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Child Mortality in Bandafassi (Senegal), 1970-1991: Increased Risk of Measles Death for Children with a Sibling of the Opposite Sex

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CHILD MORTALITY IN BANDAFASSI (SENEGAL), 1970-1991: INCREASED RISK OF MEASLES DEATH FOR CHILDREN WITH A SIBLING OF THE OPPOSITE SEX.

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Abstract

The demographic surveillance of the population of Bandafassi, a rural area of Eastern Senegal, shows a probablility of 0.68 that a new born child will survive up to age 5 during the period 1970-1991. The risk has declined slowly in the last 5 years. It is higher in large villages and large households than in small ones. There are differences according to ethnic group but no sex differences. 243 individuals were reported to have died of measles during the surveillance period. The interval between outbreaks in the same village was greater than 10 years. Though only deaths and not the cases of measles have been registered, we have tested the hypothesis that cross-sex transmission of infection increases severity of measles. In families with only two maternal siblings under 10 years of age, the risk of dying of measles during outbreaks was 14% (107/766). In a multiple logistic regression analysis adjusting for significant background factors (age, age difference between siblings and size of community), children in families with a boy and a girl were found to have significantly higher mortality than children in families with two boys or two girls (odds ratio (OR)=1.81 (1.17-2.82)). The increase in risk was the same for males and females in two-child families with a boy and a girl. These data suggest that cross-sex transmission of infection may be an important determinant of severity of measles infestion.

INTRODUCTION

The 42 villages of the Bandafassi area in Senegal (8,181 persons in 1991) have been monitored with annual demographic surveys for more than 10 years (1). Information collected is analysed here to answer two questions:

- what are the levels, trends and factors of mortality among children?
- an important risk factor for mortality in measles infection has been described recently in Guinea-Bissau and in other areas: secondary measles cases infected from someone in their own house have a higher mortality when infection is contracted from the opposite rather than the same sex (2-6) ; do we observe the same phenomenon in Bandafassi?

In the Bandafassi study, each year, the list of the people present in the compound during the preceding visit is checked, and any births, deaths, marriages, or migrations that have occurred are registered (1, 7-11). During the study period a large number of measles deaths have been reported ; 243 deaths in years with epidemics. Previous analyses from part of the data have shown that measles accounts for as much as 31% of the deaths between 6 months and 10 years of age, making measles one of the most important causes of mortality (9). Having a maternal sibling under 10 years of age was found to be an important risk factor for dying of measles (10).

It was not part of the original surveillance system to register infections, only the deaths were recorded. Even though we do not have the information on who had measles and how it was transmitted, we have used the data on measles deaths to test whether cross-sex transmission has an impact on the case fatality. If cross-sex transmission increases the case fatality ratio, we should expect that children whose siblings are of the opposite sex have a higher risk of dying of measles than children with siblings of the same sex since many of them will contract infection from a sibling. We have therefore investigated the risk of dying of measles during an epidemic in families with only two maternal siblings, two boys, two girls or a boy and a girl.

I - POPULATION AND METHODS

Population. The Bandafassi area is located in the Department of Kedougou in Eastern Senegal, near the border between Senegal and Guinea (1, 7-8). Villages belong to three ethnic groups : the Fula Bande (24 villages), the Niokholonko (7 villages) and the Bedik (11 villages). Surveillance began in 1970 among the Niokholonko, in 1975 among the Fula Bande and in 1980 among the Bedik. The residential unit is a compound in which the members of an extended patrilineal family live ; on the average there are 22 persons in a compound among the Niokholonko, 13 among the Fula Bande and 18 among the Fula Bande. A compound would contain one hut for each ever-married woman and sometimes additional huts for unmarried adult sons and/or for the head of the compound. Polygyny is frequent : there are 180 married women for 100 married men (7-8). When a man has several wives, each one has her own hut close to the others. Children sleep in their mother's hut until about age 15. Teen-age girls leave the compound to marry, and boys build small huts to sleep in, often with age-mates. Sleeping arrangements sometimes vary. Older children may sleep in the huts of old or childless women, even if their mother lives in her own hut in the compound (10).

Demographic surveys. Once each year, usually between January and March, all villages are visited, the list of people present in each compound at the preceeding visit is checked and information (lay) is obtained on new births, marriages, migrations, deaths and causes of death. Information is usually provided by the heads of the compound or key informants in the village.

Measles epidemics. Measles outbreaks take place during the dry season, from October to April. Among the Fula Bande, measles epidemics occurred in 1976-77, 1982 and 1985, among the Niokholonko in 1973 and 1981-82 and among the Bedik in 1982. Epidemics only affected some of the villages. Seven deaths which occurred outside the time of these epidemics, usually during travels to other areas of Senegal, have not been utilized in the analysis. Only one measles death was registered among the Bedik during the epidemics of 1982. As a consequence, information from the Bedik has been left aside in the analysis of the influence of cross-sex transmission of measles on mortality ; this has been restricted to the Fula Bande and the Niokholonko. Since most measles deaths occurred among children born during the study, the ages of death can be considered relatively accurate. The study is based on the parental diagnosis of measles as the cause of death. Measles is a well-known disease in these populations, with a specific name in the local languages. Since all deaths occurred during clearly defined epidemics, the risk of misclassification of measles deaths seems limited (10). Measles vaccinations campaigns were uncommon in this area until 1987. The only exception are the Bedik villages which have been cared by missionaries and started to receive vaccinations before.

Mortality. In a first step, we have calculated general mortality risks for all children born alive during the period of the surveillance study, including the data from all villages. In a second step, we focussed on measles mortality during periods of epidemics in Fula Bande and Niokholonko villages. We have calculated the measles mortality risk in families which just prior to the epidemic had two maternal siblings under 10 years of age. This analysis included only sib pairs from villages where measles was known to be present because of deaths ascribed to measles. Children who experienced two epidemics as maternal siblings under 10 years of age were only counted once.

Statistical methods. Survival analysis methods for censored failure time data have been used to estimate the probabilities that a new-born child survive up to age 5. After an univariate analysis, multivariate regression analysis was used to estimate the effects of sex, twinning status (whether a child is a twin or not), period of birth, ethnic group, village size and compound size on child survival.

In the study of measles mortality, multiple logistic regression analysis was used to assess the effect of opposite-sex and same-sex sibship controlling for sex, age, village size, age difference between siblings and relative age (older or younger). There was no tendency towards clustering of deaths in certain families. Clustering has therefore not been considered further in the analysis.

Survival analysis techniques for censored data were also used to calculated the median interval between epidemics within the Fula Bande and Niokholonko villages. Before the 1987 national vaccination campaign, there had been no systematic vaccination in these villages. The period of observation for the calculation of intervals between epidemics was censored in 1987.

II - RESULTS

1) Levels and trends of child mortality

During the study period 1970-1991 the Bandafassi study registered 5,658 deliveries of children born alive. Table 1 shows their probability of dying from birth to age 5 years (5q0) by age interval and period of birth. On the whole period 1970-1991, the probability of dying before age 1 (1q0) is 166 per 1,000 and the probability for a child alive at age 1 of dying before age 5 (4q1) is 131 per 1,000. Combining these two risks result in 5q0 being equal to 315 per 1,000. Child mortality has declined during the study period, but only recently.

Comparisons between periods may be biased by changes in the study population during the study: as yet mentionned, demographic surveillance, which was inititiated in 1970 in the 7 Niokholonko villages, has been extended in 1975, with the addition of 24 Fula Bande villages, and in 1980, with 11 Bedik villages. Child mortality differences between periods may be due in part to differences between sub-populations belonging to different ethnic group.

Variations of 1q0 and 4q1 by year of birth and ethnic group are illustrated by Figures 1 and 2. There is a decline of infant mortality (1q0) among all ethnic groups, starting with the generations born in about 1985. Figure 2 shows an increase of 4q1 for generations born in the years 1979-1981, especially among Niokholonko: about half of the children who were still alive at age 1 died before reaching age 5. A lot of them got measles during the 1982 measles epidemics, when they were between 1 and 3 years old, which are high risk ages of measles death in this area (9).

Mortality of Bedik children seems lower than that of the Fula Bande and the Niokholonko ones.

2) Factors of child mortality

Variations of 5q0 according to sex, age of mother, twinning status, period of birth, ethnic group, size of village and size of compound are shown in Table 2. In the univariate analysis, variations in child mortality are correlated with all the variables examined. Mortality of boys is slightly higher than that of girls and, as found everywhere, mortality of twins is much higher than that of single babies and children of very young mothers (less than 20 years) or of old ones (=>40) die more frequently than those whose mother's age is intermediate (aged between 20 and 39 years). Child mortality is the highest among the Niokholonko and the lowest among the Bedik, that of the Fula Bande being in between. Children from large villages and large compounds have a higher mortality than those living in small villages and small compounds. In the multivariate analysis (Table 3), the effect of the ethnic group, the compound size, the twinning status and the period of birth are the most significant ; the effects of the village size and the age of the mother are still significant ; sex differences are no more significant.

3) Measles mortality during epidemics

During the three epidemics among the Fula Bande and the Niokholonko, a total of 243 measles deaths were registered. As found elsewhere in West Africa (12), there were more older girls among the fatal cases ; 25% (32/129) of the girls who died were five years or older compared with only 14% (16/114) among the males ($p<0.05$, $x^2= 4.43$). The median age at death was 2.7 years, somewhat higher for females (2.9 years) than for males (2.5 years) ($p = 0.074$; Mann-Whitney). The deaths occurred in 6 Niokholonko and 18 Fula Bande villages. The interval between epidemics depended on the size of the population (Table 4). The median interval between epidemics was greater than 9 years for villages with more than 100 inhabitants. In smaller villages, the median interval was more than 13 years.

Forty-seven of the 243 deaths had no maternal sibling under 10 years of age and 89 belonged to families with more than two children, leaving 107 deaths for further analysis. In families with only two maternal siblings under 10 years of age, the risk of dying during outbreaks of measles was 14.0% (107/766) (Table 5). Including sex, age, sibling age difference, relative age (older/younger), village size and sex of sibship in a multiple logistic regression analysis, sex and relative age did not show significant effects. Controlling for age, sibling age difference and village size, the effect of cross-sex sibship was significant (OR=1.81, 95% confidence interval (CI) : 1.17-2.82). The risk of dying decreased with age and village size and increased with the age difference between siblings, all effects controlling for the other variables (Table 6).

III- DISCUSSION

Child mortality was high in Bandafassi during the last 21 years (1970-1991) and it has declined only slowly and recently. The national campaign of immunisation of 1987 was the first one in the area and it has contributed to the decline of child mortality: it has prevented in particular new measles epidemics : the last one observed in the area occured in 1985. Child mortality among the Bedik is lower than among the other ethnic groups. Since many years, they have access to health cares provided specially to them by missionaries. Vaccinations campaign have been organised in their villages long before the national campaign of 1987. The influence of the size of the compound on child mortality reflects crowding effects yet observed in Bissau and in other studies (10, 13).

The intervals between outbreaks in the same villages were extremely long, greater than 10 years in the majority of cases. Due to the long interval, children of the same mother would tend to contract measles during the same outbreak, often from a maternal sibling. Since case fatality ratios of much more than 14% for children under 10 years of age (Table 5) or 18% for children under five years of age (85/480) are unlikely (12), it seems probable that most children under 10 years of age contracted measles in the affected villages. We have therefore assumed that all children under 10 years of age in a village contracted measles during an outbreak. Since all studies have found that children infected at home (secondary cases) have higher mortality than the index child, i.e. the child who introduces measles into the home (13-15), it is particularly likely that the children who died contracted measles from a maternal sibling. We have, therefore, analyzed the measles mortality risk in families with two children under 10 years of age in villages with outbreaks. However, even if the analysis was limited to families with two children under five years of age, there was a similar difference in mortality risk for same-sex and double-sex pairs (Table 5).

Previous studies from West Africa have suggested that long intervals between epidemics leads to clustering of many cases and higher case fatality (13). This was also suggested by the data from Bandafassi since the mortality risk was higher in small villages which had longer intervals between epidemics. Since the interepidemic interval was more than 13 years in the small villages, siblings older than 10 years are likely to have contributed to increased clustering of measles cases. The alternative interpretation would be that fewer children were infected in the larger villages. However, given the high mortality risk observed in this area, it seems unlikely that many should not have been infected and that the case fatality ratio should be considerably higher. Increased measles mortality connected with a large age difference between siblings has not been reported before (Table 6). Though this could be a coincidence it may also reflect that siblings of the same age presumably have similar behaviour patterns and are likely to contract measles at the same time, none of them becoming a secondary case. With a large age difference between siblings they may be more likely to become infected in different context thus increasing the risk that the other sib will become a secondary case.

When these significant background factors were taken into consideration, the data from Bandafassi indicated that the risk of dying was nearly two times higher among those with a sibling of the opposite sex. Since the test is only indirect for secondary cases, this will underestimate the differential impact of contracting infection from the opposite sex as opposed to from one's own sex.

Some fatal cases were not secondary cases infected by their sibling under 10 years of age, either because they themselves were infected outside the home or because they were infected by another older sibling aged more than 10 years. These fatal cases were presumably equally distributed between those with a same-sex and those with a different-sex sibling. The differential impact of same-sex and cross-sex transmission for secondary cases is therefore likely to be greater.

In the data from Bissau (2), the difference between being infected by the opposite or one's own sex was strongest for the girls. The data from Senegal, however, suggest that the relative risk between same-sex and double-sex sib pairs is essentially the same for boys and girls (Table 5). Whereas the previous report from Bissau only dealt with children under five years of age because there was virtually no deaths among older children, the present report suggests that the tendancy is the same for older children (Table 5).

The cross-sex transmission tendency may not be limited to measles infection since we have found that male-female twins have a higher risk of post-neonatal mortality than male-male or female-female twins (3). Furthermore, it was a risk factor for child mortality to have a nearest older sibling of the opposite sex (3).

The importance of cross-sex transmission should be examined further because it offers an alternative explanation of variation in mortality by sex. In European-American culture it is usually assumed that somewhat higher mortality is "natural" or "biological" for boys (16). Where girls are experiencing higher mortality, it is interpreted as a result of preferential treatment of boys (17). Such variations, however, could be due to differences in the transmission pattern. If one sex is more likely to be the index cases due to specific behaviour patterns, the other sex would be at a dual disadvantage ; it would be more likely to be intensively exposed as secondary cases (13) and to be infected by someone of the opposite sex. There are some indications (18) that girls in European-American culture more often are index cases. On the other hand, societies with higher female measles mortality (12, 17, 19, 20) have been Muslim and it may well be that girls have tended to be at home and the boys to be those who contracted infection outside the home.

There is no immediate explanation of why measles infection contracted from someone of the opposite sex is more severe. The most simple explanation would be that close contact increasing the dose of measles virus or the risk of complicating infections was more common between a boy and a girl than between two children of the same sex. A similar difference in contact patterns has not been documented in studies of child behaviour (2). However, it may be necessary to look more specificy at interaction patterns during illness. The fact that older girls have higher mortality than older boys may well relate to their role in taking care of younger children in the household. Preferential treatment of one sex in families with both sexes could also pays some role for the higher mortality. However, since boys and girls had essentially the same risk in families with one girl and one boy (Table 5), it seems an unlikely mechanism.

No obvious behaviour pattern explaining the higher mortality connected with cross-sex transmission has been identified. Furthermore, since the tendency has been very similar in different cultures (2, 3-6), it may be worthwhile to look for a biological rather than a social explanation. As suggested previously (2), virus may take sex determinants from the host cells which could facilitate infection of cells in individuals of the opposite sex. From this perspective, it would be important to examine whether the association between cross-sex transmission and increased severity is limited to viral infections or a more general phenomenon of infections transmitted directly between humans.

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Table 1

Probability of dying (per 1,000) from birth to age 5 years according to period of birth. Bandafassi, children born alive during the study period: 1970-1991 (N=5,658)

Age interval (years)	Period of birth 1970-1976	1977-1983	1984-1991	whole period 1970-1991
0-1	190	176	142	166
1-5	225	224	128	131
0-5	360	347	247	315

Table 2
Univariate analysis of the probability of dying from birth to age 5 years (5q0, per 1,000). Bandafassi, children born alive during the study period: 1970-1991 (N=5,658)

Variable categories	5q0 (per 1,000)	p
Sex		
male	328	0.02
female	304	
Age of mother at birth of child		
less than 20 years	376	0.0001
20-29 years	293	
30-39 years	300	
40 years or more	337	
Twinning status		
singleton	302	0.0001
twin	665	
Period of birth		
1970-1976	359	0.0001
1977-1983	347	
1984-1991	247	
Ethnic group (only children born during the 1984-1991 period)		
Niokholonko	295	0.0001
Fula Bande	250	
Bedik	212	
Size of village		
less than 100	270	0.0003
between 100 and 200	332	
200 or more	324	
Size of compound		
<12	254	0.0001
12-20	328	
>20	367	
Total	315	

Table 3 - Multiple regression analysis of child survival. Bandafassi, children born alive during the study period: 1970-1991 (N=5,658)

Variable categories	ß	p
Intercept(β_0)	+2.37	
Sex		
male	-0.08	0.474
female	(ref)	
Age of mother at birth of child		
exact age	+0.01	0.055
Twinning status		
singleton	+2.15	0.0001
twin	(ref)	
Period of birth		
1970-1976	-0.32	0.053
1977-1983	-0.38	0.002
1984-1991	(ref)	
Ethnic group		
Niokholonko	-0.11	0.0001
Bedik	+0.88	0.0001
Fula Bande	(ref)	
Size of village		
exact size	-0.0007	0.031
Size of compound		
exact size	-0.045	0.0001

model : $\log(\text{Prob}(T>t|x)) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots$

with T = survival time
and X_1, X_2, etc... = covariables

Table 4 - Number of measles deaths according to village, year of death and size of village. Bandafassi (Fula Bande and Niokholonko villages), 1970-1991.

Fula Bande

Village	1976-77	1982	1985	size of village (1980)
Tiabedji	0	18	0	416
Abidian	1	1	0	49
Lande Runde	19	4	0	328
Babel	3	0	0	58
Tiarmalel	3	0	0	51
Landieni	0	2	0	145
Tioketian	4	0	0	160
Bandafassi	4	0	6	212
Ibel	10	1	11	599
Patassi	1	0	0	57
Bundukundi	0	0	0	126
Ndebu	7	1	0	178
Bandi	0	0	0	33
Kessema	15	0	0	213
Angoussaka	0	0	0	182
Namel	0	3	3	300
Kenda	0	0	0	51
Kurungoto	0	0	0	12
Lande Baitil	5	0	0	111
Lande Sabere	6	0	0	41
Lande Tyenar	17	2	0	195
Lande Baofitare	12	6	0	195
Assoni	0	0	0	58
Nianie	0	7	0	97
Total	107	45	20	3,867

Table 4 (continued)

Niokholonko

Village	1973	1976	1981-82	size of village (1980)
Batranke	19		0	215
Barraboye	0		18	182
Banion	0		6	243
Bantata	10		5	175
Lakanta	0		0	51
Tikankali	0		3	113
Semu	0	5	-	91
Tenkoto	-		5	-
Sekoto	-		0	-
Total	29	5	37	1,070

<u>Table 5</u> - Risk of dying of measles (%) for children in families with only two maternal siblings under 10 years of age. Only children from villages having measles deaths. Bandafassi (Fula Bande and Niokholonko villages), Senegal, 1970-1991.

	Percentage (deaths/no. alive prior to epidemic)	
	Same-sex families	Opposite-sex families
Total	11%(38/353)	17%(69/413)
<u>Sex</u>		
Males	10%(18/183)	16%(33/205)
Females	12%(20/170)	17%(36/208)
<u>Age (years)</u>		
0-2	18%(23/127)	23%(35/154)
3-5	8%(10/128)	16%(26/158)
6-9	5%(5/98)	8%(8/101)
<u>Relative age</u>		
Youngest	14%(26/184)	22%(45/209)
Oldest	7%(12/169)	12%(24/204)
<u>Age difference</u>		
1-3 years	9%(18/197)	15%(42/273)
4-9 years	13%(20/156)	19%(27/140)
<u>Size of village</u>		
<100	14%(5/37)	41%(14/34)
100-199	11%(12/112)	20%(24/122)
=>200	10%(21/204)	12%(31/257)
Families with two children under five years		
Total	9%(10/111)	18%(26/141)

Table 6- Multiple logistic regression analysis of measles mortality in two-child families. Bandafassi, Senegal, 1970-1991. N=766.

Variables	Odds Ratio	95% CI	P
Sex of sibling			
Opposite/same sex	1.81	1.17-2.82	0.0082
Age			
0-2/6-9 years	4.33	2.26-8.28	
3-5/6-9 years	2.38	1.20-4.74	0.0000
Size of village			
<100/=>200	3.53	1.89-6.61	
100-199/=>200	1.56	0.98-2.50	0.0003
Age difference			
4-9/1-3 years	1.57	1.00-2.44	0.0480

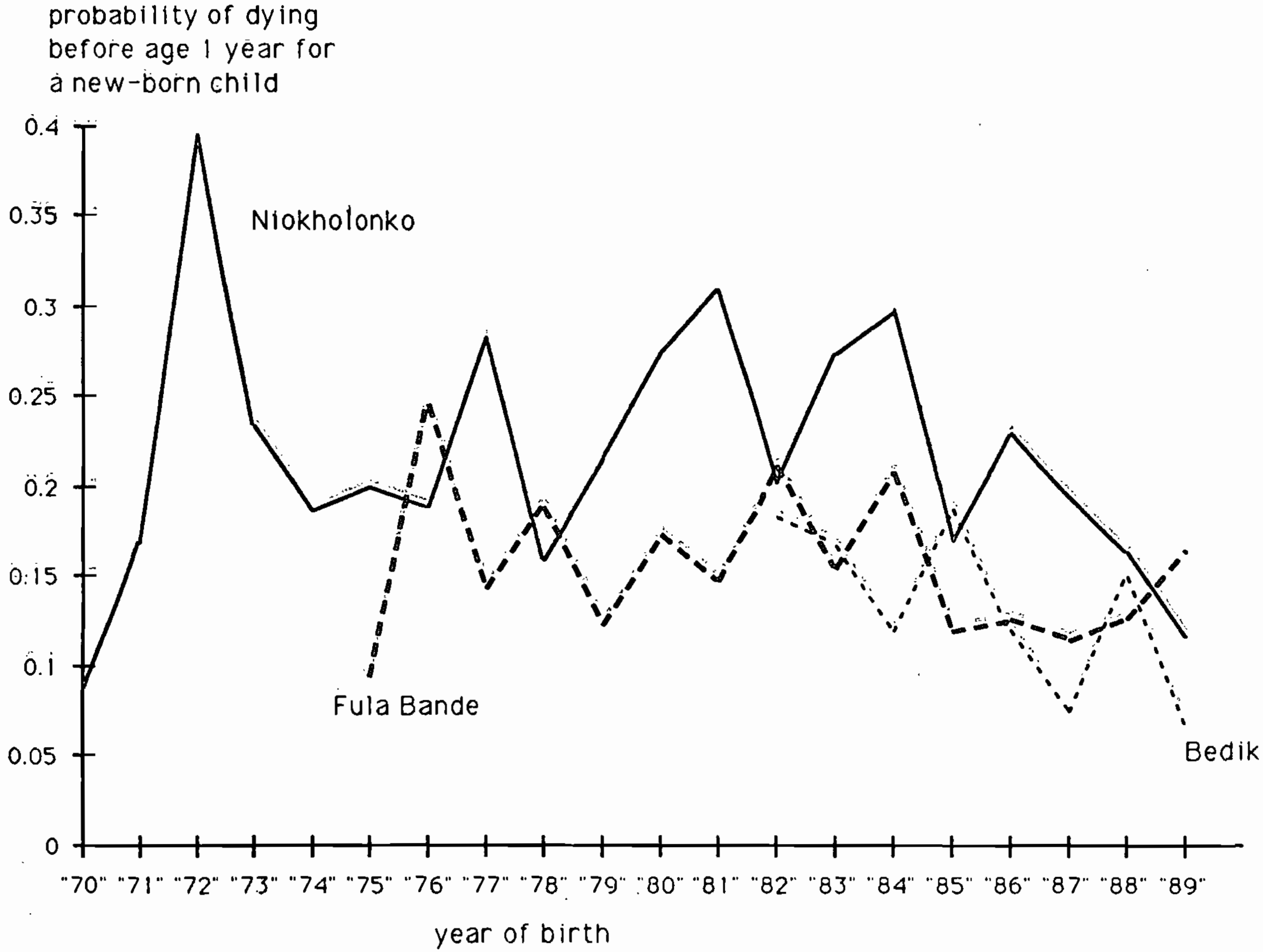

Figure 1. Infant mortality (1q0) per year of birth and ethnic group.
Bandafassi, 1970-1991.

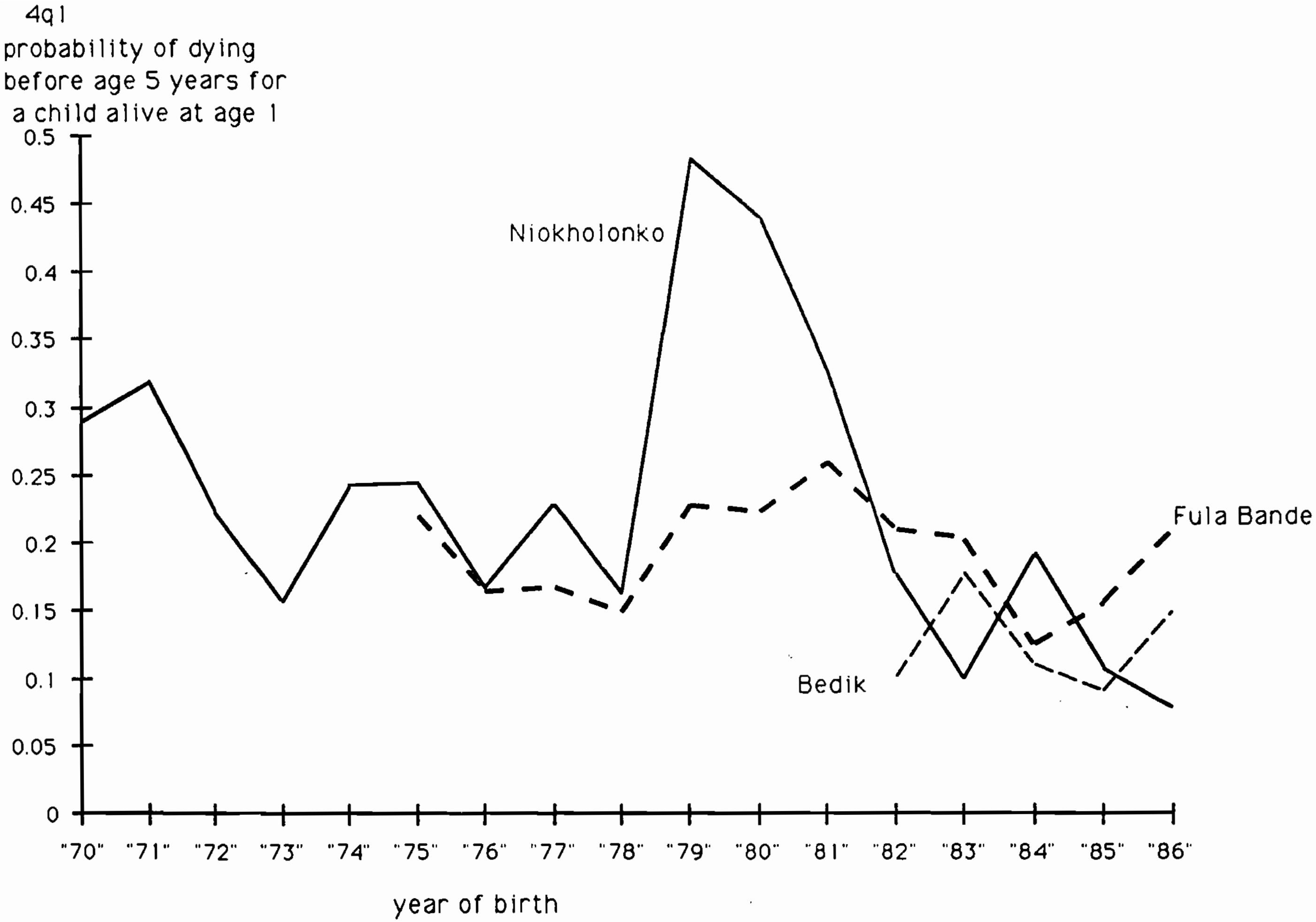

Figure 2. Mortality from age 1 to age 4 (4q1) per year of birth and ethnic group. Bandafassi, 1970-1991.

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