Effect of Famine on Child Survival in Matlab, Bangladesh*

Famine is defined as widespread food shortage leading to a significant rise in regional mortality (Blix, 1971). Historically, major causes of famine have been natural calamities. However, in modern times, when a natural disaster causes insufficient production of food, political and social factors play an important role in determining whether famine becomes widespread and who is affected (Alamgir, 1980; Langsten, 1985; Sen, 1980).

The 1974 famine in Bangladesh was one of the most severe of modern times. More than 1.5 million excess deaths reportedly occurred as a consequence (Alamgir, 1980; Sen, 1980).

Studies have found that the effect of famine on mortality depends on the socio-economic status of families and the demographic characteristics of individuals. The effect of famine is especially severe among the poor (Razzaque, 1985; Sen, 1980) and among the very young and the elderly (Chen and Chowdry, 1977; Chen, Huq and D'Souza, 1981; Razzaque, 1985 and 1989). D'Souza and Chen (1980) have documented that, among children under 14 years of age, during the Bangladesh famine of 1974, females suffered higher mortality than males.

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The excess mortality associated with famine usually continues for a time following the famine. A short while after that period, the death rate can fall below the pre-famine level (Bongaarts and Cain, 1981; Watkins and Menken, 1985). The sustained effect of famine on mortality is generally attributed to such factors as malnutrition, spread of infectious disease associated with generally lower resistance to disease, unsanitary conditions associated with floods, shortage of medical supplies and disruption of the infrastructure. The lower-than-usual level of mortality in the period following the period of sustained higher mortality may be due to premature death (including intrauterine mortality) of the more frail members of the population during famine, which results in a healthier surviving population.

Razzaque and his colleagues (1990) found that mortality was higher up to the second year of life for the children born during famine, compared with the non-famine cohort, whereas mortality in the cohort conceived during the famine was higher only for the first year. Thereafter, the children born during the famine and the children conceived during the famine experienced lower mortality compared with the children conceived after the famine.

The period of famine is also associated with a higher-than-usual rate of out-migration (Razzaque, 1985). Families whose survival is in danger apparently are more likely than others to move away from the area affected by famine. Accordingly, the level of mortality in the famine area is affected by the level of out-migration.

This paper examines how the level of child mortality and rate of out-migration, and their covariates were affected during the 1974 famine and the periods immediately following the famine in Bangladesh.

Data

The data are from Matlab, a rural area of Bangladesh, where the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) has maintained its Demographic Surveillance System since 1966. The Matlab field research area is in the low-lying deltaic plain situated 70 kilometres south-east of Dhaka.

The population covered by the surveillance was 276,000 in 228 villages at the time of the 1974 census. The population density in that area exceeds 2,000 persons per square mile.

Farming is the dominant occupation of the study population, and fishing is the second most common occupation. The average educational level is low, and sanitation in the villages is poor (Razzaque, 1989). The nutritional status of the children under age 5 is very poor. About 56 per cent of the children

weigh less than 70 per cent of the normal weight for their age group as measured by National Child Health Survey growth curves (Bhuiya, 1983).

The Demographic Surveillance System maintains continuous registration of births, deaths, migrations, marriages and divorces, and it conducts cross-sectional censuses as well. Details on field operations have been reported elsewhere (Cholera Research Laboratory, 1978; Razzaque, 1985).

For our study, children under three years of age as of 1 July 1974 and children born between July 1974 and June 1977 were selected. The basic data consisting of dates of birth, death and out-migration are extracted from the Demographic Surveillance System, and are believed to be accurate.

Characteristics of families were extracted from the census of May 1974 and merged with the basic demographic data. Some community variables have also been added to the data set. Using these data, mortality and out-migration are analyzed in the three-year period from July 1974 through June 1977.

Methods

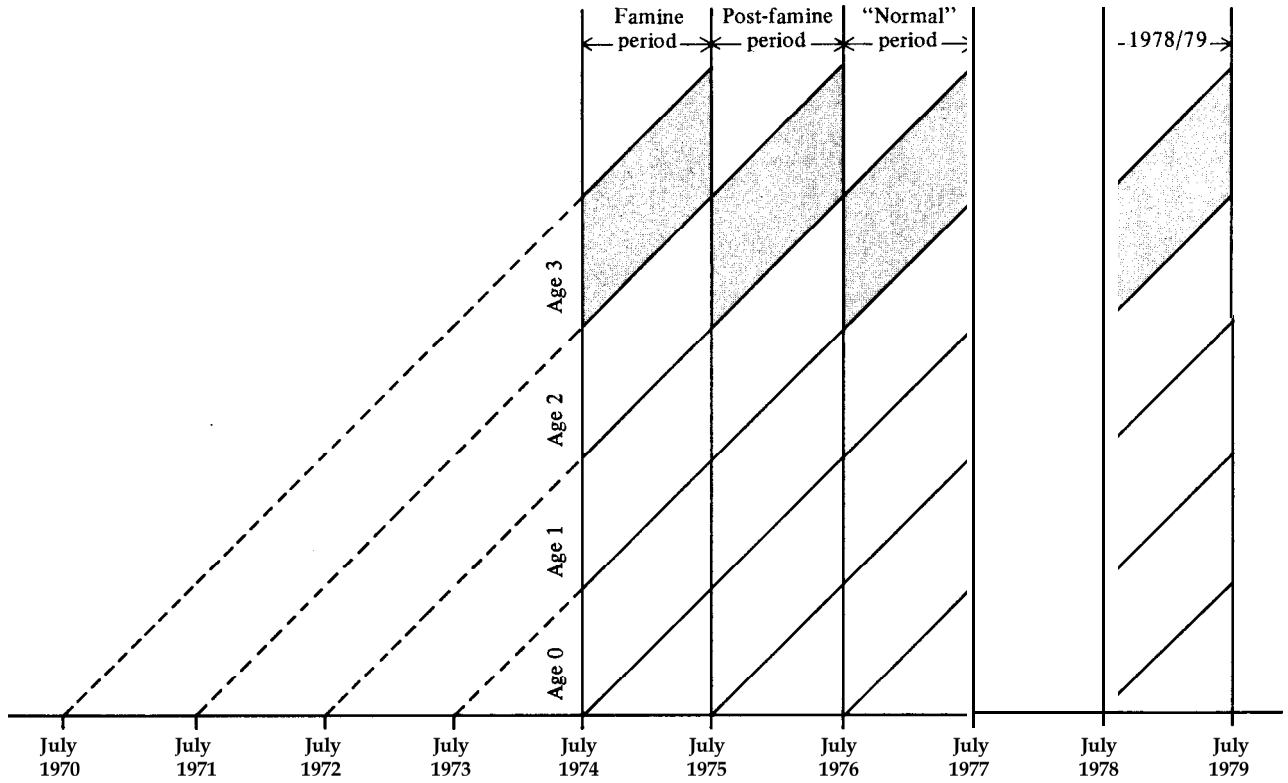
The three-year period is divided into three sub-periods: the famine period from July 1974 to June 1975; the post-famine period from July 1975 to June 1976; and a "normal" period from July 1976 to June 1977. Figure 1 shows a Lexis diagram of population and events covered by the study.

The analysis consists of a series of multivariate models, one model for each single year of age. For each model, three cohorts of children who were surviving at the beginning of each of the one-year periods have been selected. The dependent variable is the status of children at the end of the one-year period. The status is categorized as one of the three possible outcomes: death during the year, out-migration during the year, or survival. Using the multinomial logit model (Maddala, 1983; Choe, 1989), we estimate the age-specific probabilities of death, out-migration and survival, and the effects of covariates for children aged 0, 1,2 and 3 at the beginning of each of the three sub-periods. For purposes of comparison, age-specific probabilities of dying are also calculated for the period July 1978 to June 1979.

For example, to estimate the effects of the famine and other covariates on three possible outcomes, namely, death, out-migration and survival, from age 3 to age 4, three birth cohorts who were aged 3 at the beginning of the three sub-periods are analyzed (see figure 1).

The birth cohort of July 1970 to June 1971 (for convenience, this cohort is called the 1970 birth cohort) was aged 3 at the beginning of the famine period. The 1971 birth cohort was aged 3 at the beginning of the post-famine

Figure 1: Lexis diagram depicting age-specific probabilities of dying and out-migration for children aged 3 for famine, post-famine, "normal" and 1978/79 periods



period, and the 1972 birth cohort was aged 3 at the beginning of the "normal" period .

These three birth cohorts are analyzed together to estimate the effects of famine as well as other covariates of the mortality and out-migration for the three-year-old.

Each period is defined as a 12-month period so that the analysis would not be affected by the seasonality of births and deaths. Demographic events in Matlab show very clear seasonality associated with farming activities. Births are concentrated in December and January, reflecting high marriage and conception rates during the spring following the major winter harvest (Becker, 1981a, 1981b).

Figure 2, which plots the number of births by month for the period July 1970 to June 1977, shows this seasonality of births, which was disrupted somewhat during the famine.

Figure 2: Number of births by month of birth: July 1970 to June 1977, Matlab, Bangladesh

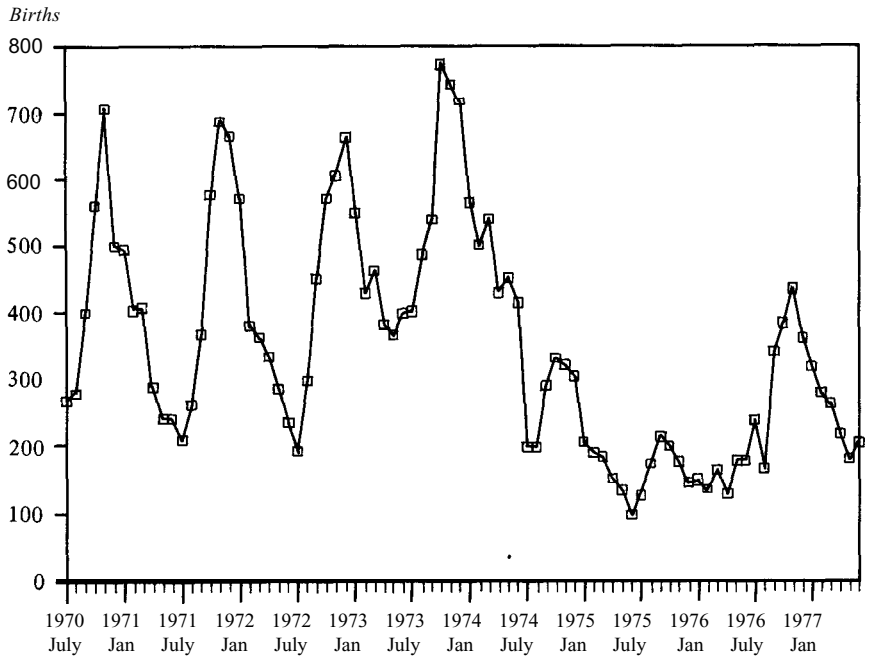
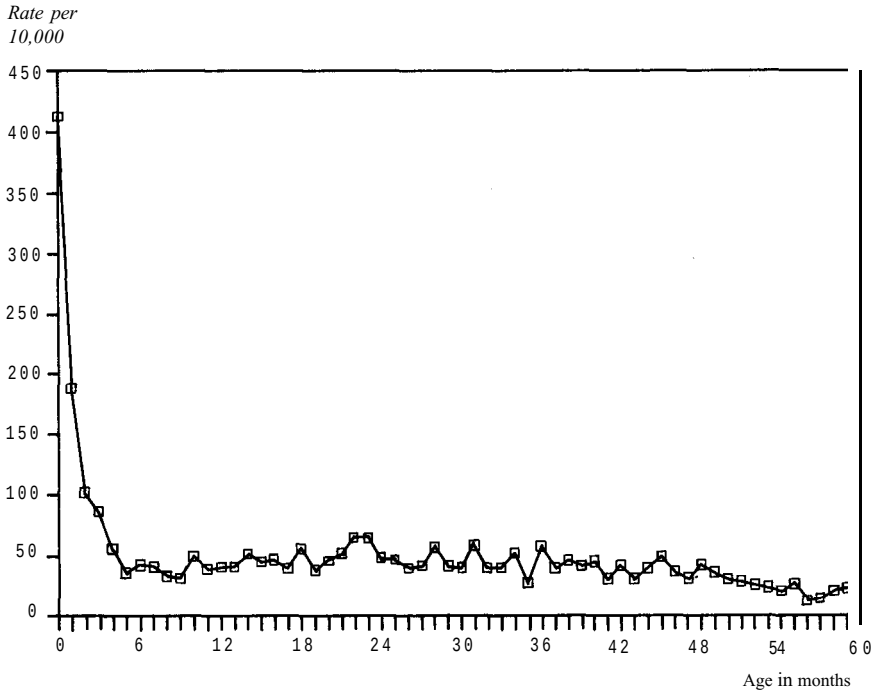


Figure 3: Monthly age-specific death rates: July 1974 toJune 1977, Matlab, Bangladesh



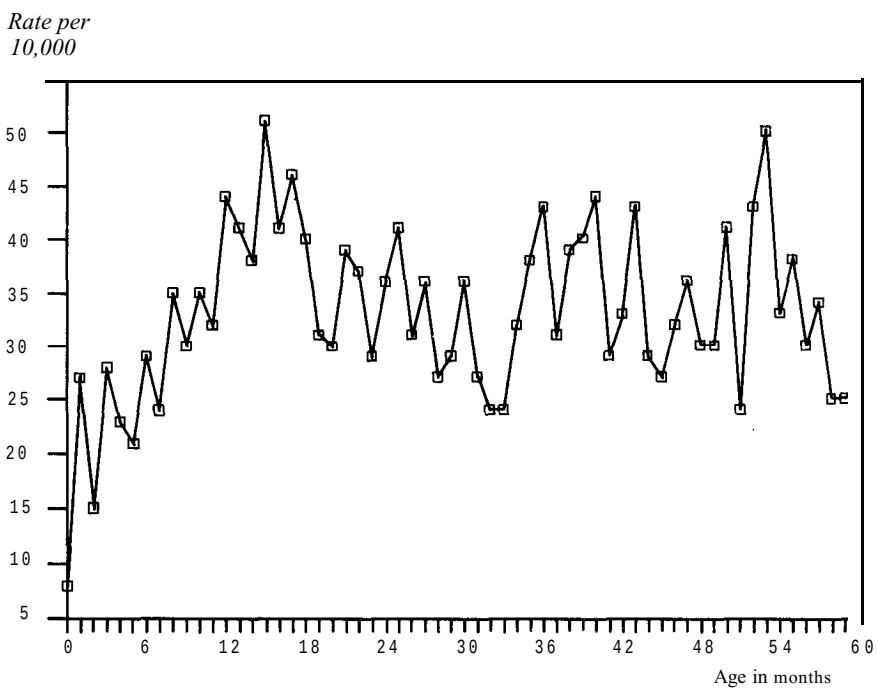
Figures 3 and 4 show overall age-specific death rates and out-migration rates. With regard to the quality of data, there is no evidence of data heaping or other severe problems.

Covariates of mortality and out-migration

The model includes two dummy variables indicating the famine period (1970 birth cohort) and the post-famine period (1971 birth cohort). The effects of the famine and post-famine periods are estimated through these dummy variables.

The model also includes other covariates we believe to be associated with mortality and out-migration rates, and the interaction terms between the dummy variable indicating the famine period and other covariates. Not included are the interaction terms between the dummy variable indicating the post-famine period and other covariates because we do not believe that

Figure 4: Monthly age-specific out-migration rates: July 1974 to June 1977, Matlab, Bangladesh



the effects of other covariates differed significantly during the post-famine period compared with the "normal" period. The covariates of mortality and out-migration consist of community characteristics, socio-economic conditions of the family, and the age and sex of children.

Socio-politica! characteristics of the community are represented by a dummy variable indicating whether any resident in the same village was a member of a local union council. Members of local union councils are responsible for informing the people of the time of arrival of relief food. Therefore, if a village resident is a member of the union council, the residents of the village may be informed of the coming relief sooner than the residents of other villages.

Three covariates describing family characteristics are included in the model: living standard, education and mother's religion. Living standard is measured by the number of items owned by a family from among the following:

radio, watch, hurricane lamp, quilt and remittances. The number of such items is recoded under two categories, 0 for one or none, and 1 for two or more items. The mortality and out-migration rate is hypothesized to be higher among families not owning many household items.

The level of education of the family is also included in the model. A higher level of education attained by any member of the family should improve the level of health of each member of the household through better information, adoption of modem technologies and utilization of services such as health centres. The educational level of the family is coded as 1 if any member of the family had some formal education; if not, then it is recorded as 0. It is hypothesized that children from a family with more education had lower mortality and a lower rate of out-migration. The mother's religion is used as an indicator of whether the family belongs to the majority religious group (Muslim). It is hypothesized that the families of the minority group (Hindu) had higher mortality and migration rates.

As individual characteristics, a dummy variable indicating whether the child is male (value 1) or female (value 0) is included in the model. In Bangladesh, female children are found to receive nutrition and health care that are inferior to that of male children (D'Souza and Chen, 1980). Table 1 shows the list of covariates with descriptive statistics.

Results

After trial runs, the interaction between the variables indicating political representation of the community and famine was found to be not significant statistically for all ages. Therefore, it was dropped from the final models.

Table 1: Descriptive statistics of covariates of mortality and out-migration for children aged 0-3, Matlab, Bangladesh

Covariates	Proportions
Community has political representation	0.693
Household has two or more household items	0.406
Someone in family has formal education	0.743
Religion is Muslim	0.869
Sex of child is male	0.516
Number of children	52,045

Note: The characteristics are as of the time of the 1974 census.

Table 2: Estimated multinomial logit regression coefficients of probabilities of death, out-migration and survival by age of children, Matlab, Bangladesh

Covariates	Age 0	Age 1	Age 2	Age 3
P (death)/P (survival)				
Famine period	1.092*	0.952*	0.658	0.239
Post-famine period	0.641*	0.493*	0.818*	1.301*
Community	-0.068	-0.221*	-0.138	-0.243
Living standard	-0.36	-0.305*	-0.255	-0.284
Education of family	-0.16	-0.14	-0.305*	-0.877*
Muslim religion	-0.004	0.282	0.634*	-0.274
Sex is male	-0.168	-0.356*	-0.359*	-0.352*
Famine x living standard	-0.003	-0.281	-0.08	-0.476
Famine x education	-0.31	-0.213	-0.032	0.21
Famine x Muslim	-0.104	-0.144	0.466	0.936*
Famine x male	-0.267	-0.399*	-0.326	-0.234
P (out-migration)/P (survival)				
Famine period	2.776*	2.435*	2.666*	2.764*
Post-famine period	0.258	0.439*	0.337*	0.299
Community	-0.182	-0.084	-0.148	-0.106
Living standard	0.412	-0.012	0.209	-0.059
Education of family	-0.164	-0.183	0.018	-0.439*
Muslim religion	0.43	0.325	0.454	0.938*
Sex is male	-0.035	-0.122	0.196	0.019
Famine x living standard	-0.957*	-0.41	-0.318	-0.346
Famine x education	-0.464	-0.678*	-0.566*	-0.2 1
Famine x Muslim	-1.628*	-1.395*	-1.397*	-1.885*
Famine x male	-0.028	0.304	0.103	-0.004
P (death)/P (out-migration)				
Famine period	-1.684*	-1.483*	-2.009*	-2.525*
Post-famine period	0.383	0.054	0.481*	1.002*
Community	0.114	-0.137	0.01	-0.137
Living standard	-0.772*	-0.293	-0.464*	-0.226
Education of family	0.003	0.043	-0.323	-0.437
Muslim religion	-0.434	-0.044	0.18	-1.212*
Sex is male	-0.133	-0.234	-0.554*	-0.371
Famine x living standard	0.954*	0.128	0.238	-0.129
Famine x education	0.155	0.465	0.534	0.42

Table 2 *(continued)*

Covariates	Age 0	Age 1	Age 2	Age 3
Famine x Muslim	1.524*	1.251*	1.863*	2.821*
Famine x male	-0.239	-0.703*	-0.428	-0.23

Notes: Community is coded as 1 if the child's community has a resident who is a member of the union council; if not, it is coded as 0. Living standard is coded as 1 if child's family owns two or more itmes: radio, watch, hurricane lamp, quilt, or remittances; if not, it is coded as 0. Education of family is coded as 1 if anyone in the family has formal education; if not, it is coded as 0.

Table 2 shows the estimated multinomial logit regression coefficients. The top panel shows the estimated coefficients associated with the probability of dying versus the probability of surviving. The second panel shows the estimated coefficients associated with the probability of out-migration versus the probability of surviving, and the bottom panel shows the estimated coefficients associated with the probability of dying versus the probability of out-migration. The column headed by "age 0" gives coefficients for those who were age 0 at the beginning of the observation, and so on for the other ages.

The results of the multinomial logit regression are also presented in terms of expected probabilities of dying and out-migration for a population with specific characteristics. For example, to see the effect of the famine and post-famine periods on child survival after adjustments are made for other factors, the expected probabilities of dying and out-migration are computed from the estimated model, by substituting the mean values of all covariates except the dummy variables indicating the famine and post-famine periods. For these dummy variables, appropriate combinations of ones and zeroes are used to indicate the famine, post-famine, and "normal" periods. Tables 3 through 7 show expected probabilities computed in this manner. The results are discussed in detail in the following paragraphs.

Effect of famine

Table 3 shows the estimated probabilities of dying and out-migration during three one-year periods: namely, the famine period, post-famine period and "normal" period, by age of children at the beginning of each period. The table is augmented by the implied level of infant mortality rate, a more familiar indicator of mortality, in the top panel.

These infant mortality rates are estimated in the following way. For the infants born during a one-year period, the probability of surviving to the

Table 3: Estimated probabilities of dying and out-migration by age of children in completed years and period

Age	Period	Probability of dying*	Probability of out-migration	Infant mortality†
0	Famine	532	752	3 238
	Post-famine	372	66	1 238
	Normal	200	52	970
1	Famine	437	730	
	Post-famine	300	108	
	Normal	186	70	
2	Famine	272	1 019	
	Post-famine	351	109	
	Normal	158	79	
3	Famine	112	985	
	Post-famine	347	90	
	Normal	97	68	

Notes: * Probability of dying in 12 months for children of specified age in completed years (per 10,000). Using complete life table notations, this probability is equal to 10,000 L(x+l)/L(x).

† Per 10,000 live births. From West regional model life table with matching probability of surviving to the end of the year for infants born during one-year period. See text for details of the procedure.

end of the period (L_0/l_0 in life-table notation) is estimated by the same multinomial logit model. Then a West model life table (Coale and Demeny, 1983) with the matching survival probability is found. From the model life tables, the infant mortality rate (q_0 in the life table) is obtained.

Compared with the "normal" period, mortality was substantially higher during the famine as well as the post-famine period for all the ages considered. For children of ages 0 and 1, mortality was highest during the famine, but for children of ages 2 and 3, mortality was highest during the post-famine period. This is not surprising because at ages 2 and 3, most children have been weaned. Their mortality is influenced more by nutrition and sanitary conditions as well as health care when they become ill than by the biological factors the children are born with.

Sanitary and health-care conditions during the post-famine period may have been as bad as or worse than during the famine itself. Moreover, these children were probably weaned during the famine and received inferior nutrition which would have weakened their 'resistance to infectious diseases

prevalent during the post-famine period. Compared with these children, the older children, i.e. those of ages 2 and 3 at the beginning of the famine, were probably weaned before the famine began and thus had the opportunity to grow and build resistance to hardship before the famine.

It may be seen that the increase in the probability of out-migration is greater than the increase in mortality during the famine, especially for older children. It may be concluded that, when children are old enough, they may avoid excess mortality partly by moving away from the area affected by the famine.

Designating the period July 1976 to July 1977 as the "normal" period needs to be interpreted with caution. This period, which immediately followed the famine and post-famine periods, may show a somewhat lower level of mortality than such periods as the pre-famine period (Bongaarts and Cain, 1981).

Unfortunately, our data do not allow direct calculation of mortality during the pre-famine period. However, it is possible to compute mortality during the period from July 1978 to June 1979. The probabilities of dying, corresponding to the third column of table 3 were 346 for children of age 0, 288 for age 1, 2 10 for age 2, and 140 for age 3. Mortality during the 1978/79 period was lower than that during the famine and post-famine periods but higher than that during the "normal" period, especially among older children.

Children who survived the famine and the immediate post-famine period had lower mortality during the subsequent period, probably because the more frail members had already died and only the healthier members of that cohort survived.

This result is consistent with the findings by Razzaque *et al*. (1990), who examined infant and child mortality of cohorts of children born during the famine, conceived during the famine, and conceived after the famine in the same Matlab area. They found that the children born or conceived during the famine experienced higher mortality than did children conceived after the famine during the first year or two, but that afterwards their mortality was lower than that of the cohort conceived after the famine.

Community representation

Community representation, indicated by whether a resident of the same community was a member of the union council proved not to be statistically significant during the "normal" time as well as during the famine and post-famine periods. Only 1 of the 12 coefficients associated with this variable was statistically significant (table 2).

This finding is contrary to our expectation. We expected that, because union council members were responsible for informing people when relief supplies would be distributed, having a village resident in the union council would speed the communication, leading to faster access to relief and lower mortality. However, our data do not support the hypothesis that political representation of a community improves the survival chances of its residents during a famine.

Living standard

Table 4 shows that, in general, children in families who owned more household items had lower mortality than children in families who owned fewer items, but the differences are statistically significant only for age 1 (table 2).

Families who owned fewer items seem to have been affected by famine more than families who own more, but these differential effects are not statistically significant. Furthermore, children in families with more possessions had lower ratios of mortality to out-migration rate than did children in families with fewer possessions, the difference being statistically significant for children ages 0 and 2.

For children of age 0, the effect of the famine on mortality was greater than its effect on migration. Among the poor, families with very young children were perhaps less mobile than other families and as a result suffered higher mortality.

Education

In general, higher education was associated with lower mortality, the relationship being larger and statistically more significant for older children (table 5). This is consistent with our hypothesis that a higher level of education of a family improves the survival of its members because of their ability to utilize resources better.

Better utilization of resources is likely to improve the survival of older children more than the younger children because, at older ages, mortality is affected by environmental factors to a larger extent than at younger ages.

The effect of famine on mortality did not depend on education very much, but the educational differences in the effect of famine on out-migration was statistically significant for families with children of ages 1 or 2. Among families with more education, the out-migration rate did not increase as much during the famine as it did among families with less education. Perhaps the

Table 4: Estimated probabilities of dying and out-migration by age of children in completed years, number of household items owned and period

Age	Number of household items owned	Period	Probability (x10,000) of:	
			Dying	Out-migration
0	Fewer than 2	Famine	609	793
		Post-famine	429	71
		Normal	231	56
	2 or more	Famine	447	485
		Post-famine	302	108
		Normal	162	85
1	Fewer than 2	Famine	511	772
		Post-famine	353	115
		Normal	219	75
	2 or more	Famine	299	533
		Post-famine	263	115
		Normal	163	75
2	Fewer than 2	Famine	306	975
		Post-famine	392	104
		Normal	177	76
	2 or more	Famine	223	892
		Post-famine	305	128
		Normal	138	94
3	Fewer than 2	Famine	132	1 046
		Post-famine	412	96
		Normal	116	73
	2 or more	Famine	65	728
		Post-famine	313	91
		Normal	87	69

Note: The probabilities are estimated from the multinomial logit model, fiiing the educational level of family, mother's religion, sex of child, and community representation at their mean values.

Table 5: Estimated probabilities of dying and out-migration by age of children in completed years, education of family and period

Age	Education of family	Period	Probability (x 10,000) of:	
			Dying	Out-migration
0	Low	Famine	659	1000
		Post-famine	474	91
		Normal	256	72
	High	Famine	443	574
		Post-famine	408	78
		Normal	219	62
1	Low	Famine	497	982
		Post-famine	350	149
		Normal	218	98
	High	Famine	376	447
		Post-famine	306	125
		Normal	190	a2
2	Low	Famine	337	1 127
		Post-famine	438	121
		Normal	199	89
	High	Famine	255	691
		Post-famine	327	125
		Normal	147	91
3	Low	Famine	193	1 364
		Post-famine	611	127
		Normal	175	100
	High	Famine	107	770
		Post-famine	265	85
		Normal	74	65

Note: The probabilities are estimated from the multinomial logit model, fixing the number of household items owned, mother's religion, sex of child and community representation at their mean values.

Table 6: Estimated probabilities of dying and out-migration by age of children in completed years, religion of mother and period

Age	Religion	Period	Probability (x10,000) of:	
			Dying	Out-migration
0	Hindu	Famine	537	1 181
		Post-famine	392	109
		Normal	211	86
	Muslim	Famine	528	391
		Post-famine	388	167
		Normal	209	132
1	Hindu	Famine	356	888
		Post-famine	247	133
		Normal	153	87
	Muslim	Famine	432	322
		Post-famine	323	181
		Normal	201	119
2	Hindu	Famine	140	1 025
		Post-famine	181	110
		Normal	81	79
	Muslim	Famine	436	413
		Post-famine	333	169
		Normal	151	123
3	Hindu	Famine	110	774
		Post-famine	335	69
		Normal	94	53
	Muslim	Famine	222	312
		Post-famine	254	177
		Normal	71	134

Note: The probabilities are estimated from the multinomial logit model, fixing the number of household items owned, educational level of family, sex of child, and community representation at their mean values.

families consisting of members with no formal education were engaged in less stable occupations and were more likely to move during a famine.

Religion

The relationship between religion and mortality is not clear (table 6). However, there is a clear relationship between religion and out-migration during the famine. Minority Hindus had much higher out-migration rates during the famine than did Muslims, although the out-migration rate at other times was not very different. In fact, religion shows a greater effect of change on out-migration during the famine than any other covariate considered. It may be that Hindus, being a minority, had less attachment to the community and were more willing to move out of the affected area during hard times.

Female mortality was higher than male mortality at all ages (table 7). Further, the increase in mortality during the famine period was higher for females compared with males at all ages. The sex differentials of mortality are statistically significant for all ages except age 0, while the interaction between sex and famine was significant for age 1.

These findings are as expected because mortality at very young ages depends more on biological factors; the sex differential for nutrition and child care would not result in differential mortality at very young ages.

At older ages, female children suffered higher mortality and the effect of famine was greater on female children. This result is consistent with findings from other studies that examined sex differentials of child mortality in Bangladesh (Bairagi, 1986; Chen, Huq and D'Souza, 1981; D'Souza and Chen, 1980).

Interestingly, the effect of sex on probability of out-migration was not statistically significant for any age, at any period. Most of the time, migration is a family event, affecting all members of the family. In contrast, mortality is an individual event and individual characteristics within a family, such as sex, can be an important factor.

Discussion

We examined age-specific mortality and out-migration rates during the famine, post-famine, and "normal" periods, and found that the famine affected both mortality and out-migration. When migration is not considered as a possible demographic response to the famine, assuming that mortality is the same among out-migrants and non-migrants, the estimated covariates

Table 7: Estimated probabilities of dying and out-migration by age in completed years, sex and period

Age	Sex	Period	Probability (x10,000) of: Dying	Out-migration
0	Male	Famine	415	736
		Post-famine	373	66
		Normal	200	52
	Female	Famine	624	763
		Post-famine	438	68
		Normal	236	54
1	Male	Famine	268	877
		Post-famine	275	96
		Normal	170	63
	Female	Famine	562	720
		Post-famine	387	107
		Normal	241	70
2	Male	Famine	173	1 207
		Post-famine	312	118
		Normal	141	86
	Female	Famine	347	909
		Post-famine	441	96
		Normal	200	70
3	Male	Famine	78	993
		Post-famine	306	91
		Normal	85	69
	Female	Famine	139	974
		Post-famine	426	88
		Normal	120	68

Note: The probabilities are estimated from the multinomial logit model, fixing the number of household items owned, educational level of family, mother's religion and community representation at their mean values.

are quite different (Razzaque, 1988) especially for socio-economic variables such as education, living standard and religion. We conclude that a study of mortality during famine should be done taking out-migration into consideration.

The effect of famine on mortality and out-migration varies considerably across different age groups. While older children suffered higher excess mortality during the famine, children aged one or two at the beginning of the famine seem to have suffered higher mortality extending to the period beyond that considered as famine by the average population.

We also found that, after this sustained higher mortality, children exhibited a lower level of mortality compared with the usual level of mortality for their age. We explain this as the consequence of premature deaths among more frail members of the population during hard times, leaving a healthier surviving population some time after the famine.

Socio-economic covariates, such as living standard, education and religion, affected both mortality and out-migration, but in somewhat different ways, especially during the famine. The effects of education and religion changed more during the famine compared with their effects during the "normal" period.

Female children suffered higher mortality, especially during older childhood. Although the sex differential of mortality increased during the famine, the additional disadvantage of female children during famine is statistically significant only for one age group (age 1) among the four age groups (0 to 3) considered.

It should be noted also that detailed analysis of age-specific mortality and out-migration rate has become possible only by using the high-quality data collected by the Demographic Surveillance System (DSS) in Matlab, and merging the information collected through the DSS system and other sources of data such as the population census.

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