Child Mortality Differentials in Sudan

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Sudan presents an excellent opportunity for studying mortality conditions in poor countries. According to UN designation, it is one of the 25 "least developed" countries, most of which have very little information on mortality and general health conditions. As the largest African country in the area, Sudan is also a land of rich ecological contrast, stretching from desert areas in the North through savannah areas to dense equatorial jungle in the South (see map). The northern portions are Arabic and Islamic, the southern portions black African. The 1955/56 census enumerated 597 tribes speaking some 115 languages. Aridity in the North and swamps in the South have retarded the development of these areas and fostered nomadism; population concentration is greatest in the middle belt and particularly along the Nile and its tributaries.

Sudan has two useful bodies of data that can be exploited for studying its basic mortality conditions. One is the census of 1973, from which a large sample of household records has been constructed. The second is an investigation of Khartoum conducted by the Changing African Family Program, under the direction of John C. Caldwell. The former source provides broad social and geographic coverage, while the latter allows more intensive investigation of certain factors believed to affect levels of mortality.

Estimates of regional differences in mortality

Tabulations from the 1973 census (Sudan, 1977) permit the estimation of child mortality levels based upon Brass-type procedures, which convert data on children ever born and surviving into estimates of conventional life table measures. Questions on number of children ever born and children surviving were asked

of all urban women and of a 10 percent sample of rural women. All results presented here are weighted to provide national representativeness.

Table 1 presents basic information on the probability of dying before age 2, q(2). Figures in the table and hereafter refer only to the settled population of Sudan and exclude nomads, 11 percent of the total population. These estimates are based on the proportions dead among children ever born to women aged 20–24, converted into probabilities of death.[1] Regional estimates of q(3) and q(5) are very consistent with those of q(2), generally being somewhat higher, as expected.

Sudan

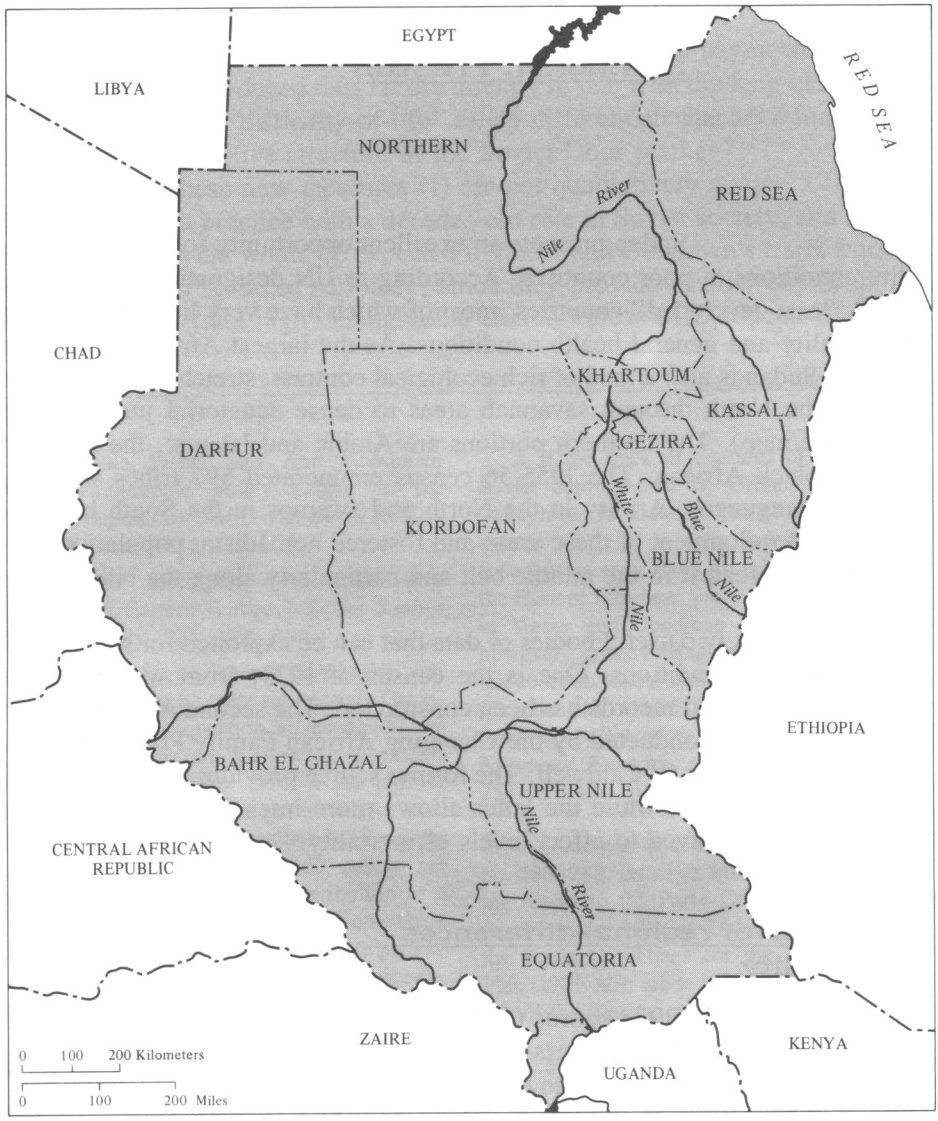

TABLE 1 Estimates of q(2) and life expectancy at birth for regions and provinces of Sudan, 1955/56 and 1973

Province/ region	Estimates based on 1955/56 census[a]		Estimates based on 1973 census[b]	
	q(2)	Life expectancy	q(2)	Implied life expectancy
Khartoum	0.145	48.63	0.121	52.46
Northern	0.147	48.32	0.143	49.05
Blue Nile	0.154	47.28	0.147	48.32
Kassala	0.157	46.84	0.136	50.02
Darfur	0.154	47.28	0.148	48.07
Kordofan	0.158	46.69	0.176	44.11
Red Sea			0.159	46.59
Upper Nile	0.252	34.41	0.241	35.69
Bahr El Ghazal	0.255	34.06	0.253	34.21
Equatoria	0.266	32.86	0.207	39.90
Northern Region			0.141	49.29
Southern Region			0.234	36.43
All-Sudan	0.183	43.09	0.170	44.85

[a]Derived from Demeny (1968) by applying North model life table to estimate both q(2) and the corresponding e_0 from Demeny's estimates of provincial death and growth rates.
[b]Derived from Sudan (1977) by applying North model life tables to estimated life expectancy from q(2). q(2) estimates based on Trussell's North equation applied to proportion dead among children ever born to women aged 20–24.

It is clear from Table 1 that there are enormous regional differences in child mortality in Sudan. As a group, the three southern provinces—Upper Nile, Bahr El Ghazal, and Equatoria—have levels of child mortality that are roughly 66 percent higher than the northern provinces. These differences, in conjunction with "North" model mortality patterns, are consistent with a difference of about 12 years in life expectancy at birth between North and South. Khartoum province, containing the capital city, has the lowest estimated level of child mortality. The estimates of regional and national child mortality levels are similar to those that can be made using the "North" model in conjunction with Demeny's (1968) regional estimates of general mortality levels based on the 1955/56 census. However, in the absence of Brass-type data, Demeny was forced to use strong assumptions of stability and tribal closure and homogeneity. The lack of any decisive mortality trend over the 1955–73 period is also suggested by an analysis of proportions dead among children of women at other ages using Feeney's (1980) procedure (Farah, 1981). Although the evidence is not very good, it suggests that mortality in Sudan has not improved at anywhere near the pace that has come to be accepted as normal in developing countries. The absence of improvement is consistent with evidence that the prevalence of malaria has increased with the spread of irrigation in the past several decades. Judged by visits to health units, malaria is the most serious health problem in Sudan, afflicting particularly the southern region. Nearly 1 million cases of malaria (in a population of 14.9 million) were treated in health units in 1974 (WHO and Government of Sudan, 1977). In the Gezira area, the

heart of the agricultural sector, the prevalence rate of malaria among children increased from 3 percent in 1962 to 20 percent in 1974, an epidemic year (ILO, 1976: 139).

The sharp regional differences in q(2) are highly correlated with other socioeconomic and health indicators. For the ten provinces, the correlation between q(2) and per capita income is −.97; with adult female literacy rates it is −.80; with population per doctor it is +.90. It is not surprising to find that the most disadvantaged areas in other respects also have the highest mortality. But ten observations are certainly too few to permit analysis of the factors that are most closely associated with mortality levels. Fortunately, a sample of household-level census returns is available to permit a more detailed analysis.

Factors influencing child mortality levels among Sudanese households

A "determinant" of mortality can be defined as a variable that would change a population's mortality level if its own value were altered. This definition is broad enough to encompass the proximate biological determinants of mortality (e.g., nutritional intake, exposure to disease) and the socioeconomic and cultural factors that operate indirectly through the proximate factors. Some of the socioeconomic and cultural factors are themselves arranged hierarchically. Increased levels of education, for example, may alter many other features of a household's living conditions such as knowledge of proper health practices, income levels, sexual balance of power, and access to health facilities (Caldwell, 1979).

Many of the determinants of child mortality are properties of the household in which the child is located. These include levels of household income, adult literacy, health practices among members, sanitary facilities, and so on. Other determinants are properties of the "community" of households: organization of the health care system; ecological characteristics such as climate, rainfall, presence of disease vectors; distribution of land and resources.

Unfortunately, in the census sample we are unable to measure the value of many of the main variables that would be of interest. Two central issues in mortality analysis can be effectively addressed, however: the role of parental—and particularly maternal—education in reducing infant and child mortality and whether the regional mortality differences identified earlier are a product of differences in the distribution of households' socioeconomic characteristics among the regions or whether they persist independent of this distribution. Several other issues and controversies in mortality analysis can also be addressed with the Sudanese data.

This analysis is based on data for females aged 15–49 in the 1973 census. As noted above, questions on children ever born and children surviving were asked of all urban women and a 10 percent sample of rural women. From a census tape containing all of these responses, we have extracted a sample of 10 percent of all households. Thus, our sample of 42,586 women retains the over-

weighting of urban areas. However, each observation will be weighted by a factor assigned by the Sudan Census Office that averages unity for urban residents and 10 for rural residents. Currently married women were matched with husbands through relation-to-head codes, and some error in making these matches is unavoidably present in the data.

Maternal education

Caldwell (1979) and Preston (1978) have argued that advances in female education may represent a potent and cost-effective means of reducing child mortality. Behm (1976–78) presents abundant information suggesting that maternal education powerfully differentiates among child mortality levels in Latin America, and Cochrane (1980) compiles confirmatory evidence from other regions. Sudan is one of the least advanced countries in female education; mothers in our sample (i.e., women weighted by their births) had an average of only 0.3 years of schooling, while fathers had 0.8 years. The limited opportunity for observing the effects of education suggests that maternal education plays an important role in Sudan. Table 2 presents cumulative probabilities of dying according to mother's years of schooling in Sudan. For all ages the ratio of cumulative mortality for those with no schooling to those with 7+ years is greater than 2:1, and the relations are all monotonic; that is, they invariably decline as education is increased. The ratio of q(x)s in the table falls into the middle range of those tabulated by Cochrane (1980).

TABLE 2 Probabilities of dying by age 1 through 5 by maternal years of schooling, Sudan, 1973

	Maternal years of schooling			
q(a)[a]	None	1–3	4–6	7+
q(1)	0.1911	0.1344	0.0970	0.0700
q(2)	0.2001	0.1500	0.1088	0.0811
q(3)	0.2090	0.1598	0.1194	0.0904
q(5)	0.2181	0.1698	0.1346	0.1079

[a]q(a) is estimated by applying Trussell's (1975) North model to proportion dead by age of mother and years of schooling.
SOURCE: Sudan 1973 census sample.

Table 3 presents some cross-tabulations of proportions dead by mother's years of schooling and other variables. It is clear that the effect of education is maintained within categories of region, urban-rural residence, and paternal education. It is interesting to note that the effect of maternal education is greater in the South. South-North differences in proportions of children who have died are on the order of only 10–15 percent for women with four or more years of schooling, but they are 35–60 percent for women with no schooling. Urban-rural contrasts also tend to be greatest for women with no schooling. It is plausible to suggest that maternal schooling is overcoming the effects of a

hostile setting, perhaps by providing some rudimentary personal resources that can be used as a substitute for satisfactory environmental resources (O'Hara, 1980). There is also some attenuation of maternal education effects at higher levels of paternal education, although these variables for the most part seem to work independently. It is striking that the improvement in child mortality associated with an added year of parental schooling is much greater for mothers than for fathers. Since father's education would be more closely associated than mother's with household income, the results suggest that education is working principally through other routes related to child care and health practices.

TABLE 3 Proportion dead among children ever born by maternal education, maternal age, paternal education, and region

Maternal years of schooling	Women 20–29		
	Paternal years of schooling		
	0	1–4	5+
0	.197	.162	.147
1–4	.139	.120	.119
5+	.127	.109	.101

	Women 15–24		Women 25–34		Women 35–44	
	North	South	North	South	North	South
0	.182	.243	.190	.279	.206	.327
1–4	.125	.179	.141	.190	.189	.266
5+	.092	.101	.099	.117	.104	.121

	Women 15–24		Women 25–34		Women 35–44	
	Urban	Rural	Urban	Rural	Urban	Rural
0	.179	.249	.186	.267	.220	.322
1–3	.137	.176	.154	.183	.179	.205
4–6	.093	.107	.101	.128	.111	.184
7+	.057	.096	.069	.101	.074	.124

The effects of mother's and father's education also appear in multivariate analysis. The procedure used for this purpose was developed by Trussell and Preston (1981). For each woman, an expected proportion dead among her children ever born is assigned on the basis of her age. This expected proportion is based for present purposes on the relationships between proportions dead at age a and q(a)—the probability of dying before age a—established by Brass (United Nations, 1967). The "standard" q(a) converted into the expected proportion dead was the Coale-Demeny "West" model life table at level 11.7 (equivalent to life expectancy at birth of 45.2 years), which is the estimated level for all-Sudan. For each woman, the ratio of the proportion dead among children ever born to the expected proportion dead is formed. This ratio is then used as the dependent variable in an ordinary least squares regression analysis of the form:

$$\frac{PD_i}{EPD_i} = \alpha + B_1 X_{1i} + B_2 X_{2i} + \ldots,$$

where PD_i = the proportion dead for woman i
EPD_i = expected proportion dead for woman i, based upon her age
X_{1i} = value of variable 1 for woman i
X_{2i} = value of variable 2 for woman i
α, B_1, B_2 = regression coefficients.

The value of B_1 is thus an estimate of the proportionate effect of a unit increment in variable X_1 on child mortality (or, for dummy variables, the proportionate effect of membership in a category relative to being in the reference category). This procedure is introduced because it permits different age groups of women to be combined in one analysis. Each woman's observation is weighted by her number of children ever born.

Table 4 presents the basic results of the multivariate analysis. The mean value of the dependent variable—the ratio of number dead to expected number dead—is 1.004. This value indicates that the q(a) standard chosen on the basis of the aggregate-level analysis provides an excellent representation of the average mortality level in the sample.

TABLE 4 Proportionate effect of various factors on proportions dead among children ever born to women in Sudan, 1973 census sample (weighted number of births = 572,394)

Variable	Coefficient of variable	Mean of variable (birth-weighted)
Years of schooling for mother	−.0363*	.273
Years of schooling for father	−.0115*	.816
Employment status of mother (housewife = 1; employed = 0)	−.0958*	.745
Employment status of father (employer and own-account worker = 0; others = 1)	.0105	.735
Birthplace of mother (urban = 0; rural = 1)	.0037	.808
Age of mother (15–19 = 5; 20–24 = 6...)	.0268*	8.247
Type of union of husband (monogamous = 0; polygamous = 1)	.0058	.273
Type of walls in house [modern (brick, wood, etc.) = 0; traditional (mud, grass) = 1]	.0711*	.647
Place of residence (Khartoum = 0)		
Bahr El Ghazal (S) = 1	.7054*	.082
Upper Nile (S) = 1	.5489*	.064
Equatoria (S) = 1	.4814*	.057
Kordofan (N) = 1	.2500*	.149
Red Sea (N) = 1	.1909*	.021
Darfur (N) = 1	.1513*	.132
Blue Nile (N) = 1	.0939*	.265
Kassala (N) = 1	.0591*	.072
Northern (N) = 1	.0265	.075
Constant	1.0508	
R^2	.0453	

*Significant at 10 percent or less; N = Northern Region; S = Southern Region

Mother's education continues to have a large effect on mortality. Each additional year of schooling is associated with a proportionate reduction of .036 in the proportion dead among children, so that five years of maternal schooling is expected to reduce child mortality by 18 percent. Father's education, while significant, has an effect only about one-third as large. The relative importance of the two is consistent with the average levels found in Cochrane's (1980) review of studies that examine the separate effects of father's and mother's schooling. The analysis described below provides more opportunity to examine the paths through which education may be operating on child mortality.

As expected, children whose fathers are employers and own-account workers experience lower mortality. Unfortunately, poor response to census occupational questions and occupational homogeneity prevented analysis of occupational differences. Contrary to expectations, children of working women had higher mortality than children of housewives. One explanation may be that children of working women are more deprived of adequate child care (direct effect); a second is that women's work is an indicator of economic stress in the household, since full-time childrearing is a strongly sanctioned normative status of mothers in Sudan (proxy variable); a third is that women who have lost a child are freed from child care responsibilities and therefore more likely to work (reverse causation).

Although it does not discriminate decisively among these competing explanations, Table 5 sheds light on their relative importance. If maternal deprivation is the principal explanation of the relationship, then the effect of the mother's absence should be greater where the mother is educated, since we have seen that such women seem to have skills producing higher survival chances among children; their absence should have greater health consequences. However, the table shows that absolute and relative mortality differences by work status are similar for well-educated and uneducated women. For women 25–44, the negative effect of working narrows somewhat as education advances; for younger women it widens.[2] Also, the effect of reverse causality should be greater among young women, since the loss of a child should make a greater difference in the younger woman's availability for work because she is less likely to have other children needing care. But there is no clear-cut age difference in the relation of work status to mortality. The stress hypothesis cannot be addressed in the table. It is worth noting that a similar strong relation between women's work and child mortality appeared in the United States in 1900, where it was attributed principally to stress mechanisms because the relation was essentially confined to the black population (Preston, Haines, Pamuk, 1981). Woodbury's (1918) excellent study of infant mortality in eight US cities for the years 1911–15 also showed that much of the effect of mother's work on infant mortality in the year following childbirth was attributable to very low income among husbands of working mothers. However, there was also a significant direct effect of work that operated through shortened breast-

feeding by working mothers. Caldwell (1981) also found in World Fertility Survey data some tendency for children of working women to experience higher child mortality. Clearly, the issue merits detailed attention.

TABLE 5 Proportion dead of children ever born by work status of mothers, years of maternal education, and age

Age group	Housewives			Economically active
15–24	0.1790			0.1848
25–34	0.1940			0.2138
35–44	0.2115			0.2322
Housewives (by years of schooling)				
0	**1–3**	**4–6**	**6+**	
0.1927	0.1274	0.1184	0.0606	
0.2091	0.1726	0.1144	0.0999	
0.2240	0.2103	0.1231	0.1210	
Economically active (by years of schooling)				
0	**1–3**	**4–6**	**6+**	
0.1979	0.1425	0.1338	0.0922	
0.2311	0.2064	0.1380	0.1041	
0.2614	0.2293	0.1472	0.1126	

Region of residence

Perhaps the most interesting result presented in Table 4 relates to region of residence. The regional dummy variables have very large effects on child mortality. Being located in one of the three southern regions raises child mortality rates relative to those in Khartoum by 48–71 percent. Location in one of the other northern regions also raises mortality relative to those in Khartoum, but by a smaller amount. That these large differences persist even after controlling for father's and mother's education and employment status, type of marriage, housing structure, and so on suggests that the raw regional differences in mortality observed above are not for the most part attributable to differences in the distribution of these socioeconomic variables. The regional pattern of mortality remains almost completely unchanged by introduction of individual socioeconomic variables, and the proportionate impact of region of residence on mortality is scarcely diminished from that shown in Table 1.

Region of residence is not a determinant of mortality in the sense in which we are using the term. It acts as a proxy for other variables that are themselves determinants. On the basis of this analysis, it is impossible to say what variables it represents. The most logical candidates are the disease environment, particularly the higher endemicity of malaria in the South, and the general level of development, including the health system. That is, there may

be important influences of community levels of education or income on mortality, apart from the characteristics of a particular household. Although we cannot rule out the importance of the social community factors, we lean toward an explanation emphasizing the disease environment. Partial support for its importance is drawn from studies in Kenya (Anker and Knowles, 1971) and Tanzania (Hogan and Jiwani, n.d.). Both studies found that levels of regional malaria endemicity had very strong effects on childhood mortality levels, quite apart from levels of household or community socioeconomic variables. In addition, we note that the urban-rural variable has little explanatory power in Sudan, in contrast to the great variability associated with region; presumably the community-level social variables that would be pertinent to mortality are more sharply differentiated along an urban-rural than a regional dimension. We shall now turn our attention to a data set that pertains to only one of Sudan's regions but that provides a much better opportunity for examining the determinants of mortality.

Factors influencing child mortality levels in Khartoum

A very rich source of data for studying determinants of child mortality is provided by a survey of Greater Khartoum in 1975 conducted by John Caldwell, who generously made it available to us. Greater Khartoum, the capital of Sudan, increased in population from 245,736 in 1955/56 to 798,593 in 1973 (Kawabe and Farah, 1973: 153–154). It is the educational, commercial, and administrative center of the country, and, as we have demonstrated above, it enjoys the lowest level of child mortality in Sudan. Nevertheless, the estimated q(2) of 0.121 in 1973 is consistent with a life expectancy of only 52 years, placing Khartoum's life expectancy slightly below the average for developing countries in the 1970–75 period (United Nations, 1977: 138).

Area sampling was used in the survey. Ten percent of blocks in the first-class residential area were sampled, 5 percent in the second-class area, and 1.5 percent in remaining areas. All married women aged 15–49 in the sampled blocks were considered to be within the sample domain, and were thus subject to interview. In all, 2,714 interviews were conducted, of which 2,213 respondents are included here. Childless women, those above age 49, and those with missing information on important variables have been excluded. Analysis is confined to married women with the husband present. Altogether, these women reported on the survival experience of 10,403 births.

Child mortality information again takes the form of data on total number of children ever born and surviving for each woman. The procedure used for studying these data is the same as that outlined above: assign each woman an expected proportion of children dead based on her age, and use the ratio of actual dead to expected dead as a dependent variable for multivariate analysis (with each woman weighted by her number of births). The expected proportion dead is based on "North" level 17 model life tables, equivalent to a life expectancy at birth of 58.1 years (Coale and Demeny, 1966).

A rich array of variables is available for inclusion in the analysis. The study was not designed for demographic analysis of mortality and included a number of variables that have rarely if ever been examined in this context. Our analytical strategy is to estimate a sequential set of equations via ordinary least squares regression, with the ratio of dead to expected dead children the dependent variable in each case. The sequence reflects the fact that the values of variables are established at different stages of a woman's life, as follows:

1 Variables established by early childhood: father's occupation (i.e., the father of the woman reporting); place of birth.
2 Variables established by later childhood: all of the above plus educational attainment (years of schooling).
3 Variables established at the time of marriage: all of the above plus husband's education; blood relation between spouses; and type of residence in the early years of marriage (nuclear family residence or extended family residence).
4 Variables established by time of survey: all of the above plus type of housing structure; possession of modern goods; wife's status in the family; woman's economic activity; husband's occupation; husband's income; and woman's usual means of delivery in childbirth.

Missing from this list is a fifth stage that would represent the proximate biological processes that produce child death or survival. The strategy used here is similar to path analysis, although we do not introduce explicitly the equations of path analysis because of the complexity of the variable array and because many of the variables are proxies for important variables that are missing from the data set, which renders "indirect effects" meaningless. Results of this analysis are presented in Table 6 and discussed below.

Father's occupation

The coefficient, −0.3013, in the upper left corner of Table 6 means that, controlling a woman's place of birth, women born into the administrative and professional classes have mortality levels among their children that are 30 percent below the levels among women born into the farming class. Women born into the class of traders and other white-collar workers had lower child mortality by 23 percent, but a blue-collar origin conferred virtually no advantage relative to a farm origin. These are believed to be among the first results demonstrating intergenerational effects on child mortality in developing countries. Results are clearly in the expected direction. It is interesting to note that the effects of social class origin are diminished as each successive layer of independent variables is introduced, to the point where in the complete model the five origin classes have mortality levels within 5 percent of one another. In other words, class of origin is operating almost exclusively through other variables present in the model. The largest reduction occurs when "woman's education" is introduced. That is, the endowment bestowed by maternal

TABLE 6 Child mortality analysis in Khartoum, 1975; dependent variable: ratio of observed to expected deaths (woman weighted by number of births)

Explanatory variables	Equation 1	2	3	4	Mean value of variable (birth-weighted)
Father's occupation					
Administrator and professional	−0.3013	−0.1178	−0.0461	−0.0031*	0.0726
Trader	−0.2306	−0.1427	−0.0970	−0.0491	0.2486
Other white collar	−0.2322	−0.0897	−0.0333*	−0.0074*	0.1120
Blue collar	−0.0142	−0.0032*	+0.0062*	−0.1162*	0.3480
Farmer, unemployed, and retired[e]	—	—	—	—	0.2078
Birthplace of woman					
Khartoum metropolitan area	−0.2576	−0.1920	−0.1419	−0.1436	0.4413
Large urban centers (30,000+ in 1973)	−0.1654	−0.1156	−0.0772	−0.0751	0.1487
Small urban centers	−0.1567	−0.1473	−0.1233	−0.1234	0.1342
Abroad	+0.0559*	−0.1880	+0.26311	−0.3042	0.0594
Village[e]	—	—	—	—	—
Woman's education					
Years of schooling		−0.0489	−0.0329	−0.0362	2.8092
Husband's education					
Years of schooling			−0.0186	−0.0196	7.0641
Blood relation between spouses					
No relation			−0.2088	−0.2039	0.3532
Some relation			−0.1483	−0.1453	0.2759
Cousins[e]			—	—	0.3709
Nuclear family residence after marriage					
Lived with in-laws for 2+ years[e]			—	—	
Lived apart from in-laws within 2 years of marriage			+0.0460	+0.0613	0.2020
Building materials					
Traditional (mud)[e]					
Modern (other)				−0.0638	0.4277
Number of modern goods					
1 through 7 items				−0.0051*	2.0500
Status of woman					
Scale of husband–wife interaction (0 = lowest; 4 = highest)				−0.0309	1.5154
Occupation of woman					
(housewife = 0; working = 1)				+0.2679	0.9591
Husband's occupation					
White collar				+0.3354	0.1950
Trader				+0.0555*	0.1740
Blue collar				+0.0656*	0.3900
Farmer, retired, unemployed				+0.2710	0.0450
Administrator and professional[e]				—	0.1950
Usual means of delivery					
By medical doctors				+0.1814	0.2190
By others				−0.1036	0.1100
By midwife[e]				—	.6710
Husband's monthly income					
High (75+ £)				−0.4942	0.2448
Medium (30–75 £)				−0.3220	0.3091
Unknown and not applicable				−0.3129	0.3139
Low[e] (below 30 £)				—	0.1322
Constant	1.1437	1.1808	1.2832	1.5020	
R^2	0.0173	0.0311	0.0392	0.0578	

NOTE: e refers to the excluded category; Reference Category. *F-ratio not significant at the 10 percent level.

grandparents for the rearing of grandchildren seems principally (but not exclusively) to take the form of their daughter's years of schooling.

Woman's place of birth

Women born in Greater Khartoum have 26 percent lower mortality among their children than women born in villages, controlling their social class of origin. Other urban origins are intermediate in their levels. Unlike social class of origin, these effects persist, though in somewhat diminished form, when other variables are introduced. The effects are firmly established by the time of marriage, and introducing "current" socioeconomic characteristics has virtually no effect on the values of place-of-birth coefficients. One can only speculate about the remaining paths through which place of birth operates. Since Khartoum has enjoyed a substantial mortality advantage for at least several decades (see Table 1) and probably longer, these variables may well reflect the enduring effects of childhood disease environment and health conditions. One such effect may operate through a woman's physique, which has been shown to have a significant effect on child mortality in Bangladesh (Chowdhury, 1981), Guatemala (Mata, 1977), and elsewhere. Alternatively, one might argue that an urban birth confers the advantage of familiarity with urban ways that might produce easier access to social and health services. Finally, it seems likely that the rural-born are residentially and occupationally marginal in ways that are not reflected in standard categories included in the analysis. In any event, the result is one of the first demonstrations of an urban mortality disadvantage for children of rural-urban migrants.

Children of foreign-born women, who constitute 6 percent of the total sample, have mortality levels in Khartoum that are 30 percent higher than that of village-born women, once all other variables are introduced. The foreign-born are principally African, especially Nigerians, many of whom are migrant agricultural laborers temporarily located in the city.

Woman's education

We have seen that much of the influence of childhood origin variables operates through a woman's years of schooling. This variable has a strong and persistent impact; it is not merely working through other socioeconomic variables in the household but maintains an important independent role. Its coefficient of $-.036$ in the "complete" model implies that achieving 10 years of schooling reduces mortality by 36 percent. Surprisingly, this coefficient is identical with that reported for the same variable in Table 4 for all-Sudan, even though the level of female schooling is much higher in Khartoum (mean years = 2.8) than in Sudan (0.3).

It is particularly noteworthy that the effect of maternal schooling persists when women's status in the home is added to the model. Status is measured in a crude approximate fashion, on a scale from 0 to 4, based on a woman's response to two questions: "Do you accompany your husband to the theater,

cinema, etc.?"; and "Do you visit friends together?" The response "always" was scored as 2, "sometimes" as 1, and "no" (or no response) as zero, and the two scores were added to produce the status variable. Caldwell (1979) has argued that a principal path through which increased maternal education operates to reduce child mortality in Ibadan is an elevation of the mother's status in the home. A woman's education and her status are positively correlated at .49 in Khartoum. We find significant effects of both education and status in the postulated direction, but no diminution of education effects when status is introduced. Simply put, maternal education seems to work primarily through other paths in Khartoum. Some of these are related to assortative mating, since the maternal education coefficient is reduced by a third when characteristics of the husband/marriage are introduced.

Characteristics established at marriage

Some of the features of a woman's background are significant for child mortality because they help determine the type of man she marries. A well-educated woman is more likely to marry a well-educated man (r = .59) and a man who is not a blood relation. Some 37 percent of women in the sample are married to their cousins, and child mortality among this group is 20 percent higher than among families in which the husband and wife are not related by blood. More distant relations have intermediate child mortality. There may, of course, be genetic reasons for higher mortality among offspring of close kin, and the magnitude of effects in Khartoum (roughly 3 extra deaths per 100 births among cousin marriages) does not seem too large to rule out an explanation totally reliant on genetic mechanisms. The effect is by no means inconsequential; in terms of regression coefficients, it requires about six additional years of education for a woman (or ten for a man) to offset the child-survival consequences of marrying a cousin.

Just as in the all-Sudan analysis reported above, and in most of those reviewed by Cochrane, an additional year of husband's schooling has a smaller effect on child mortality than an additional year of mother's schooling. The effect of husband's schooling is, however, significant and is not diminished when other factors through which his education would be expected to operate—especially his income—are introduced. For both husband and wife, then, education seems to exert an important "direct" effect on child mortality—that is, an effect that does not principally operate through other measured socioeconomic variables in the household. The survey, of course, does not measure such factors as attitudes toward children, access to and use of health care systems, knowledge of simple preventative and curative medical measures, and fatalistic outlook, and it is likely that schooling works largely through these less material routes.

Couples who live in an extended family for more than two years after marriage have child mortality levels about 5 to 6 percent higher than those who do not. This variable is introduced as a measure of traditionalism, and the coefficient implies that early nucleation of the family is associated with slightly lower mortality.

Characteristics at time of survey

The measure of child mortality used is cumulated over the lifetime of reporting women. Values of independent variables at the time of survey can, of course, have no effect on this measure of mortality. They are included because they are presumably highly correlated with past values of these same variables that *can* influence mortality risks of children.

Economic variables have an effect on mortality in the expected direction. An enormous mortality differential by husband's income is revealed in Khartoum. When the husband earns 75 Sudanese pounds per month or more (24 percent of the sample), child mortality is 49 percent below the level pertaining to husbands earning less than 30 pounds per month (13 percent of the total). Other income groups are intermediate. This is the largest differential in the table, and it pertains to sizable groups. It is unusual in micro-level studies for income to be such an important factor in mortality; a common explanation of its poor performance is that income is poorly measured. The simple question asked in Khartoum was "How much money does your husband earn per month?" It is likely that in an urban setting such as Khartoum there is less nonmonetary income than is typical in developing countries, so that the variable is a more reliable indicator of actual economic circumstances.

Husband's occupation does not have a major effect on child mortality once income, education, and other factors are controlled. Traders and blue-collar workers have child mortality levels within 6 percent of professionals and administrators. "Farmers, retired, and unemployed" have high mortality conditions but they are a small group, some 4.5 percent of the total. "Other white-collar" workers have anomalously high child mortality levels for which we have no explanation.

Possession of modern goods is negatively but weakly and insignificantly associated with mortality. This variable is simply the sum of the number of the following items possessed by the household: radio, television, refrigerator, oven, phonograph, air cooler, auto. A high score on this item, of course, reflects a high level of household wealth, but it also reflects, at a given income level, high expenditure on nonchild items. That is, it may in part function as a (inverse) proxy for parental tastes and attitudes toward investment in children.

Dwelling in a house made from mud raises child mortality by a statistically significant but substantively minor 6 percent. This is about the same level of influence revealed above for all-Sudan (7 percent). Again, an important wealth variable is far less influential in Khartoum than the income variable. Also as in the all-Sudan analysis, wife's participation in the labor force is positively associated with child mortality. In this case it raises mortality by 27 percent, compared with 10 percent in all-Sudan. The difference may reflect the greater competition between childraising and woman's work in Khartoum. This competition would strengthen the association regardless of whether the predominant line of causation ran from woman's work to child health or the other way around. Again, we are unable to discriminate effectively among the competing explanations.

The woman's status variable is constructed somewhat crudely but never-

theless is significantly associated with child mortality. A woman who "always" accompanies her husband to movies and to see friends (i.e., who attains a score of 4) has 12 percent lower child mortality than a woman who answers "no" to both questions. Following Caldwell (1979), we may argue that a woman's status is associated with her degree of influence in the childrearing process; since she is presumably somewhat better equipped for childrearing than grandparents, another important influence group, this transfer of influence may have favorable consequences. It is also possible that causation runs in the opposite direction: successful childrearers are rewarded with higher status by their husbands. In any case, we believe that the important point is that woman's education and woman's status vis-à-vis her husband play independent roles in child-survival rates.

The only seriously anomalous result in the table relates to method of delivery. If a woman is "usually" delivered by a medical doctor, child mortality is 18 percent higher than if she is usually delivered by a midwife. Our only explanation of this result is that women suffering from problems during pregnancy or childbirth may be more likely to seek out medical doctors for the delivery.

Future research agenda

Sudan is a land of extraordinary contrasts in mortality. Regional variations are extremely large, with provinces in the South having child mortality levels two-thirds higher than in the North. In view of the fact that regional differences persist largely unabated when certain household-level variables are introduced, it seems likely that differences in the disease environment account for most of the regional contrast.

Khartoum is the area of lowest mortality in Sudan, although it is still high compared with many developing countries. Within Khartoum, there are very large differences in the mortality levels of different groups. Women born into higher classes and in urban areas have lower mortality among their children. The relationship with social class of origin largely works through the greater amount of education that the woman typically receives. In turn, about a third of the "total" effect of a woman's education works through characteristics of the man she marries. In particular, marrying a cousin raises child mortality by 21 percent. The remaining effects of woman's education work through variables and processes other than those represented in the analysis, including conventional socioeconomic variables as well as a woman's status relative to her husband. Among the other socioeconomic variables, husband's income has the largest effect in terms of variance explained and of quantitative impact: the highest quartile on the income distribution has child mortality 50 percent lower than that of the lowest octile.

When the same variables can be examined in the different data sets pertaining to Khartoum and to all-Sudan, they have quite similar effects on mortality. The coefficient of woman's years of schooling is $-.036$ in both data sets; husband's schooling has lower impact in both cases, $-.020$ in Khartoum

and −.012 in all Sudan.[3] Living in a dwelling formed of traditional materials raises child mortality by 7 percent in all-Sudan and by 6 percent in Khartoum. Labor force participation of the mother is associated with 27 percent higher child mortality in Khartoum and 10 percent higher mortality in all-Sudan. The general similarity of direction and magnitude of impact for these variables in the two data sets lends credibility to each set of results.

Discussion

There is relatively little knowledge regarding mortality differentials by socio-geographic categories in sub-Saharan Africa. Part of the problem results from the absence of data, but another part, perhaps of equal importance, results from failure to exploit data that already exist. The road is littered with African surveys that have never been coded, code sheets that have never been punched, punch cards that have never been analyzed, and analyses that have never been published. Donors often find it easier to justify launching a new survey than paying to complete an unfinished project. Census and survey organizations that are responsible for data gathering activities often lack the capacity to convert their data into information, and the data never reach those who could.

The widespread failure of African survey activities is particularly regrettable in the field of mortality. Mortality levels in sub-Saharan Africa are the highest in the world and are the object of substantial national and international concern. Furthermore, simple procedures exist, based upon questions on members of children born and surviving, to permit efficient, detailed, and informative analyses of child mortality differentials. The few such analyses that have been conducted reveal socioeconomic differentials in mortality that are similar to those observed more widely in other developing regions. But they also reveal a regional structure to mortality in sub-Saharan Africa that seems much more distinctive and important than regional differences elsewhere. Such differences point to the importance of the macro-environment of diseases as a major factor underlying current African mortality conditions.[4] But little confidence can be placed in this inference until far more vigorous efforts are undertaken by demographers and others to characterize major features of the African mortality landscape.

Notes

1 This was done using Trussell's (1975) "North" model equations. Use of other procedures (Brass multipliers, Sullivan multipliers, and other regional models) gave results for all-Sudan that are within .01 of the estimated value of .170.

2 One could of course argue that the better educated working women are able to arrange better child care surrogates (perhaps by virtue of their higher wages earned) and thereby offset the greater consequences of their absence.

3 One would expect this coefficient to be lower in Khartoum because we also include husband's income, presumably an important path through which his education affects child mortality. However, introducing income (and other factors simultaneously) actually raises the estimated coefficient of husband's education in Khartoum.

4 See the exceptionally interesting comparison between child health circumstances in East Africa and West Africa in Rowland (1979).

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