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Child Mortality Levels and Survival Patterns from Southern Sudan

DEMOGRAPHIC data pertaining to infant and child mortality patterns in southern Sudan are scarce. With a population of approximately five million and encompassing an area of 650 square kilometres, this region remains largely isolated due to poor communication and transportation systems, plus periodic long-term episodes of civil war. The last factor adversely affected Sudan's national censuses, curtailing areal enumeration in the 1983 census and resulting in underenumeration in the first, 1955/56 National Census (Demeny 1968). The civil war also forced specific studies, notably the 1979 World Fertility Survey (1982) and an *ad hoc* World Health Organisation survey (Callum 1983) to restrict their investigations to northern Sudanese populations.

This dearth of data is exacerbated by an apparently severe mortality differential between northern and southern Sudan. The results of the 1973 National Census indicated a *12-year* difference in life expectancy between the regions, representing levels of childhood mortality approximately 66 per cent higher in the South (Sudan, Department of Statistics 1979). A multivariate analysis of the 1973 census data by Farah and Preston (1982) revealed that residence in one of the then three southern provinces raised child mortality rates relative to Khartoum by 48-71 per cent, with such large differences persisting after controlling for paternal education, employment status, housing structure, and marriage type. The authors noted that residence was not a true mortality determinant, but rather was a proxy variable representing a severe disease environment, a poorly developed health system and widespread malnutrition in the southern region.

It was into this milieu that Unicef-Sudan introduced its child survival strategy. This is best known by the acronym GOBI-FFF representing the component parts of Growth monitoring charts, Oral rehydration therapy, Breast-feeding, Immunisation, Female education, Family planning, and Feeding supplements. Their common goal is the delivery of inexpensive effective child health technology and education at the village level. Unicef has targeted Africa as the main focus of GOBI-FFF implementation, and Sudan today represents its largest African programme.

While undoubtedly constituting a powerful constellation of child health technology with proven field effectiveness in diverse cultures (Unicef 1986), recent concerns have been raised about the long-term effect of the GOBI-FFF strategy. Essentially these revolve around two issues: (a) the hesitancy to accept the more modem components of the strategy, e.g. immunisation, oral rehydration therapy and, (b) the emphasis on technological, rather than social change (Mosley 1984). The former is exemplified by World Health Organisation (1981) findings of low tetanus toxoid usage among expeclant Third World mothers due to multiple rationale including fear of injection, lack of information and traditional, familial objections. The latter is represented by a Bangladeshi study denoting higher child morbidity and mortality rates for children treated in oral rehydration centres, as these children are released into household environments with a constantly high risk of reinfection (Roy et al. 1983).

In an attempt to delineate levels of childhood mortality in southern Sudan as well as to assess the impact of the GOBI-FFF strategy, Unicef-Sudan sponsored a 1985 survey of mothers with children in the major urban centres of Juba and Wau. Juba is the main administrative centre of the region, while Wau is the most important urban area for the Dinka, southern Sudan's largest tribal group.

Materials and Methods

A random sample of 5,120 mothers with a total of 21,509 offspring ever born was collected from both towns (Juba, number of mothers = 3,061, number of children = 11,352; Wau, number of mothers = 2,059, number of children = 10,157). To form a sample representing southern Sudanese urban populations these data sets were pooled, as shown in Table 1. To delineate levels of mortality the last column of this table, reflecting proportions

TABLE 1 : FERTILITY AND MORTALITY DATA, JUBA AND WAU

Maternal Age	*Number of Mothers*	*Number of Children*	*X Parity*	*Children Died*	*Proportion Died(Di)*
15-19	5,109	872	1.6802	121	0.1388
20-24	1,092	2,610	2.3901	506	0.1939
25-29	1,319	4,703	3.5656	941	0.2001
30-34	802	3,953	4.9289	1,018	0.2575
35-39	790	4,772	6.0405	1,275	0.2672
40-44	311	2,348	7.5498	654	0.2785
45-49	245	1,977	8.0694	607	0.3070
50+	42	274	6.5238	90	0.3285
Total	5,120	21,509	-	5,212	-

of children ever born who subsequently died by maternal age *(Di),* was analysed via indirect demographic estimation methodology as first formulated by Brass and Coale (1968) and subsequently refined (United Nations 1983). In this methodology *Di* values are converted to *ax* values in life table format, representing the cumulative probability of dying from birth to age *x.* The value 1 .0 - *ax* yields *lx,* or survivorship probabilities to age *x.* In the Brass logit life table system these last values are used to generate model life tables in the form:

$$\lambda l*(x) = \alpha + \beta \lambda (l(x)) \quad (1)$$

where $l^*(x)$ and $l(x)$ are different life tables, alpha and beta constants and λ defined as:

$$\lambda\, l(x) = .5\, lx(1 - l(x)/l(x) \qquad (2)$$

Estimates of alpha and beta values followed United Nations (1983: 150) methodology of fitting group means for observed logit values to a model life table, in this case Brass's (1968) original African standard, as shown in Table 2. From this a smoothed life table was produced in relation to the formula:

$$l*(x) = (1.0 + \exp(2\alpha + 2\beta\,(ls(x))^{-1}) \qquad (3)$$

where s is the age-specific logit from the standard.

TABLE 2 : FIT OF OBSERVED MORTALITY DATA TO BRASS' AFRICAN STANDARD

Mothers' Ages		*Juba and Wau*			*African standard*		
	Child's Age	*Probability of Dying*	*Probability of Surviving*	*Logit*[1]	*Probability a/Dying*	*Probability of Surviving*	*Logit*
		qx	*lx*		*qx*	*Ix*	
15-19	1	0.1388	0.8612	-0.9126	0.1198	0.8802	-0.9972
20-24	2	0.1939	0.8061	-0.7124	0.1665	0.8335	-0.8053
25-29	3	0.2001	0.7999	-0.6928	0.1899	0.8101	-0.7253
30-34	5	0.2575	0.7425	-0.5295	0.2137	0.7863	-0.6514
35-39	10	0.2672	0.7328	-0.5044	0.2498	0.7502	-0.5498
40-44	15	0.2785	0.7215	-0.4760	0.2638	0.7362	-0.5132
45-49	20	0.3070	0.6930	-0.4071	0.2870	0.7130	-0.4550

[1] logit = 0.5 in (1.0 − lx/lx) $\qquad \beta = +0.9216 \qquad \alpha = +0.0207$

Maternal GOBI-FFF usage patterns formed the independent variables for a multivariate logistic regression analysis of child survival determinants. These variables are shown in Table 3. The omission of some variables, including growth monitoring charts, family planning, and feeding supplements reflects either the recent introduction or total lack of these components in the study population. Another component, breast-feeding, takes on different connotations in this study. Usually referring to the use of infant formula versus breast milk, universal breast-feeding is present in the samples. The variable as currently used therefore reflects the known deleterious effects of early weaning (Muganzi 1984). Other independent variables include maternal responses to survey questions on treatment of childhood diarrhoeal disease (Do you use oral rehydration therapy? Yes/No) and immunisation (Are any of your children immunised? Yes/No). The final variable, maternal education, has repeatedly been shown (Caldwell and McDonald 1981; Ware 1984) to be an important determinant of child survival. Dichotomising the education variable into literate and illiterate mothers reflects the low proportion of mothers who .have more than a primary school education. All together the selected variables reflect the mix of traditional and modern, cultural and biological factors comprising the GOBI-FFF strategy.

TABLE 3 : SUMMARY DATA FOR INDEPENDENT VARIABLES

	Variable	*Number of Children*		
		Died	*Survived*	*Born*
n	Maternal Education			
	1 = Illiterate	2,412	7,088	9,500
	2 = Literate	1,449	5,961	7,410
2)	Oral Rehydration Therapy			
	1 = Not used	2,661	8,704	11,365
	2 = Used	1,200	4,345	5,545
3)	Breastfeeding Period			
	1 = $\leq$ one year	778	2,618	3,396
	2 = $\geq$ one year	3,083	10,431	13,514
4)	Immunisation			
	1 = No Children Immunised	2,202	5,870	8,072
	2 = Children Immunised	1,659	7,179	8,838

To analyse the effects of these factors on child survival logistic regression methodology was employed. Logistic regression assesses the effects of multiple independent variables upon a dichotomous categorical variable, in this case child survival/death, through generation of maximum likelihood-based coefficients. These coefficients can be multiplied by their antilogs to determine the multiplicative effect of an independent variable upon the dependent variable. Thus a coefficient of 1.0 represents no effect, those above 1.0 a positive effect, and those less than 1.0 a negative effect.

The S AS (1986) subroutine C ATMOD performed a logistic regression for offspring born to women aged 15-39. This represented 16,910 births and 3,861 deaths to age ten in the Brass and Coale (1968) methodology. While this differs from the traditional definition of childhood mortality as encompassing the ages 0-4, it compiles with the recent definition used by Preston (1986) in discussing child mortality patterns from the World Fertility" Survey.

Results

a) Levels of Child Mortality

The level of child mortality is shown in Table (2), based on deaths to women aged 15-49. Probability of dying from birth to age *x (ax)* and inversely, survivorship *(Ix)* values reflect logit-based smoothed values.

Overall, these values reflect continued high infant and child mortality levels for southern Sudan. Linear interpolation of survivorship values from the logit-based family of model life tables derived by Carrier and Hobcraft (1971) for developing countries yielded a life expectancy at birth of 40.6 years, with a similar value at age 5 of 41.2 years. Figure 1 plots observed *ix* values in comparison with model life table survivorship figures. Observed values compare unfavourably with those determined from the 1979 World Fertility Survey (1981) of northern Sudan. Based on a sample of 3,115 women, survivorship values from this sample are irregular and hard to interpret. Nevertheless, employing linear interpolation again with the Carrier and Hobcraft (1971) models the World Fertility Survey *qs* value of 0.1450 yields an average life expectancy of 51.2 years, a full ten-year difference in relation to the present southern sample.

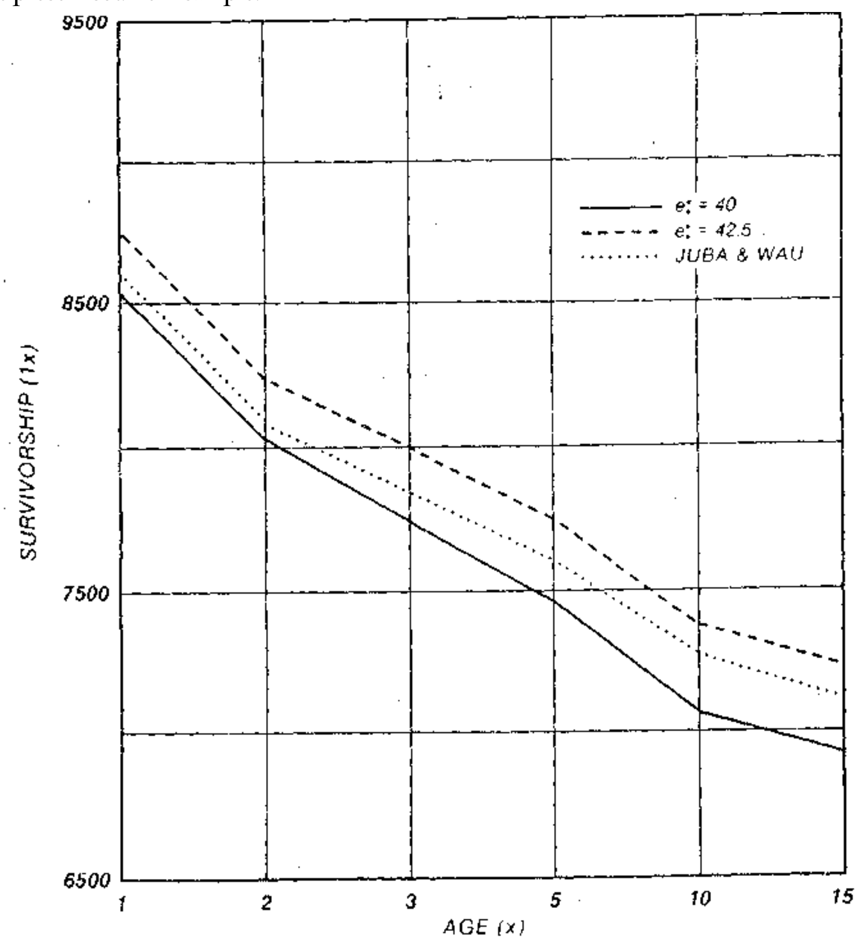

Figure 1. Plot of observed survivorship values in comparison with Carrier and Hobcraft Model life tables for average expectation of life at birth $\left(e_0^0\right)$ of 40 :. .d 42.5 years

Sadly, the values in Table 4 compare more closely with those reported for the 1973 National Sudan Census. At that time the southern region consisted of three provinces, Upper Nile, Bahral Ghazal, and Equatoria. Respectively, these had average life expectancies at birth of 35.7,34.2, and 39.9 years. The slow improvement in life expectancy derived from the present sample can be best summarised in the words of Farah and Preston (1982: 367): ' mortality in Sudan has not improved at anywhere near the pace that has come to be accepted in developing countries'.

TABLE 4 : MORTALITY DATA AND'LIFE TABLE FORMED BY LOOT ANALYSIS

Maternal Age	*Ch'dcfs Age*	*Proportion Died D (i)*	*Probability.of Dying qx*	*Survivorship*
15-19	1	0.1388	-0.1423	0.8577
20-24	2	0.1939	0.1911	0.8089
25-29	3	0.2001	0.2149	0.7851
30-34	5	0.2575	0.2388	0.7612
35-39	10	0.2672	0.2745	0.7255
40-44	15	0.2785	0.2881	0.7119
45-49	20	0.3070	0.3106	0.6894

1qx = Probability of dying from birth to age *x* ; *2lx* = (1.0 + exp ($2\alpha a + 2\beta\lambda$ *(x)*))

b) *Survival Determinants*

Table 5 shows the results of the logistic regression model for the four independent variables, maternal education, oral rehydration therapy, breast-feeding period, and immunisation. As can be seen, all resulting maximum likelihood coefficients are positive, indicating an increased likelihood of child survival for offspring born to literate mothers, mothers using oral rehydration therapy, mothers featuring breast-feeding periods longer than a year, and mothers who give their children at least some degree of protection from infectious diseases via immunisation. Of the four variables, however, only two, maternal education and immunisation, are statistically significant determinants of child survival. Their relative ranking can be derived from column 4 of Table 5, which gives the antilog values of specific coefficients. The most significant variable, maternal education, indicates that children born to literate mothers would be 1.34 times as likely to survive as offspring born to illiterate mothers.

The importance of maternal education is not surprising in the light of multiple past studies (cf. Caldwell and McDonald 1979; Ware 1984) noting this variable as the singularly most important determinant of child mortality. What remains unclear are the exact pathways that lead from this variable to reduced child mortality. These pathways may be as diverse as the simple task of having children wash their hands before eating to the more culturally elaborate processes of female autonomy, perhaps exemplified by the overriding of cultural taboos associated with traditional childhood feeding or medical treatment practices. Equally important is the realisation that maternal education can make its effects felt through simultaneous, often highly associated, mechanisms. In a recent analysis of the present sample Roth and Kurup (1987) found that maternal education was a highly significant factor in the acceptence of both oral rehydration therapy and child immunisation. As such it is expected that other variables in the present analysis will be related to maternal education, an expectation supported by the overall log- likelihood chi-squared value *(L*) of the models as shown in Table 5, This measure is the equivalent of an *F-SCOK* in the analysis of variance for Ordinary Least Squares regression, and tests the joint null hypotheses that all coefficients except the intercept equal zero, indicating no linear relationships between dependent and independent variables. Rejection of the null hypothesis in this case suggests association between independent variables, most probably maternal education, given the findings of Roth and Kurup (1987).

TABLE 5-LOGISTIC REGRESSION RESULTS

Variable	*Maximum Likelihood-Coefficient*	*Standard Error*	*Antilog of Coefficient*
Maternal Education	+0.2928***	0.1214	1.3402
Oral Rehydration Therapy	$+0.0530^{N.S}$	0.0387	1.0544
Breastfeeding Period	$+0.03\ 19^{n.s}$	0.0400	1.0324
Immunisation	+0.1810***	0.0380	1.1984

Intercept = 0.4 117 — *** = $P < 0.001$

Model Log Likehood Chi-Square = 26.27** — ** = $P < 0.01$

N.S. =P>0.05

Discussion and Summary

The preceding analysis of southern Sudanese data was undertaken to delineate levels and patterns of childhood mortality in two major population centres. Indirect estimation techniques revealed high levels of childhood mortality, indicating a continuation of the severe mortality differential previously noted (cf. Farah and Preston 1982) between northern and southern Sudanese populations. More optimistically, logistic regression analysis indicated all four GOBI-FFF components examined were found positively associated with child survival. This is particularly encouraging in the light of this study's, as well as almost all studies of this type combining essentially cross-sectional variables (e.g. diarrhoeal treatment) with longitudinal factors (e.g. maternal education) (see Ware 1984).

Whether these findings mark the beginning of a long-term significant decline in child mortality precipitated by GOBI-FFF components in southern Sudan is of course unknown. An alternative explanation is that the association of these components with increased child survival may represent erosion only of the soft rock of child mortality, reflecting the control and/or eradication of communicable disease by modem medical technology (United Nations 1963). The remaining hard rock of child mortality, representing crowded housing conditions, unclean drinking water and poor public sanitation systems may constitute a more important preventive aspect of child mortality charts. Obviously these hard rock aspects will entail great technological and logistic costs, exemplified by the implementation of large-scale sewerage systems. One possible bridge between these different facets of child mortality in developing countries is maternal education, manifesting both curative and preventive aspects of child health. The finding of this study that maternal education is the most significant determinant of child survival concurs with past studies noting its importance for developing countries with scarce resources.

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