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Impact of Breast-feeding on Infant and Child Mortality with Varying Incidence of Malaria - Evidence from the Kenya Fertility Survey 1977-78

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1) INTRODUCTION

The breakdown of traditional social values governing child care in pre-transitional societies has resulted in a great reduction of breastfeeding duration in many countries in the Third World. Scientists all over the world have voiced their fear that infant and child mortality may increase significantly if the trend of reducing breastfeeding durations and the replacement of human milk by infant formulaes continues. It is the aim of the present paper to contribute to the understanding of the relationship breastfeeding-child mortality by giving statistical evidence of various facets of this relationship in a Sub-Saharan African country.
The data for this study are obtained from the Kenya Fertility Survey (1977-1978). Only those children who are born within a period of ten years before the survey and for whom information on breastfeeding is available are selected. Unweighted data are used throughout the analysis.

The analysis of the influence of breastfeeding duration on infant and child mortality involves four basic problems: selection, common dependence, reverse causation and heaping. A first selection process arises when children who are weak or sick are weaned at older ages than those who are healthy. CANTRELLE & LERIDON (1971) found that the average age at weaning in a rural zone in Senegal, for children who died between the ages of 2 and 3 year, was somewhat higher than for those children who survived beyond 3 years. A second selection problem comes about because children who were never breastfed do not form a homogeneous group, but can be classified in distinct subgroups: those who were never nursed because their mothers decided voluntarily to use alternative feeding, those who were never breastfed because they were either too weak or sick or because their mother's health or milk supply did not allow adequate breastfeeding (1). Neonatal mortality will generally be much higher in the second subgroup. To avoid this selection problem no attempt was made in the rest of this study to estimate the effect of weaning on neonatal mortality. In our study it is possible that a third selection process is in operation: since children with very long durations of breastfeeding may belong to more traditional oriented mothers, who have little notion of hygiene, child care and the dietary requirements of young children, and normally child mortality is much higher among more traditional groups in society.

The common dependence problem arises because a disease may cause both the cessation of nursing and, at a later stage, the death of the child. In the KFS a question was asked regarding the reason for weaning the penultimate child.

Unfortunately, the range of answers to this question is too limited. Only three categories were elicited and coded: child died, mother became pregnant or stopped voluntarily. It becomes consequently impossible to trace back those children who were weaned because they were sick, and we can expect our results to be slightly biased upwards because of this problem.

The normal procedure to study child mortality determinants consist of constructing a regression equation in which the dependent variable is a dichotomy: in casu whether the child survives up to a certain age or not. This dichotomy is made a function of a set of independent variables in which the researcher is interested (2). Introducing breastfeeding as just another independent variable among other socio-economic and demographic variables is impossible because of the following reverse causation problem: the inclusion of the duration of breastfeeding of those children who died at young ages, and who were breastfed until death would make it look as if they died because they were breastfed for such a short time and not vice versa. To avoid this problem BUTZ, DAVANZO & HABICHT (1981) simply ignore all children whose breastfeeding period was curtailed because they died. By doing so, the proportion deaths not attributed to weaning decreases. Owing to this, the regression coefficients of breastfeeding are overestimated in their study. SULLIVAN, ADLAKHA & SUCHINDRAN (1982) avoid the reverse causation problem in a very effective way. Their logit regressions involve three age-intervals (1-5, 6-11 and 12-60 months), in which the dependent variable is binary, indicating whether the child survives throughout the interval or not. This dichotomy is made a function of a set of demographic and socio-economic variables and of an additional dummy variable which indicates the breastfeeding status of the child at the beginning of the interval under consideration.

Finally, in retrospective studies problems often arise with the accuracy of recall of distant events such as duration of breastfeeding and age at death of a bereaved child. This leads usually to distortions in the data due to heaping at 6, 12, 18 and 24 months. A weakness of the study of SULLIVAN et al (1982) is that two of their age-intervals start exactly at the ages of highest heaping (6 and 12 months). The breastfeeding status at the beginning of the interval can therefore be expected to be wrong for a large number of children.

2) MODELS

The gross effects of the relationship partial breastfeeding-child mortality are first examined through simple life-table techniques. A number of regression models are than constructed to analyse the net effect (i.e. after

controlling for other intervening factors) of breastfeeding. To investigate the net effect of full weaning , the first three years of a child's life are subdivided into three unorthodox age-intervals : 1-8, 9-17 and 18-36 months. This was done in order to avoid the large heaping problems at ages 6 and 12 months. For each interval only those who survived up to the beginning of the interval and who were born at least 9, 18 and 36 months respectively before the survey are selected. The dependent variable in the regression is dichotomous and indicates whether the child survives up to the end of the interval or not (0=survived, 1=died).

The partial breastfeeding variable (FWEANED) is introduced in the regression as a dummy variable: 0 if the child is not fully weaned at the beginning of the age-interval, 1 if the child is fully weaned (3). To control for other intervening factors a selected group of socio-economic and demographic variables is included in the regressions. The criteria used to include these other control variables in the model are twofold. First, the independent variables have to be as uncorrelated as possible in order to avoid problems of mulicollinearity. Second, the control variables have to to be related with infant and child mortality and also with breastfeeding duration. The variables which meet these requirements are:

"Male": (0 if female, 1 if male) ANKER & KNOWLES (1980) showed that male children in Kenya-as in many other parts of the developing world, have survival probabilities which are somewhat lower than those of female children.

"Edm": higher education of mother is generally accepted as one of the most important factors in suppressing child mortality in Tropical Africa (FARAH & PRESTON (1981); KANDEH (1979); KIBET (1980)). In our regression model education of mother is introduced as a binary variable (0 if the mother has 0 to 4 years of education, 1 if she has 5 or more years of schooling).

"Work": is a substitute variable for the work related status of the mother at he time of birth of the child (0 if never worked, 1 if ever worked). Breastfeeding is normally of shorter duration -which may increase child mortality, among working women than among housewives. On the other hand, working women have higher incomes-which normally reduces child mortality.

"Ageb": age of mother at the birth of the child is generally highly correlated with infant mortality. Very young and older women tend to have higher mortality among their offspring

(KANDEH (1979)). The age of mother at the birth of the child is introduced in the analysis as a set of two dummy variables ("Ageb1 is 1 if the age of mother at birth of the child is below 20, "Ageo2" is 1 if the age of mother is above 35, which implies that the reference category is the group of mothers with ages at birth between 20 and 34 years).

"Mal": each child in the study obtained a code ranging from 1 to 4 according to the severity of malaria in the district in which he lived at the time of the survey. The code was given on the basis of the percentage of all outpatient cases (as recorded in hospitals) who were sick with malaria (4). Children who lived in districts with malaria cases ranging from 0 to 9.9 % were coded 1, from 10 to 19.9 % , 2; from 20 to 29.9 % , 3, and above 30, code 4. These codes were then translated into three dummy variables (reference category if code is 1, Mal1 is 1 if code is 2, Mal2 is 1 if code is 3 and Mal3 is 1 if code is 4) .

The most appropriate model available with a binary dependent variable is the logit (or probit) regression. Unfortunately, with the computer facilities of the Free University in Brussels it is impossible to run logit regressions with large individual data sets. Therefore we had to rely on an ordinary least squares procedure (5). To provide an indication of the impact of breastfeeding on child mortality two additional statistics are calculated: the absolute response value and the relative risk ratio . The absolute response value measures the absolute difference between the fitted mortality rates for those still breastfed and those already weaned , while holding all other variables constant at their mean. The relative risk ratio shows the ratio of the fitted mortality rates for those weaned to those still breastfed , again holding all other variables constant. Note that a number of these statistics are based on regression results which are not significantly different from 0. These statistics should therefore not be interpreted as specific population estimates but merely as indicators of certain trends and patterns.

A second aspect of the influence of breastfeeding on child mortality is examined by comparing mortality probabilities within the interval, for those children who are still fully breastfed with those who are already partially weaned; again after controlling for other intervening factors. The regression models to perform this comparison are set up in a way similar to the previous model. The only differences between the two models are that 1) a decomposition of the full

breastfeeding status in the beginning of the interval (PWEANED) into totally breastfed (PWEANED=0) and partially weaned (PWEANED=1) was used instead of the dichotomy fully weaned-not fully weaned and 2)that because full breastfeeding hardly exceeds 9 months, the age-intervals are choosen as 1-8, 4-12 and 6-14 months. The results of this analysis are presented in section 5.

After the investigation of the main effects of breastfeeding on mortality, th interaction between (full and partial) breastfeeding duration and prevalence of malaria on child mortality is examined. To avoid multicollinearity between the main effects and the interaction terms, the interactions were not introduced directly into the previous models, but a more explorative approach was adopted through median polish techniques (6) and regression equations (similar to the first two models)based on malaria subgroups (see Section 6).

Finally, the relationship between the duration of partial breastfeeding of the penultimate child and the mortality probabilities of the last child is examined (Section 7). This is done through two regression equations in which the dependent variable is again dichotimous: 0 if the last child survived up to the age of 3 months, 1 if the child died before that age. Again the same set of control variables is used as before. In the first regression the duration of partial breastfeeding ("-9MONTHS") of the penultimate child is introduced as a dummy variable, indicating whether the child was breastfed for more or less than 9 months (0 if more, 1 if less). In the second equation the breastfeeding dummy variable ("NOTBF") shows whether not breastfeeding the penultimate child has an influence on the mortality risks of the next child (0 if penultimate child was ever-breastfed, 1 if not). These two regressions were also used to test whether the reason leading a mother to cease nursing her penultimate child can have an influence on the survivorship of the newborn. A dummy variable "STOPDEATH" was set equal to 1 if the mother stopped breastfeeding because the child died , while "STOPPPREG" was given the value 1 if the mother stopped because she became pregnant (i.e. the reference category is : stopped voluntarily).

3) BREASTFEEDING AND CHILD MORTALITY IN KENYA: GENERAL FINDINGS.

It is evident from various sources that infant and child mortality in Kenya has declined dramatically over the recent years. In a study based on the birth histories in the KFS MOTT (1979) estimates infant mortality rates for women aged 15-34

of 159 per 1000 prior to 1958, 109 in the period 1958-1967 and 92 in 1966-1976. Using the Brass' procedure to estimate l(2) and l(3)-values per region, ANKER & KNOWLES (1980) show that large differentials among districts exist. The Central Province has the lowest mortality and low levels are also found in the adjacent Rift Valley and Eastern Province. Highest levels are found in the Lake Victoria Basin (Nyanza and Western Province) and in the Central and Coast Provinces. KIBET (1981) shows that women's education and malaria are the most discriminating factors of infant and child mortality at the macro level. High averages of education and malaria within a district lead respectively to lower and higher levels of infant and child mortality. In their regression analysis of survival of births to age 3 years ANKER & KNOWLES (1980) equally show the importance of endemicity of malaria and education of mother as mortality determinants. Other important factors conducive to higher mortality are found to be: earlier period of birth, male sex, low household income, traditional medical care, unsanitory toilet use and poor health of the mother.

According to the data of the KFS, Kenyan women breastfeed their children for 13 months on the average. Only a small minority of 3 percent of women do not breastfeed at all, and another 7 percent breastfeed for less than 6 months. About half of the children are weaned around their first birthday and about 20 to 25 percent are breastfed until the age of 2 years. Only very few mothers however keep on breastfeeding beyond this age. These figures indicate that the system of traditional long lactation has not yet been eroded dramatically through modernisation. This makes a study of the effect of early weaning on mortality even more necessary; since there is a good chance that a strong reduction of breastfeeding may occur in the next decade. Also for policy reason it is of great value to know what consequences on the levels of infant and child mortality such a reduction will have if no protective measures are taken.

Table 1 shows that better educated women have a tendency to breastfeed for shorter durations -a trend which exist in many developing countries. Women who live in regions with higher prevalence of malaria breastfeed for longer durations . This finding could easily lead to the conclusion that women living in an unhealthy environment try to protect their children through longer lactation periods. However, those regions with higher prevalence of malaria are also the regions with a more traditional cultural pattern, including long breastfeeding durations. Very young mothers breastfeed for shorter durations while mothers above 35 breastfeed much longer . Women who were coded as never worked have longer durations of breastfeeding . No significant differences according to their breastfeeding durations were reported between male and female children.

Table 1 : Proportion of children fully weaned at the beginning of the age interval by background characteristics of the mother and the child

Background characteristics	Categories	1 - 8 months	9 - 14 months	18 - 36 months
Education mother	0 - 4 y.	.9	9.2	64.9
	5 + y.	1.4	18.8	78.7
Malaria prevalence	Mal 1	1.7	19.3	80.9
	Mal 2	1.0	10.5	66.5
	Mal 3	1.0	9.1	67.2
	Mal 4	.5	8.0	58.8
Age of Mother at Birth of Child	Below 20	4.2	14.2	73.5
	20 - 35 y.	3.0	11.8	69.0
	35 + y.	5.7	6.8	52.7
Work status mother	Ever worked	1.3	18.6	73.7
	Never worked	1.0	9.5	66.1
Sex of child	Male	1.1	11.3	68.0
	Female	1.0	12.1	68.0

Table 2 : Proportion of children partially weaned at the beginning of the interval by malaria prevalence

Age interval	Mal 1	Mal 2	Mal 3	Mal 4
1 - 8 m.	9.2	7.9	6.4	3.9
4 - 12 m.	70.0	68.4	54.1	45.7
6 - 14 m.	80.5	83.0	77.6	66.4

The mean duration of full breastfeeding in the KFS is 3.3 months. No marked differences with respect to length of full breastfeeding seem to exist between educational groups, sex of child and work status of the mother (Tables not displayed). In regions with higher incidence of malaria however, children are partially weaned at older ages (Table 2).

The first step to detect whether there exists any relationship in Kenya between the duration of (partial) breastfeeding and child mortality consists in the construction of two life-tables, according to the breastfeeding status of the child. These life-tables are constructed in the following way: after the age of 1 month the infant and childhood period is subdivided in 4 month intervals. All children surviving up to the beginning of each interval are classified as being breastfed or weaned. Mortality rates are than computed for each interval and compared for both statuses in order to detect statistical significant differences. Note that the mortality rates obtained through this procedure are slightly biased because the breastfeeding status is taken at the beginning of the interval and not at the time of death.

Mortality rates for both breastfeeding statuses are presented numerically in Table 3 and graphically in Figure 1. It is clear that the weaning effect on mortality is strongest during the first months of life. For the age-interval 1-4 months the mortality rate for weanlings is 125 per thousand, which means that of all children surviving and weaned at the beginning of the second month, 1 in every 8 dies in the next 4 months. Although this figure is only based on few observations it is significantly higher than the mortality rate of those still breastfed (14 per thousand).

In the course of the first year of life the weaning effect becomes weaker with age. Although the risk of dying in the interval 5-8 months is still around 8 and (in the interval 9-12) 4 per thousand higher for those who are no longer breastfed, the differences are not significant at the 10% level. In the age-interval 13 to 16 months mortality rates are almost the same for breastfeeders (5.4 per thousand) as for non-breasfeeders (5.6 per thousand). Note that the mortality rates in this interval are quite low in comparison with those of the surrounding intervals. This may be an indication of misreporting of age and of duration of breastfeeding - children who died or who were weaned in the age-interval 13-16 months may have been shifted to the intervals with heaping, i.e. 9-12 months or 17-20 months.

After 17 months of life the risk of dying becomes higher for those children who are still breastfed in the beginning of the interval relative to those who are weaned. We have

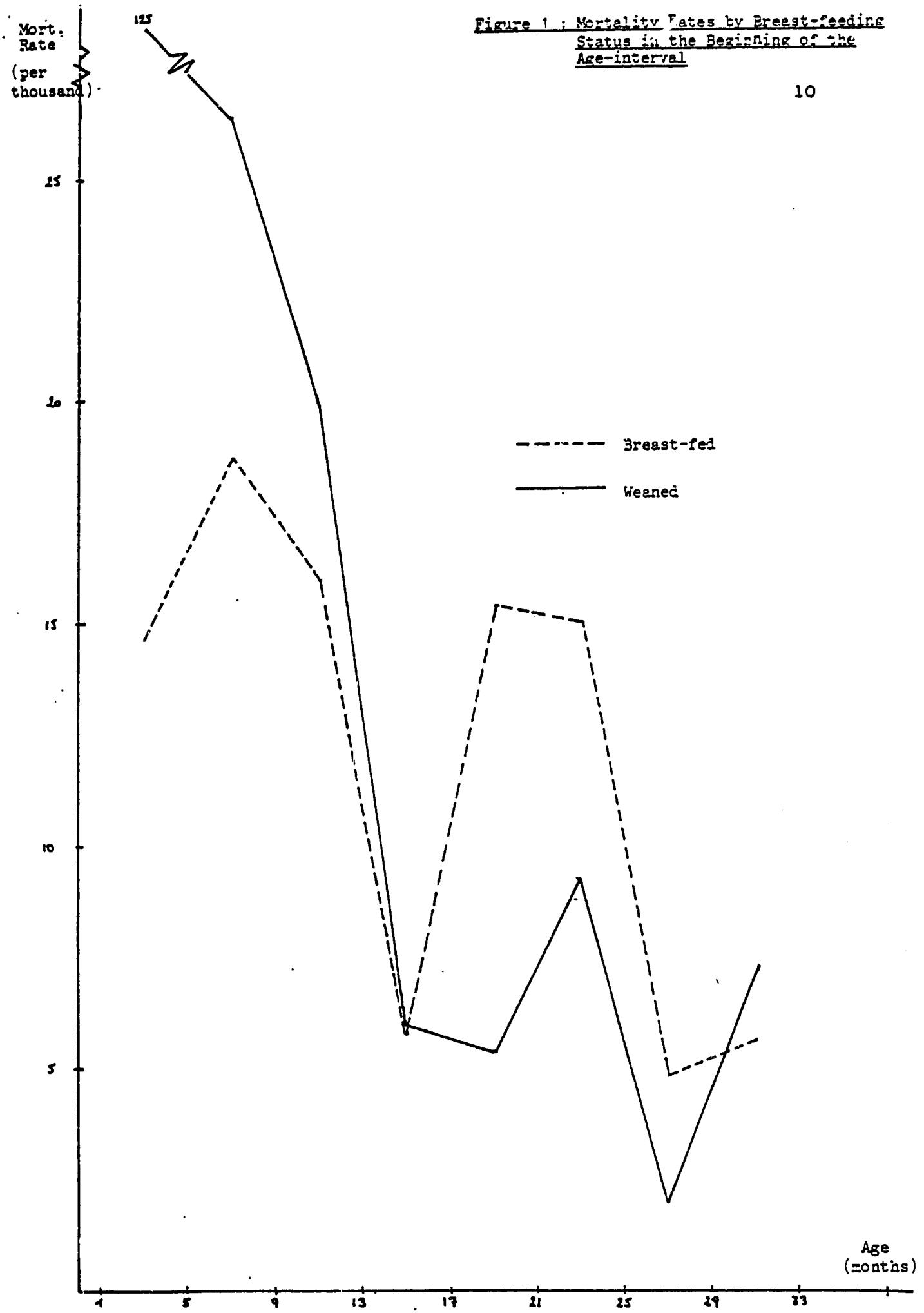
Table 3 : Life Table Mortality Probabilities by Breast-feeding Status in the beginning of the Interval (KFS : 1977-78)

Age Interval	BREAST-FEEDERS				NON-BREAST-FEEDERS		
	Persons in the beginning of the interval	Deaths in the interval	Number of children weaned in the interval	Mortality rate (x1000)	Persons in the beginning of the interval	Deaths in the interval	Mortality rate (x1000)
0 m.	3772		40				
1 - 4 m.	3732	53	179	14.20 (xx)	40	5	125.00 (xx)
5 - 8 m.	3500	64	495	18.29	231	6	25.97
9 - 12 m.	2961	46	1346	15.54	720	14	19.44
13 - 16 m.	1667	9	456	5.40	1967	11	.60
17 - 20 m.	1202	18	429	14.98 (xxx)	2413	12	4.97 (xxx)
21 - 24 m.	755	11	516	14.57 (xxx)	2835	25	8.82 (xxx)
25 - 28 m.	228	1	33	4.39 (xxx)	3333	5	1.50 (xxx)
29 - 32 m.	194	1	30	5.15	3361	23	6.84

(xx) Difference between mortality rates of breast-feeders and non-breast-feeders is significant at 5% level.

(xxx) Difference between mortality rates of breast-feeders and non-breast-feeders is significant at 1% level.

Figure 1 : Mortality Rates by Breast-feeding Status in the Beginning of the Age-interval



commented already on the selection processes which can result in higher mortality rates for breastfeeding in spite of the many benefits from breastfeeding. To detect whether sick children are indeed breastfed for longer periods, the following test was performed. The mean duration of breastfeeding was calculated for those children who survived up to their second birthday and who stayed alive during the next year. The mean duration of breastfeeding was then computed for those children who died in their third year of life. Normally we would expect the mean duration of breastfeeding to be smaller for those who died in the interval, because breastfeeding is curtailed for a number of those children. However, the mean duration of breastfeeding is higher among those children who died (25.7 months) than among those who survived (24.8 months). Although the difference between the two mean durations is not significant- because the computation among those who died is only based on few cases , the higher mean duration for the children who died suggests that indeed a selection process may be in operation.

The findings for Kenya are in line with those for Jordan by SULLIVAN , ADLAKHA & SUCHINDRAN (1982). According to their findings child mortality rates in the interval 1-5 months are 48.1 per thousand for non-breastfeeders and 15.1 per thousand for breastfeeders. In the interval 6-11 months mortality rates for breastfeeders (10.4 per thousand) and for non-breastfeeders are almost the same. Between 12 and 60 months of life the mortality rates for those who were no longer breastfed at the beginning of the second year is also lower than for those still breastfed (8.5 against 18.3).

4) THE NET EFFECT OF FULL WEANING ON MORTALITY

Various statistical studies have pointed out that partial breastfeeding duration has indeed a significant net effect on infant and child mortality risks (BUTZ et al, (1982) , SULLIVAN et al (1982)). Table 4 shows that in Kenya the duration of partial breastfeeding also has to be considered as a mortality determinant of primary importance

Let us first examine the regression results for the age interval 1-8 months. The most important factors leading to higher mortality are: high prevalence of malaria, very young or very old age of mother at the birth of the child and being fully weaned at the beginning of the second month. The mortality probability for a weanling is no less than 81 per thousand higher than for a child still breastfed, which is associated with a relative risk ratio of 3.46 . However, one has to be cautious in the interpretation of this result

Table 4 : Net Effect of Partial Breast-feeding Status in the Beginning of the Interval on Mortality Probabilities during the Interval (KFS : 1977-78)

VARIABLE	Age interval 1 - 8 months		Age interval 9 - 17 months		Age interval 18 - 36 months	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
MALE	.0013	.0043	.0015	.0043	.0014	.0055
EDM	-.0068	.0050	-.0058	.0051	-.0116 (x)	.0070
WORK	-.0021	.0052	-.0020	.0052	.0078	.0067
AGEB1	.0109 (x)	.0063	.0094	.0064	.0225 (xxx)	.0083
AGEB2	.0252 (xxx)	.0081	.0050	.0080	-.0013	.0095
MAL1	-.0018	.0058	.0017	.0058	-.0040	.0075
MAL2	.0046	.0073	.0085	.0073	.0009	.0094
MAL3	.0280 (xxx)	.0062	.0312 (xxx)	.0063	.0253 (xxx)	.0081
FWEANED	.0807 (xxx)	.0209	.0127 (x)	.0068	-.0175 (xxx)	.0061
Constant	.0238 (xxx)	.0056	.0155 (xxx)	.0057	.0306 (xxx)	.0087
No. of cases	7064		5715		3376	
R-square	.009		.009		.012	
Absolute Response Value	80.65 (per thousand)		12.74 (per thousand)		17.47 (per thousand)	
Relative Risk Ratio	3.46		1.50		.55	

(x) 10% significance level (xx) 5% significance level (xxx) 1% significance level.

because of the fact that disease or genetic malformation, which may cause both weaning and death , is probably highest in the first few months of life. This common dependence problem -of which the extend is impossible to capture given our data, may lead to an overestimation of the real effect of full weaning.

In the age interval 9-17 months the factors which cause an increase in mortality risks are: high prevalence of malaria (1% significance level) and lack of breastfeeding in the beginning of the interval(10% significance level). The probability of dying in the next 9 months is 13 per thousand higher for a weaned child than that of a child who is still breastfed. The relative risk ratio for such a child is 1.50 . This figure proves that the benefits of partial breastfeeding in Kenya continue well into the second year of life.

However, between 18 and 36 months the probability of dying for those children who are still breastfed is significantly higher (at the 1% level) than for those already weaned. The relative risk ratio in this interval drops to .55. This may be a possible consequence of the selection processes on the observed effect of breastfeeding on mortality. Unfortunately, with the data from the KFS it is impossible to clarify this issue further and more work based on appropriate data sets needs to be done .

5) THE NET EFFECT OF PARTIAL WEANING ON MORTALITY

After birth the moment of partial weaning constitutes the first hazardous period in an infant's life. It is at that moment that the child comes for the first time in contact with food from sources other than the mother. Coping with this difficult period will depend on the quality of the weaning food, the disease environment and the immunological condition of the child. The age at which a child is given food in addition to the mother's milk is crucial for his well being. If partial weaning starts too early it will prevent the child from growing normally (MONDOT-BERNARD (1977)). On the other hand if full breastfeeding is maintained for too long a time -say 9 months-the nutritional requirements of the child are no longer satisfied and the baby may "starve at the breast".

The effects of full breastfeeding on infant mortality , in the intervals 1-8, 4-12 and 6-14 months are presented in Table 5. Children who are already given additional food in the second month of life have probabilities of dying in the next

Table 5 : Net Effect of Full Breast-feeding Status in the Beginning of the Interval on Mortality Probabilities during the Interval (KFS : 1977-78)

VARIABLE	Age interval 1 - 8 months		Age interval 4 - 12 months		Age interval 6 - 14 months	
	Estimate	St. Error	Estimate	St. Error	Estimate	St. Error
MALE	.0012	.0043	-.0031	.0039	-.0004	.0048
EDM	-.0068	.0050	-.0030	.0045	-.0009	.0061
WORK	-.0023	.0052	-.0020	.0047	-.0075	.0059
AGEB1	.0112 (x)	.0063	.0055	.0057	.0053	.0081
AGEB2	.0248 (xxx)	.0081	.0174 (xx)	.0073	.0152 (xx)	.0072
MAL1	-.0021	.0058	.0002	.0052	.0091	.0066
MAL2	.0045	.0073	.0118 (x)	.0066	.0091	.0080
MAL3	.0277 (xxx)	.0062	.0299 (xxx)	.0057	.0291 (xxx)	.0071
PWEANED	.0141 (x)	.0085	.0022	.0041	.0133 (xx)	.0058
Constant	.0239 (xxx)	.0057	.0166 (xxx)	.0057	.0043	.0078
No. of cases	7064		6965		4512	
R-square	.007		.007		.007	
Absolute Response Value	14.27		2.20		13.35	
Relative Risk Ratio	1.44		1.09		1.72	

(x) 10% significance level (xx) 5% significance level (xxx) 1% significance level.

half year which are 14 per thousand higher than in the case of those still breastfed (significant at the 10% level). This is accompanied with a relative risk ratio of 1.44. In the interval 4-12 months the estimated regression coefficient for the partial weaning effect is positive but not significant. The third interval shows again a positive correlation between partial weaning and child mortality. The absolute mortality differential between weaned and non-weaned is 13 per thousand (significant at the 5% level) and the relative risk becomes 1.72. These results show that in Kenya the duration of full breastfeeding has an important influence on the survival probabilities of young children.

6) THE INTERACTIVE EFFECT OF BREASTFEEDING AND MALARIA ON MORTALITY

It is generally accepted that the better chances of survival of children with long breastfeeding durations in unsanitary environments is a result of 1) the qualities of human milk - its complete nutritional composition and the presence of host-resistant substances , and 2) indirectly, the avoidance of the use of contaminated weaning foods. Thus it can be hypothesized that the weaning effect on mortality is more severe in those regions where malaria is highly endemic, because a child who lives in a disease ridden environment has higher chances of being infected as soon as the protective action of breastfeeding is no longer present.

This hypothesis is first tested for partial breastfeeding by using a median-polish of the mortality rates within the interval, by partial breastfeeding status at the beginning of the interval and prevalence of malaria (subdivided as before). The median polish was only performed for the age interval 9-17 months, because of the reverse causation problem and the small number of weanlings in the interval 1-8 months and the possible selection problem in the last interval. Table 6 shows the crosstabulation of the observed mortality probabilities by breastfeeding and malaria and ,between brackets, the fit and the residuals of a All+Row+Column analysis. An examination of the residuals of such an analysis can reveal whether an interactive process is operating or not. Figure 2 shows that no straightforward interaction is taking place. For those children who are fully weaned in the beginning of the second interval, the effect of breastfeeding and malaria on mortality is less than the additive effect in the low malaria region (MAL1), more (and increasing) than the additive effect for the medium malaria regions(MAL2 & MAL3) but less again for the region where

Table 6 : Crosstabulation of mortality probabilities in the interval 9 - 17 months by breast-feeding status in the beginning of the interval and prevalence of malaria (Kenya Fertility Survey : 1977-1978)

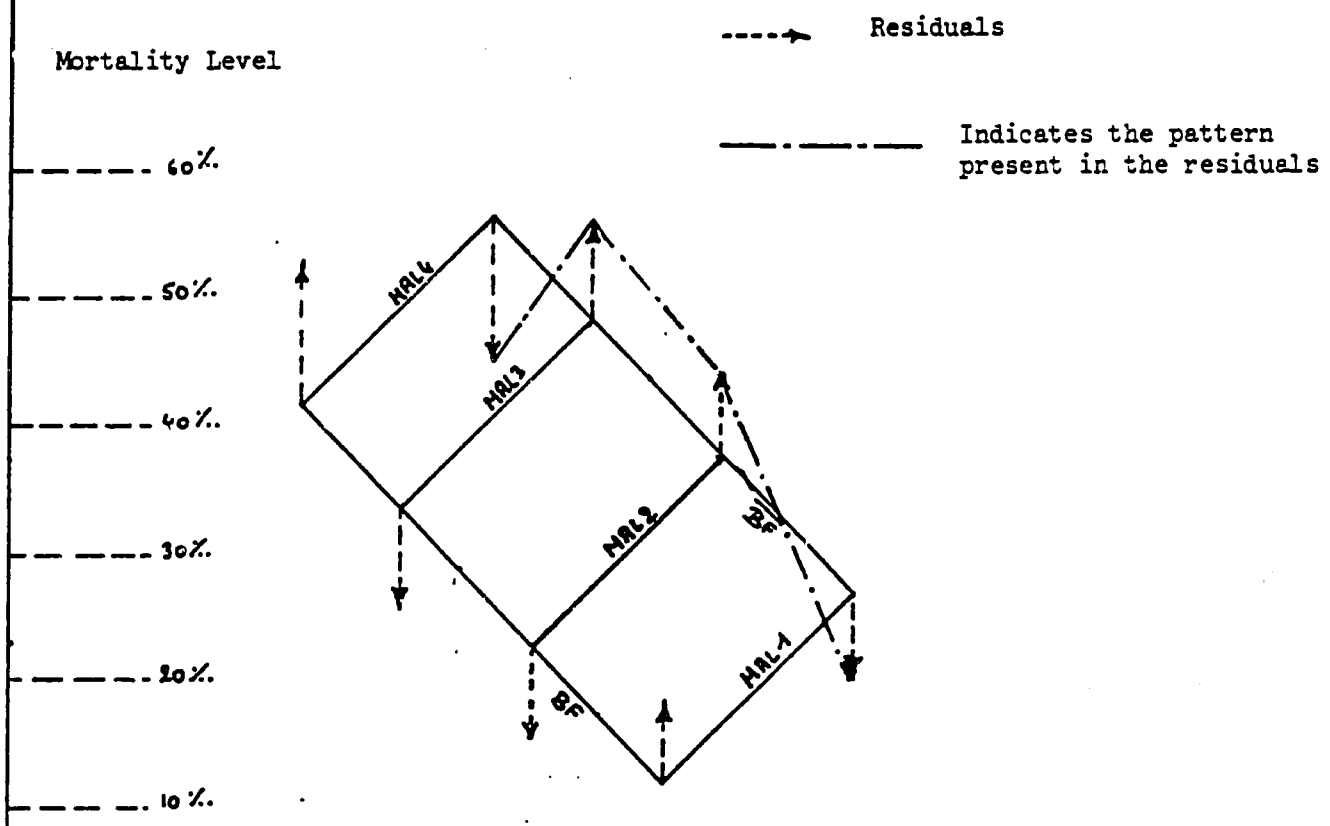
5715 cases (20 missing values)

(34.82)	MAL1 (-16.45)	MAL2 (-4.61)	MAL3 (4.61)	MAL4 (12.96)
BF (-7.43)	16.98 (6.05)	16.74 (-6.05)	24.80 (-7.20)	50.90 (10.57)
$\overline{BF}$ (7.43)	19.76 (-6.05)	43.69 (6.05)	54.05 (7.20)	44.64 (-10.57)

BF = still partial breast-fed in the beginning of the 10th month

$\overline{BF}$ = weaned at beginning of 10th month.

Figure 2 : Two-way plot of the additive effect of malaria and breast-feeding status in the beginning of the age-interval (9 - 17 months) on mortality probabilities within the interval



BF : Partially or full breast-fed in the beginning of the interval.

$\overline{BF}$: fully weaned in the beginning of the interval.

malaria is highly prevalent (MAL4). This finding goes against our hypothesis but suggests that the effect of full weaning becomes greater if the prevalence of malaria is higher; when malaria however becomes to great a threat to child health, partial breastfeeding does not act as an adequate form of protection anymore and death strikes those weaned and still breastfed in almost the same way.

To investigate this relationship at greater depth an OLS-regression was run for each of the three age intervals. The format of the regressions is the same as that used in the section which dealt with the effect of full weaning. However, separate regressions were run for 1) the 3 regions where malaria is not highest and 2) the highest malaria region (see Table 7).

In the age interval 1-8 months the relative risk ratio in the low malaria region, for those already weaned is 4.27 with the FWEANED-variable significant at the 1% level. In the high malaria region the relative risk ratio is much smaller : 2.47 accompanied by a breastfeeding variable which is not significantly different from 0. The mortality probabilities within the second interval (9-17 months) for those fully weaned are 15 per thousand higher (1% significance level) in the low malaria, but virtually equal to 0 in the high malaria regions. These results confirm the finding we made earlier, following the use of the median polish: namely that the effect of full weaning becomes minimal or nil if the level of malaria passes a certain threshold.

In the interval 18-36 months, for both subgroups of malaria, the probabilities of dying are higher for those children who are weaned than for those who are not. However, the effect is much stronger in the high malaria region. This could perhaps be explained by the presence of a more pronounced selection effect in regions of higher malaria incidence; -the selection effect being the inverse association between longer breastfeeding and child health. The higher selection effect may operate because in those regions, more children are weak or sick as they may be more susceptible to infection during the lactation period than in regions with lower endemicity of malaria. If this supposition were true, it would again confirm the previous conclusion. However more work needs to be done in this connection.

The interaction between full breastfeeding and malaria on mortality is investigated in a way similar to that in the case of partial breastfeeding. Since the problems due to small numbers of weanlings and to selection problems are less severe here, a median polish is performed for each of the three age-intervals (1-8, 4-12 and 6-14 months). After an All+Row+Column fit a clear pattern in the residuals still

Table 7 : Net Effect of Partial Breast-feeding on Infant and Child Mortality by Prevalence of Malaria

VARIABLE	Interval 1 - 8 months		Interval 9 - 17 months		Interval 18 - 36 months	
	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)
WORK	.0051 (.0051)	-.0334 (xx) (.0141)	-.0005 (.0050)	-.0106 (.0150)	.0112 (x) (.0064)	-.0018 (.0197)
MALE	.0006 (.0044)	.0026 (.0106)	.0004 (.0043)	.0050 (.0113)	.0090 (.0055)	-.0196 (.0147)
EDM	-.0030 (.0051)	-.0168 (.0126)	-.0028 (.0051	-.0170 (.0137)	-.0086 (.0068)	-.0185 (.0193)
FWEANED	.0829 (xxx) (.0199)	.0773 (.0757)	.0153 (xxx) (.0065)	-.0001 (.0210)	-.0117 (x) (.0061)	-.0326 (xx) (.0152)
AGEB1	.0080 (.0067)	.0191 (.0145)	.0004 (.0004)	.0324 (xx) (.0157)	.0049 (.0083)	.0689 (xxx) (.0213)
AGEB2	.0125 (.0084)	.0611 (xxx) (.0194)	.0064 (.0080)	.0019 (.0206)	.0044 (.0095)	-.0161 (.0245)
Constant	.0225 (xxx) (.0038)	.0552 (xxx) (.0089)	.0182 (xxx) (.0037)	.0471 (xxx) (.0095)	.0212 (xxx) (.0063)	.0738 (xxx) (.0151)
R-square	.004	.012	.005	.005	.004	.027
Absolute response value (per 1000)	82.9	77.3	15.3	-.01	-11.7	-32.6
Relative risk ratio	4.27	2.43	1.85	1.00	.58	.52

(x) 10% significance level (xx) 5% significance level (xxx) 1% significance level

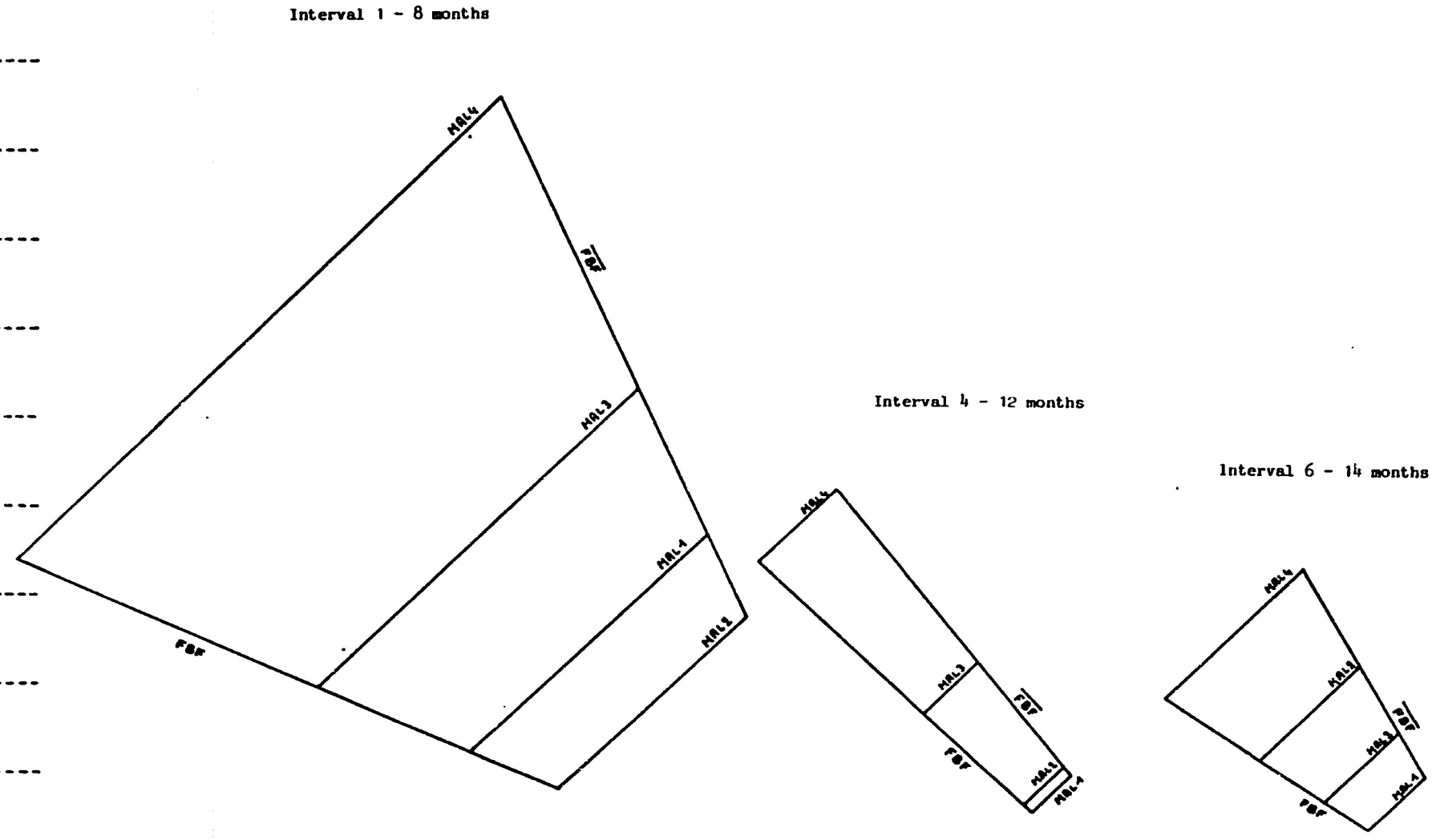
Table 8 : Net Effect of Full Breast-feeding on Infant and Child Mortality by Prevalence of Malaria

VARIABLE	Interval 1 - 8 months		Interval 4 - 12 months		Interval 6 - 14 months	
	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)	Lower prevalence of malaria (s.e.)	Higher prevalence of malaria (s.e.)
WORK	.0050	-.0331 (xx)	.0012	-.0204	-.0049	-.0229
MALE	.0005	.0028	-.0033	-.0026	-.0058	.0170
EDM	-.0029	-.0172	.0006	-.0155	.0040	-.0165
PWEANED	.0104	.0389	-.0004	.0065	-.0008	.0421 (xxx)
AGEB1	.0084	.0201	-.0016	.0250 (x)	-.0024	-.0024
AGEB2	.0121	.0613 (xxx)	.0055	.0510 (xxx)	.0105	.0346 (xx)
Constant	.0227 (xxx)	.0539 (xxx)	.0210 (xx)	.0453 (xxx)	.0242 (xxx)	.0061
R-square	.001	.013	.000	.009	.001	.020
Absolute response value (per 1000)	10.4	38.9	-.4	6.5	-.8	42.[illegible]

(x) 10% significance level (xx) 5% significance level (xxx) 1% significance level

in the interval

Figure 3 : Two-way plot of the interactive effect of malaria and full breast-feeding status on mortality within various age-intervals



FBF : fully breast-fed in the beginning of the interval

$\overline{\text{FBF}}$: partially weaned in the beginning of the interval

remained, which made it possible to fit an interactive model of the form All+Row+column+[(Row)(Column)/(All)]. The results of this fit are displayed graphically in Figure 3 (no tables are reproduced).

From this graph it can be seen that the high malaria region again occupies an outstanding position. It is clear that the effect of partial weaning on mortality is much larger if the weaning takes place in a region where malaria incidence is higher. Among the other three regions no clear pattern exists with regard to the magnitude of the effect of partial weaning on mortality.

Once again a regression was run for each set of malaria regions, which were subdivided as before (see Table 8). Although only one regression coefficient is significantly different from 0 (interval 6-14 months, MAL4) the results suggest that the partial weaning effect is stronger in regions where malaria is highly prevalent.

In conclusion, the analysis of the interaction between malaria and (full and partial) breastfeeding shows that in disease laden environments the partial weaning effect on mortality is quite severe. The full weaning effect in such an environment is however negligible. These findings suggest that full breastfeeding gives a reasonable protection against the threats of the environment, but as soon as additional food is given the protective action of breastfeeding becomes very small. In healthier environments both full and partial breastfeeding suppress mortality significantly in the first years of life.

7) THE EFFECT OF PARTIAL BREASTFEEDING DURATION ON THE SURVIVAL PROBABILITIES OF THE NEXT CHILD

Many authors have shown that the duration of breastfeeding, in societies where contraceptive use is low , influences the birth interval through the intermediacy of postpartum amenorrhea (LESTHAEGHE & PAGE (1981) ; HUFFMAN, CHOWDHURY, CHAKRABORTY & MOSLEY (1978) ; MONDOT-BERNARD (1977)). Several authors have also pointed out that short inter- pregnancy intervals can be associated with a marked rise in the mortality risk in the early months of life of the next child (WRAY (1977), KANDEH (1979), SULLIVAN, ADLAKHA & SUCHINDRAN (1982)). The relatively higher mortality risks of the children born after short birth intervals can be explained through the burden laid on the mother. Very short birth intervals create a pressure on the mother's nutritional state since it becomes harder for her to recover physically from

both pregnancy and lactation. Poor nutritional condition of the mother can lead to premature childbirth and low birthweight; which are highly correlated with neonatal mortality. Moreover a short birth interval when the previous child is still alive, implies that the mother has to divide her time, attention and resources between two very young children - which may decrease maternal care and increase domestic accidents.

The question we will try to answer in this section is straightforward: since breastfeeding influences length of birth interval and short intervals increase probabilities of dying of the newborn, can short breastfeeding duration of the penultimate child be directly associated with higher mortality chances of the last child ?

Table 9 shows that the duration of breastfeeding of the penultimate child does have a significant effect on the mortality probabilities of the last child. If the breastfeeding duration of the penultimate child is less than 9 months, the last child's probability of dying in the first 3 months of life is 14 per thousand higher than if the penultimate child is breastfed for more than 9 months. However, if the penultimate child is not breastfed at all, the survival chances of the last child decrease by almost 30 per thousand. This last effect is not to be attributed only to the breastfeeding/weaning of the penultimate child. Other explanations can also be put forward. First, if the mother decides not to breastfeed the penultimate child, there is a pretty good chance that she does not breastfeed the last child either. And, as we saw earlier, not being breastfed decreases the survival probabilities in the first months of life. Secondly, if the penultimate child is not breastfed because he is either too weak or sick at birth, it is possible that the last child is weak or sick too - which increases his mortality risks. This effect is also partially shown through the regression coefficient of STOPDEATH: if a mother stops nursing the next to the last child because it died, the chance of dying in the first few months of life of the last child increases by 35 per thousand (44 in the second regression). If a mother however stops because she became pregnant, the survival probability of her last child increases with 16 per thousand (14 in the second regression). This is somewhat contrary to the expectations. If a woman gives up breastfeeding we would expect that she starts her pregnancy in a fairly weakened state, especially in environments characterised by poor nutritional conditions. This weakness can lead to having babies of low birth-weight and to high neonatal mortality. A possible explanation why our results go against this hypothesis may be that again a selection process is in operation. In a country like Kenya, where traditional child-spacing practices are still common, it is possible that

Table 9 : Mortality probabilities in the first 3 months of life of the open-interval according to the breast-feeding in the closed interval

VARIABLE	Breast-feeding variable more or less than 9 months included (penultimate child) $R^2 = .009$	Breast-feeding variable ever/never breast-fed included (penultimate child) $R^2 = .010$
SEX	.0100 (x)	.0100 (x)
EDM	.0030	.0047
AGEB1	-.0014	-.0024
AGEB2	.0183 (xx)	.0168 (x)
STOPDEATH	.0351 (xxx)	.0442 (xxx)
STOPPREG	-.0156 (xx)	-.0138 (x)
MAL1	-.0003	-.0009
MAL2	.0096	.0089
MAL3	.0009	.0000
-9MONTHSBF	.0142 (xx)	
NOTBF		.0297 (xxx)
Constant	.0164 (xx)	.0179 (xx)

(x) 10% significance level (xx) 5% significance level (xxx) 1% significance level

women who become pregnant during lactation belong to a more modernised stratum of society. In a transitional society , modern women have higher chances of conceiving since they are not protected by the post-partum abstinence. Although conception during nursing may increase infant mortality, modern women are more likely to seek medical assistence during pregnancy and at time of delivery, they are better fed and have better notions of hygiene . All these factors may explain the lower mortality among children of women who gave up breastfeeding because they became pregnant.

8) CONCLUSION:

Breastfeeding durations have not yet decreased dramatically in Kenya. The present paper has shown that a reduction in the duration of both full and partial breastfeeding would lead to a significant increase of the mortality probalities in the early years of life. It can be expected that the effect of shorter partial breastfeeding durations would be greatest in areas with low or median endemicity of malaria, because partial breastfeeding does not provide adequate protection against disease in regions where malaria is hyperendemic. A reduction in full breastfeeding duration would however lead to a greater increase in mortality risks in high malaria regions. The policy implications of these findings are that in regions with high malaria prevalence campaigns should be oriented towards encouraging longer full breastfeeding periods. It is not however possible to arrive at an estimate of the ideal number of months: since no decission regarding the point at which full breastfeeding becomes unfavourable to the child's nutritional well being can be made on the base of the KFS-data. In lower malaria regions the campaigns should be oriented to stimulate the mothers to give breastmilk for at least as long as one year.

Furthermore, reduced breastfeeding duration would not only lay a burden on the survival chances of the child itself , but also , through short birth- interval of the next child.

NOTES

(1) One has to be cautious in the interpretation of the results of those studies (such as GORDON et al. (1963) and DEL PINAL (1981)) which compare mortality rates of ever and never breastfed children to estimate the weaning effect on mortality. The observed difference in mortality in these studies is not the mere effect of feeding regime on infant health ,but also the effect of the health status of the infant and the mother at the time of birth of the child.

(2) Recently a new statistical technique to study child mortality determinants was developed by PRESTON & TRUSSELL (1982). The dependent variable in their regression is not a dichotomy but the ratio PD(i)/EPD(i), where PD(i) is the observed proportion of children who died , born to the i woman and EPD(i) is the expected proportion of her children dead .This dependent variable is then made a function of a number of demographic and socio-economic characteristics of the mother. Now, if we were to include breastfeeding in this model, the average duration of breastfeeding per woman should be included. This information is however not available in most surveys because breastfeeding information is mostly provided only for the most recent births or for a limited time period before the survey. Therefore , the PRESTON & TRUSSELL method is of little value in the study of the influence of breastfeeding on child mortality.

(3) By using this dummy variable in the regression equation we avoid the reverse causation problem (children breastfed until death) : but some other problems remain. The effect of weaning will not show up in our model for a child who is weaned shortly after the beginning of the age-interval and who dies because of some complication due to weaning before the end of the interval. The effect of weaning on mortality for such a child will not be detected by our model.

(4) The percentage values were taken from M. KIBET (1980). M. KIBET's data show that malaria is highest in Western, Nyanza and Coast Province. Districts in the Rift Valley, Central, Eastern and North-Eastern are not as prone to malaria.

(5) The use of OLS-regression techniques as applied to a binary dependent variable is not without problems. First, it is possible that the fitted values of the dependent variable fall outside the 0-1 range. Since we attach a probalistic meaning to our dependent variable, fitted values outside the range 0-1 would be meaningless. Second, the error term is heteroskedastic since its variance depends on E[y]. Because of the heteroskedastic nature of the disturbance the least square

estimators are not efficient, although unbiased. A third problem is that the regression coefficients are not normally distributed and hence the classic tests for significance are distorted.

In spite of these statistical problems OLS-techniques are very often used for binary dependent variables instead of the more sophisticated logistic regression. For instance, the analyses of BUTZ & DAVANZO and ANKER & KNOWLES are totally based on OLS.

In order to check whether the results obtained through OLS were plausible, all regressions were run again with a logit model for grouped data, which revealed quite similar results.

(6) The median polish is an exploratory data analysis technique developed by J. W. TUKEY, which can be used to estimate the all, the column and the row effect of a two by two contingency table. On the basis of these estimates simple fits of the form FIT=ALL+ROW+COLUMN can easily be made for each cell. If there still exists a pattern in the residuals of the median polish, a better fit is often provided by FIT=ALL+ROW+COLUMN+((ROW)(COLUMN)/(ALL)).

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