaningful measure of fertility, varies by maternal stature. The unadjusted values indicate a tendency for more surviving children in the taller group. Controlling for age as a metric covariate increases this tendency but still the statistical significance remains below accepted levels. Once both age and parity are controlled for, the number of surviving children becomes clearly related to maternal stature, the number of surviving children being 2.71 for the lower tercile, 3.09 for the middle tercile, and 3.20 for the upper tercile. Clearly, women of the same age and parity, but who are taller, will have more living children.

If taller mothers tend to have fewer children but more surviving children, the mortality rates should be higher in children from shorter mothers. This is indeed the case as shown in Table 5. Infant mortality rates are very high for the lowest tercile of stature, over 200 deaths per 1,000 live born. Rates drop by 50, to 150 per thousand, in the intermediate group. Again, rates drop by 50, to 100 per thousand, in the upper tercile. Even the tallest group of mothers have high infant mortality rates. (The infant mortality rate in California's San Francisco Bay Area is 17 per thousand by comparison, Puffer and Serrano, 1973.)

The mortality rates corresponding to each tercile were adjusted by the metric covariates maternal age and parity as shown in Table 5. The similarity between unadjusted and adjusted values indicates that age and parity do not explain the negative relationship between maternal stature and infant mortality. Finally, the pattern of relationships observed for infant mortality is also maintained for mortality by 2 and 5 years of age.

Discussion

The results shown can be discussed in light of the concerns of human biologists and the concerns of public health professionals.

Evolutionary Implications

Over the years, many researchers have looked at the question of height and fertility. Who contributes more to the next generation: short, average, or tall people? The appropriate variable for this question, as Mueller notes, is neither parity, nor percent survival but number of living children (Mueller, 1979). Dwarfs and giants, as Lasker and Thomas (1976) point out, have low fertilities. With regards to what could be called "normal variation," the literature is not in agreement. Some researchers found no relationship (Lasker and Thomas, 1976; Damon and Thomas, 1967), others found shorter women to have higher fertility (Clark and Spuhler, 1975), and others suggest instead that the relationship is shaped like an arch or a normal curve, with those of average stature being favored, the very short and very tall having reduced fertilities (Vetta, 1975; Mitton, 1975; Mueller, 1979).

In comparing our findings to those of others, two aspects should be kept in mind. First, we studied a population that had little variability in socioeconomic status. They were all agricultural workers paid the same low wages. Secondly, we studied a chronically malnourished population with maternal heights at the lower end of the distribution. There are shorter populations in the world, but probably not many and probably not very much shorter. In this restricted range of variation, we found that mortality was significantly greater for children of shorter women. We also observed a tendency for shorter women to have greater parities (not statistically significant; Tables 2 and 5). Perhaps this reflects conscious efforts by shorter women to have more children to compensate for greater child losses. In addition (or alternatively), the cessation of breastfeeding brought on by the death of an infant may have hastened the return of menstruation, shortened the interval between births, and thus increased parity. If indeed shorter women had greater parities, it was not to the extent that they fully compensated for the higher mortality rates in their children because shorter women had fewer living children. After adjusting for either age, parity or both, the relationship between maternal stature and number of living children became statistically significant (Tables 2 and 5). For example, after adjusting for age, women in the top third of the distribution had 3.15 living children in comparison to women at the bottom third of the distribution who had an average of 2.83 children. In conclusion, it appears that taller women contribute more to the next generation in this population.

It is conceivable that our findings are consistent with the hypothesis that the relationship between fertility (i.e., number of surviving children) and maternal stature has the shape of the normal curve. The range we studied may correspond to the lower left half of the curve where a positive association between maternal stature and the number of living children would be expected.

Public Health Significance

The public health significance of our results rests on much more solid ground. Our data in this paper, combined with our earlier work on different Guatemalan populations (Lechtig et al. 1975, 1976), as well as the previous work of others (Furusho, 1964), clearly show that mortality is greater in children of shorter mothers. After standardization to the average age of 28.4 years and the average parity of 4.4 children, we estimate that an average of 1.6 children of mothers in the shortest tercile had died before five years of age. This compares to only 1 death in children of mothers in the tallest tercile. The difference is highly significant in both human and statistical terms. There is no basis for the claim, therefore, that in malnourished societies the child of a shorter mother is more likely to survive (Frisancho et al. 1973). The situation is exactly the opposite.

Some of the mechanisms linking maternal stature and offspring survival are known. Taller women generally have heavier babies. In our data, women in the shortest tercile delivered babies weighing 2.845 kg (n = 115), those in the middle group had babies weighing 2.998 kg (n = 111), and those in the tallest tercile had babies weighing 3.016 kg (n = 116). The relationship was statistically significant by analysis of variance (pooled S.D. = 0.466; F = 4.69, p = .0098), Birthweight differences of this magnitude (i.e., 170 gm difference between upper and lower tercile) may explain much of the mortality gradient observed.

Finally, our data indicate that maternal height can be used to identify infants at high mortality risk. Maternal stature is an ideal risk indicator because it can be measured at any time during pregnancy, or even before pregnancy, avoiding therefore the need to correct for gestational age and the problem of serial measurements as in the determination of weight gain. This is a great advantage in developing nations where many women may be examined no more than once during pregnancy.

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