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Abstract
The data collected by the Bandafassi demographic study in Eastern Senegal, a small-scale intensive and experimental follow-up survey on a population of about 7,000 inhabitants in 1983, were analyzed to derive an estimation of the life table. The use of the multi-round survey technique, combined with anthropological methods to estimate the ages or collect genealogies, results in unusually reliable data. Taking into account the uncertainty of the estimates related to the small size of the population, the measures of mortality show a high mortality level, with life-expectancy at birth close to 31 years; a pattern of infant and child mortality close to what has been observed in other rural areas of Senegal; a seasonal pattern in child mortality with two high risk periods, the rainy season and the end of the dry season; an adult mortality pattern similar to what is described in model life tables for developed countries; no significant differences according to sex or ethnic group. The example of the Bandafassi population study and of a few similar studies, suggests that one possible way to improve demographic estimates in countries where vital registration systems are defective would be to set up a sample of population laboratories where intensive methods of data collection would continue for extended periods.

Keywords
Africa, Senegal, Bandafassi, Bandafassi Demographic Study, Eastern Senegal, population survey, demographic surveys, data, multi-round survey, mortality, measures of mortality, life table, seasonal patterns, child mortality, infant mortality, mortality, life-expectancy at birth, adult mortality, ethnic groups, mortality patterns, vital statistics, vital registration, Kendougou, climate, environmental conditions, weather, public health, Bedik, Niokholonko, Fula Bande, census, age survey, genealogical survey, genealogy, age, fertility survey, fertility, misreporting, sex, age, population, seasonality, infectious diseases, public health, measles, Sub-Saharan Africa

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ABSTRACT

The data collected by the Bandafassi demographic study in Eastern Senegal, a small-scale intensive and experimental follow-up survey on a population of about 7,000 inhabitants in 1983, were analyzed to derive an estimation of the life table. The use of the multi-round survey technique, combined with anthropological methods to estimate the ages or collect genealogies, results in unusually reliable data. Taking into account the uncertainty of the estimates related to the small size of the population, the measures of mortality show a high mortality level, with life-expectancy at birth close to 31 years; a pattern of infant and child mortality close to what has been observed in other rural areas of Senegal; a seasonal pattern in child mortality with two high risk periods, the rainy season and the end of the dry season; an adult mortality pattern similar to what is described in model life tables for developed countries; no significant differences according to sex or ethnic group. The example of the Bandafassi population study and of a few similar studies, suggests that one possible way to improve demographic estimates in countries where vital registration systems are defective would be to set up a sample of population laboratories where intensive methods of data collection would continue for extended periods.

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Introduction

Small-scale and intensive demographic surveys contribute to the study of population in many ways. One of their potential contributions is an improvement in measurement. The increase in reliability may be especially valuable in the case of most of the developing countries, where censuses and civil registration systems cannot provide the data necessary to derive reliable demographic measures, and estimates using indirect techniques are rough approximations based on assumptions that may not be true. The aim of this paper is to illustrate the potential contribution of the small-scale and intensive approach for these countries using as an example the estimation of a life table for the populations of the area of Bandafassi in Eastern Senegal. In this example, the estimates are derived from demographic data collected during the 1970-1983 period. Part 1 is a description of the populations and of the methods of data collection. Part 2 presents the mortality estimates and compares then with available African life tables and with model life tables.[1]

1. THE SURVEYS

The principal aim of this study was to investigate the biological diversity of three populations living in the same area of Eastern Senegal, but with different histories and cultural patterns; and to check if some of the biological differences could be linked with cultural ones. We attempt to describe

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[1]In a forthcoming paper, we compare these mortality measures obtained using classical procedures with estimates obtained using indirect techniques.

the demographic characteristics of each population and to compare these characteristics between populations is a part of this study. This task necessitated the collection of accurate demographic data.

The area chosen for this study is located in the departement of Kedougou in Eastern Senegal, near the triple border between Senegal, Mali and Guinea. It includes approximately half the total population of the arrondissement of Bandafassi (Figure 1). The climate is characterized by two main seasons, a rainy season, from June to October, and a dry season, from November to May, with average rainfall of 1300 mm per year. The population of the area comprises three ethnic groups. In order of the time of settlement in the area, these are:

-The Bedik, 1829 inhabitants in six villages on the 1st of March, 1983. This small isolated group, probably more extensive in the past, has its own language. All its members are included in the population studied here. Culturally, the Bedik are close to three other small ethnic groups in Senegal and Guinea, forming with them the Tenda linguistic group, itself related to the larger Mande group (Ferry, 1967).

-The Niokholonko, 1075 inhabitants in seven villages on the 1st of March, 1983. They are part of the Mandekka people widespread in Eastern Senegal, West Mali, Guinea and West Ivory Coast, and are also related to the Mande

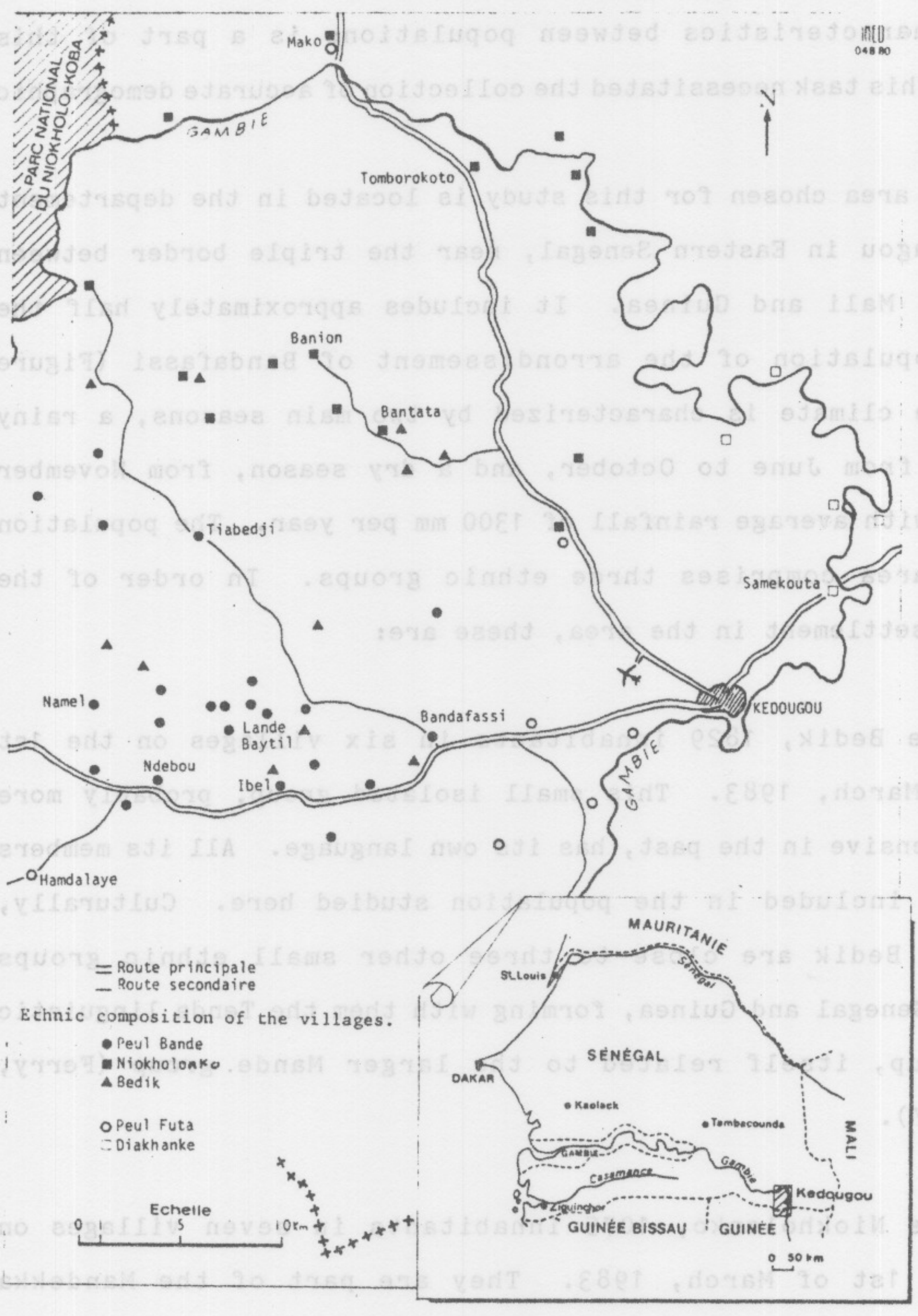


Figure 1. – Map of the Bandafassi area in Eastern Senegal.

linguistic group.

-The Fula Bande, 4002 inhabitants in 24 villages on the 1st of March, 1983. They are a part of the Fula people widespread in West Africa. Culturally, they are very close to the Fula subgroup of the Futa-Djalon area in NOrth Guinea (Dupire 1963). The Fula Bande are Moslems, while the other two populations are mainly animists.

The methods of data collection have been described in detail in a previous publication (Pison, 1982b). It is not necessary, therefore, to review them at length; we will only give a brief summary. Five kinds of surveys were conducted:

-A census, followed by a multi-roundsurvey. The interval between two successive rounds was one year. The duration of the multi-round survey varies from 3 years in the case of the Bedik to 13 years for the Niokholonko. During the base-line census, information about marriages was collected for each adult and about all live-births for each woman. At each round, all the demographic events--births, deaths, marriages and migratory moves--occurring since the previous round, and all current pregnancies, were registered. The months of events were determined using cultural and lunar calendars. The respondent in this survey was in most cases the head of the compound.

-A genealogical survey. Genealogies going up to known ascendents and them down to living collateral relatives were collected, starting with any chief of a compound, and any of the resident adult females. The genealogies collected in related compounds were matched afterwards.

-An age survey. The age of individuals was estimated using an indirect method based on two kinds of data: the classification of the population of a village by birth-rank and the calendar of the circumcision groups. The ordering of the population of a village by birth-rank provides relative ages; to obtain absolute ages, we turned to a second type of chronological classification, concerning circumcision groups. Circumcision, which is performed roughly around 15 years of age, with variations according to ethnic group and period, is a very important occasion. It usually takes place in February or March, every 3 or 4 years. Circumcision groups, identified by members' names, were listed in chronological order for each village. The dates of the circumcision festivals were estimated using both the chronological order of the festivals of all the villages of the area, and an historical calendar. These data, coupled with various assumptions concerning the mean age at circumcision, form the basis of our computations of ages. Our estimation centers on the age at which each male was circumcised. We thus compute the age of these males and then, by interpolation, the age of the non-circumcised population. Details regarding the method of age estimation can be found in earlier publications (Langaney, Dallier and Pison, 1979; Pison, 1980).

-A fertility survey. The data collected in the first census on children ever born to women show a high rate of under-reporting of dead children, as illustrated below. Interviews with all living women regarding their maternity histories were conducted with more care after the initial census to register the children who were originally omitted. Another aim of this new data collection was to compare the efficiency of two different methods for registering births in the follow-up period: retrospective interviews and multi-round surveys.

Table 1 shows the dates of the demographic surveys in the three populations. The periods covered by the multi-round surveys are of different length, because the study was initiated in each population at different times, last for the Fula Bande. Moreover, the study of the Bedik, undertaken and followed by J. Gomila before his death (in 1977), was not conducted in the same manner as those of the two other populations. A few rounds were performed after the first census in 1964, but the data of the 1970 round are the only available to us. After March 1980, a follow-up survey with one year intervals was started, using the list of the population alive in January 1970. Dates

Table 1

The calendar of the Bandafassi demographic surveys

rvey		Population		
		Bedik	Niokholonko	Fula Bande
irst enumeration	date	January 1964	Jan.-March 1970	Jan.-March 1975
ollow-up survey	period(1)	1980-1983(2)	1970-1983	1975-1983
	duration in years	3	13	8
	number of year-persons observed	17,948(3)	14,000	30,418
enealogical survey	date	1963	Feb.-March 1971	Feb.March 1976
ge survey	date	Feb.-March 1981	Feb.-March 1974	Feb.-March 1977
ertility survey	date	Feb.-March 1981	Feb.-March 1981	
Size of the population on the 1st of March 1983		1829	1075	4002

(1) An interval of approximately one year separates two successive visits in the same village. As the visits take place during March, it is easy to locate the recent events as earlier or later than the 1st of March, the reference date for the tabulations. As a result, one year in these surveys goes from the 1st of March to the following 28th or 29th of February.

(2) The demographic survey for the Bedik was restarted in March 1980, with a list of the individuals alive in January 1970. The data concerning the events which occured between 1964 and 1970 are not yet available.

(3) This number results from the addition of 5,394 year-persons of all ages observed during the 1980-1983 follow-up period and 12,554 year-persons of age 10 years old and over during the 1970-1980 period. We do not consider here the life-experience of the children born during this period since the risks of omission are greater for them.

of events which occured between January 1970 and March 1980 were registered retrospectively, and are inaccurate. Note also that no retrospective fertility survey has been conducted for the Fula Bande.

Demographic data in Africa are affected by two kinds of errors: an under-enumeration of people in censuses or an under-registration of events in retrospective reports on the one hand, and a misreporting of ages on the other (for a recent review of typical patterns of errors, see Ewbank, 1981). In the Bandafassi surveys, a large amount of time and ingenuity has been spent to reduce errors. For some of the classical errors, we have evidence that the quality of the available data is much better than that of conventional data.

Concerning the first kind of error, the multi-round survey method, when applied with enough care in small intensive surveys, greatly lowers the risk of omission of events which occur during the period of observation. The risk remains for children who die within a few days after birth. But the registration of pregnancies at each round decreases the risk of omission. Concerning the risk of under-enumeration of people, the different surveys which followed the first census of the Fula Bande in 1975 showed that it missed at least 7% of the total population. Half of the omissions were detected at the following rounds, and the other half by the genealogical survey. The analysis of these omissions, by socioeconomic characteristics, age, and status - marital status for women, survival status of parents for children - provides information about the individuals with high risk of omission and about the probably number of people still missing (Pison, 1982a). Their frequency is estimated as very low, probably less than 1%, and the omission problem, after all the corrections, is negligible compared with other problems such as the uncertainty of resident status.

Concerning the other kind of error, the misreporting of ages, the method we used to estimate the ages eliminates many of the usual biases. Age heaping errors do not exist here. We have also strong evidence that the classical effect of marital status or parity of women younger than 30 on the estimation of their age does not exist in the Fula Bande data (Pison, 1982b). But the indirect method we used to estimate the ages may introduce new biases; in particular, it may cause a shift of all ages if the mean age at circumcision is under- or over-estimated. Comparisons between estimated ages and real ages using the few reliable birth dates available, though we do not consider them a real test, were quite encouraging. We are confident that the final estimates of age obtained with this indirect method are far more reliable than any other estimates that would have been obtained in these populations using conventional methods.

2. DIRECT ESTIMATION OF THE LIFE TABLES.

The demographic data we collected provide accurate information on the age and sex distributions of the three populations, and on the events which occurred during the observation periods. Estimates of the age-specific mortality rates can be derived directly as if dealing with conventional data.

The death rates were calculated by population, sex and age, as the ratio of the number of deaths registered in the category during the follow-up period to the number of person-years lived in the category during that period. The death rates were then transformed into probabilities of dying between exact ages. Here are some details:

-We worked with single years from birth to exact age 5, and intervals of five years thereafter.

-For the first interval of the life table, from birth to the first birthday, the probability of dying estimated corresponds to the experience of the generations born after the first census. It was calculated directly, not derived from death rates. This true cohort measure is preferable because of the great variation in mortality during the first year of life, but it is not strictly analogous to the cross-sectional measures for older ages.

-The last interval is the open-ended interval 85 years and more. In the absence of reliable measures, we assumed that the expectancy of life at age 85 was four years, a reasonable value, not too far from that observed in populations with similar levels for adult mortality, and from what is proposed by the "general pattern" of the model tables for developing countries (U.N., 1982a).

-In the case of the Bedik, the data on events that occurred during the 1970-1980 period were collected in 1980, and are not of the same quality as for the other two populations. The risk of omission of events is not negligible here. It concerns mainly "double" events, children who were born and who died during this period. The experience of these individuals during this period was excluded from the data. Concerning the deaths of people who were alive in 1970, the risk of omission is considerably reduced because they are in the list of the population living in 1970, which is assumed to be complete. The experience during the 1970-1980 period of the individuals alive in 1970 was taken into account in the death rate calculations, although the dates of death are less reliable than for the other two populations.

The standard deviations of the mortality measures were estimated using the Chiang formulas (Chiang, 1968). Here we focus on two morality indexes. The first is ${}_nq_x$, the probability of dying between exact age x and x+n for a person alive at age x. We use the variance formula:

where $$V({}_nq_x) = {}_nq_x^2\,(1 - {}_nq_x)\;/\;D(x,x+n)$$

with $V({}_nq_x)$ in the variance of ${}_nq_x$ and D(x,x+n) is the number of deaths registered between age x and age x+n. This is an approximation to the true variance when the life table is derived from cross sectional data and the ${}_nq_x$ are computed from mortality rates, as is the case here.

The second index of mortality considered here is the life expectancy at age x, e_x. The approximate formula for its variance, as proposed by Keyfitz (1977) from the results obtained by Wilson (1938) and Chiang (1969), is:

$$V(e_x) = \sum_{y \geq x} \left[l_y(n-a_y+e_{y+n})/l_x \right]^2 V({}_nq_y)$$

where l_x is the proportion surviving to age x, n is the length of the age interval and a_y is the average age of death of those dying between y and y+n (usually estimates as n/2).

A. <u>MORTALITY DURING THE FIRST FIVE YEARS OF LIFE</u>

Tables 2, 3 and 4 show the life tables directly estimated from the multi-round survey data for each population. The calculations were made separately for each sex and for both sexes combined. Standard errors for the probabilities of death and for the life expectancies were computed with the approximation formulas indicated above. We focus first on the mortality estimates from birth to age 5.

Former studies of populations of West Africa living in areas where the climate is similar to the Bandafassi one, with a dry season and a rainy season, have shown seasonal variations of infant and child mortality. Mortality is higher during the rainy season, because of a higher rate of malaria transmission

Table 2

Life-table. Fula Bande 1975-1983.

DATA			LIFE-TABLE					
Interval exact age in years	Number of deaths	Number of year-persons	Probability of dying within the interval		Survivors at the beginning of the interval	Deaths within the interval	Life-expectancy at the beginning of the interval	
			q (1)	(st. dev.) (2)	l	d	e (3)	(st. dev.) (4)
Males								
0 - 1	158	666	0.212	0.015	1.000	0.212	30.584	1.244
1 - 2	64	572	0.106	0.013	0.788	0.083	37.681	1.402
2 - 3	58	500	0.095	0.013	0.704	0.067	41.088	1.456
3 - 4	24	447	0.052	0.010	0.637	0.033	44.360	1.478
4 - 5	16	407	0.039	0.009	0.604	0.023	45.780	1.475
5 - 10	31	1783	0.083	0.014	0.581	0.048	46.596	1.463
10 - 15	8	1892	0.021	0.007	0.532	0.011	45.604	1.407
15 - 20	14	1655	0.041	0.011	0.521	0.022	41.525	1.399
20 - 25	9	1048	0.042	0.014	0.500	0.021	38.211	1.385
25 - 30	7	809	0.039	0.014	0.479	0.018	34.778	1.344
30 - 35	12	937	0.062	0.017	0.460	0.029	31.074	1.306
35 - 40	11	828	0.064	0.019	0.432	0.028	27.964	1.273
40 - 45	9	604	0.072	0.023	0.404	0.029	24.714	1.246
45 - 50	16	591	0.127	0.030	0.375	0.048	21.433	1.204
50 - 55	17	538	0.146	0.033	0.327	0.048	19.182	1.166
55 - 60	14	460	0.141	0.035	0.279	0.040	17.044	1.141
60 - 65	11	335	0.152	0.042	0.240	0.036	14.439	1.135
65 - 70	3	164	0.087	0.048	0.203	0.018	11.575	1.141
70 - 75	10	82	0.467	0.108	0.186	0.087	7.444	1.134
75 - 80	7	71	0.395	0.116	0.099	0.039	6.782	1.002
80 - 85	7	34	0.680	0.145	0.060	0.041	4.583	0.945
Females								
0 - 1	135	651	0.188	0.015	1.000	0.188	32.367	1.272
1 - 2	54	564	0.091	0.012	0.812	0.074	38.740	1.399
2 - 3	59	506	0.110	0.014	0.738	0.081	41.585	1.450
3 - 4	28	464	0.059	0.011	0.657	0.038	45.672	1.456
4 - 5	20	436	0.045	0.010	0.618	0.028	47.483	1.447
5 - 10	30	1987	0.073	0.013	0.590	0.043	48.688	1.428
10 - 15	15	1836	0.040	0.010	0.547	0.022	47.312	1.378
15 - 20	12	1566	0.038	0.011	0.526	0.020	44.181	1.349
20 - 25	6	1358	0.022	0.009	0.506	0.011	40.809	1.317
25 - 30	7	1027	0.034	0.012	0.495	0.017	36.665	1.299
30 - 35	11	964	0.055	0.016	0.478	0.027	32.849	1.265
35 - 40	10	868	0.056	0.017	0.452	0.025	29.631	1.219
40 - 45	10	737	0.066	0.020	0.426	0.028	26.241	1.181
45 - 50	17	779	0.103	0.024	0.398	0.041	22.908	1.140
50 - 55	16	710	0.107	0.025	0.357	0.038	20.263	1.119
55 - 60	17	564	0.140	0.032	0.319	0.045	17.384	1.120
60 - 65	13	388	0.155	0.039	0.274	0.042	14.810	1.138
65 - 70	12	254	0.211	0.054	0.232	0.049	12.061	1.162
70 - 75	11	129	0.351	0.085	0.183	0.064	9.622	1.216
75 - 80	7	93	0.317	0.099	0.119	0.038	8.481	1.195
80 - 85	3	28	0.423	0.185	0.081	0.034	6.254	1.205
Both sexes								
0 - 1	293	1317	0.200	0.010	1.000	0.200	31.495	[illegible]
1 - 2	118	1136	0.099	0.009	0.800	0.079	38.254	[illegible]
2 - 3	107	1006	0.103	0.009	0.721	0.074	41.390	1.020
3 - 4	52	911	0.055	0.007	0.647	0.036	45.074	1.036
4 - 5	36	843	0.042	0.007	0.611	0.026	46.693	1.029
5 - 10	61	3770	0.078	0.010	0.585	0.046	47.709	1.017
10 - 15	23	3728	0.030	0.006	0.540	0.016	46.521	0.979
15 - 20	26	3221	0.040	0.008	0.523	0.021	42.900	0.967
20 - 25	15	2406	0.031	0.008	0.503	0.015	39.564	0.950
25 - 30	14	1916	0.036	0.009	0.487	0.017	35.738	0.938
30 - 35	23	1901	0.059	0.012	0.470	0.028	31.975	0.904
35 - 40	21	1696	0.060	0.013	0.442	0.027	28.813	0.876
40 - 45	19	1341	0.068	0.015	0.416	0.028	25.494	0.851
45 - 50	33	1370	0.114	0.019	0.387	0.044	22.183	0.821
50 - 55	33	1248	0.124	0.020	0.343	0.043	19.706	0.800
55 - 60	31	1024	0.141	0.023	0.301	0.042	17.141	0.793
60 - 65	24	723	0.153	0.029	0.258	0.040	14.539	0.798
65 - 70	15	418	0.165	0.039	0.219	0.036	11.718	0.808
70 - 75	21	211	0.398	0.067	0.183	0.073	8.535	0.820
75 - 80	14	164	0.352	0.076	0.110	0.039	7.533	0.771
80 - 85	10	62	0.575	0.119	0.071	0.041	5.264	0.776

(1) ${}_1q_0$ is a cohort measure for the generations born after the first census, ${}_nq_x$ when x > 0 is a cross-sectionnal measure, derived from death rates.
(2) standard deviation of q.
(3) the life-expectancy at age 85, the end of the last closed interval, has been chosen equal to 4 years.
(4) standard deviation of the life-expectancy.

Table 3

Life-table. Riokholonko 1970-1983.

Interval exact age in years	DATA: Number of deaths	DATA: Number of year-persons	LIFE-TABLE: Probability of dying within the interval q[1]	(st. dev.)[2]	Survivors at the beginning of the interval l	Deaths within the interval d	Life-expectancy at the beginning of the interval e[3]	(st. dev.)[4]
				Males				
0 - 1	74	311	0.213	0.022	1.000	0.213	31.677	1.807
1 - 2	39	269	0.135	0.020	0.787	0.106	39.097	2.012
2 - 3	25	237	0.100	0.019	0.681	0.068	44.130	2.082
3 - 4	14	220	0.062	0.016	0.613	0.038	47.989	2.075
4 - 5	3	206	0.014	0.008	0.575	0.008	50.110	2.036
5 - 10	10	968	0.050	0.016	0.567	0.029	49.838	2.022
10 - 15	3	871	0.017	0.010	0.538	0.009	47.348	1.968
15 - 20	6	698	0.042	0.017	0.529	0.022	43.127	1.950
20 - 25	1	537	0.009	0.009	0.507	0.005	39.912	1.894
25 - 30	4	504	0.039	0.019	0.502	0.020	35.261	1.880
30 - 35	4	482	0.041	0.020	0.482	0.020	31.588	1.835
35 - 40	4	442	0.044	0.022	0.463	0.020	27.820	1.806
40 - 45	4	378	0.052	0.025	0.442	0.023	23.993	1.792
45 - 50	3	286	0.051	0.029	0.420	0.021	20.161	1.792
50 - 55	11	218	0.224	0.060	0.398	0.089	16.112	1.802
55 - 60	7	164	0.193	0.065	0.309	0.060	15.042	1.893
60 - 65	6	114	0.233	0.083	0.249	0.058	13.038	1.978
65 - 70	3	61	0.219	0.112	0.191	0.042	11.232	2.105
70 - 75	4	36	0.435	0.163	0.149	0.065	8.680	2.169
75 - 80	2	25	0.333	0.192	0.084	0.028	8.433	2.176
80 - 85	1	10	0.400	0.310	0.056	0.023	6.400	2.014
				Females				
0 - 1	75	251	0.260	0.026	1.000	0.260	27.321	1.749
1 - 2	36	212	0.157	0.024	0.740	0.116	35.743	1.997
2 - 3	18	192	0.090	0.020	0.624	0.056	41.283	2.049
3 - 4	11	179	0.060	0.017	0.568	0.034	44.294	2.020
4 - 5	6	173	0.034	0.014	0.534	0.018	46.071	1.967
5 - 10	13	796	0.078	0.021	0.516	0.040	46.679	1.924
10 - 15	1	818	0.006	0.006	0.476	0.003	45.441	1.783
15 - 20	7	727	0.047	0.017	0.473	0.022	40.704	1.774
20 - 25	3	685	0.022	0.012	0.451	0.010	37.588	1.712
25 - 30	5	555	0.044	0.019	0.441	0.019	33.365	1.691
30 - 35	8	461	0.083	0.028	0.421	0.035	29.788	1.645
35 - 40	2	343	0.029	0.020	0.386	0.011	27.263	1.543
40 - 45	5	316	0.076	0.033	0.375	0.029	22.995	1.500
45 - 50	10	299	0.154	0.045	0.347	0.054	19.684	1.420
50 - 55	4	271	0.071	0.034	0.293	0.021	17.819	1.288
55 - 60	10	241	0.188	0.054	0.272	0.051	13.993	1.246
60 - 65	9	200	0.202	0.060	0.221	0.045	11.654	1.217
65 - 70	11	149	0.312	0.078	0.176	0.055	8.974	1.256
70 - 75	10	70	0.526	0.115	0.121	0.064	6.905	1.481
75 - 80	2	20	0.400	0.219	0.058	0.023	6.800	2.172
80 - 85	1	5	0.667	0.385	0.035	0.023	4.667	2.502
				Both sexes				
0 - 1	149	562	0.234	0.017	1.000	0.234	29.570	1.249
1 - 2	75	481	0.145	0.015	0.766	0.111	37.455	1.403
2 - 3	43	429	0.095	0.014	0.655	0.063	42.705	1.442
3 - 4	25	399	0.061	0.012	0.593	0.036	46.158	1.426
4 - 5	9	379	0.023	0.008	0.557	0.013	48.112	1.390
5 - 10	23	1764	0.063	0.013	0.544	0.034	48.256	1.370
10 - 15	4	1689	0.012	0.006	0.509	0.006	46.339	1.303
15 - 20	13	1425	0.045	0.012	0.503	0.022	41.862	1.292
20 - 25	4	1222	0.016	0.008	0.481	0.008	38.699	1.248
25 - 30	9	1059	0.042	0.014	0.473	0.020	34.296	1.232
30 - 35	12	943	0.062	0.017	0.453	0.028	30.677	1.197
35 - 40	6	785	0.038	0.015	0.425	0.016	27.528	1.150
40 - 45	9	694	0.063	0.020	0.409	0.026	23.504	1.123
45 - 50	13	585	0.105	0.028	0.384	0.040	19.911	1.096
50 - 55	15	489	0.142	0.034	0.343	0.049	16.959	1.068
55 - 60	17	405	0.190	0.041	0.294	0.056	14.361	1.050
60 - 65	15	314	0.213	0.049	0.238	0.051	12.143	1.058
65 - 70	14	210	0.286	0.065	0.188	0.054	9.758	1.109
70 - 75	14	106	0.496	0.094	0.134	0.067	7.661	1.251
75 - 80	4	45	0.364	0.145	0.067	0.025	7.750	1.582
80 - 85	2	15	0.500	0.250	0.043	0.021	5.750	1.625

(1) ${}_1q_0$ is a cohort measure for the generations born after the first census. ${}_nq_x$ when x > 0 is a cross-sectionnal measure, derived from death rates.

(2) standard deviation of q.

(3) the life-expectancy at age 85, the end of the last closed interval, has been chosen equal to 4 years.

(4) standard deviation of the life-expectancy.

Table 4

Life-table. Bedik 1970-1983.

Interval exact age in years	Number of deaths	Number of year-persons	Probability of dying within the interval $q^{(1)}$	(st. dev.)[2]	Survivors at the beginning of the interval l	Deaths within the interval d	Life-expectancy at the beginning of the interval $e^{(3)}$	(st. dev.)[4]
Males								
0 - 1	17	80	0.192	0.042	1.000	0.192	35.360	2.919
1 - 2	7	73	0.092	0.033	0.808	0.074	43.096	2.706
2 - 3	5	68	0.071	0.031	0.734	0.052	47.267	2.530
3 - 4	1	62	0.016	0.016	0.682	0.011	49.837	2.162
4 - 5	1	61	0.016	0.016	0.671	0.011	49.639	2.042
5 - 10	2	327	0.030	0.021	0.660	0.020	49.452	1.908
10 - 15	10	1164	0.042	0.013	0.640	0.027	45.910	1.665
15 - 20	3	1016	0.015	0.008	0.613	0.009	42.815	1.626
20 - 25	9	827	0.053	0.017	0.604	0.032	38.415	1.613
25 - 30	12	793	0.082	0.023	0.572	0.047	35.424	1.558
30 - 35	3	701	0.021	0.012	0.525	0.011	33.359	1.440
35 - 40	4	726	0.027	0.013	0.514	0.014	29.027	1.427
40 - 45	10	793	0.069	0.031	0.500	0.034	24.768	1.418
45 - 50	13	574	0.107	0.028	0.466	0.050	21.410	1.424
50 - 55	6	351	0.074	0.029	0.416	0.031	18.680	1.449
55 - 60	10	249	0.182	0.052	0.385	0.070	14.971	1.466
60 - 65	12	181	0.284	0.069	0.315	0.090	12.754	1.506
65 - 70	9	135	0.286	0.080	0.225	0.064	11.829	1.379
70 - 75	4	74	0.238	0.104	0.161	0.038	10.560	1.650
75 - 80	4	41	0.392	0.153	0.123	0.048	8.079	1.615
80 - 85	2	23	0.357	0.202	0.075	0.027	6.679	1.316
Females								
0 - 1	20	96	0.189	0.038	1.000	0.189	35.567	2.869
1 - 2	7	78	0.086	0.031	0.811	0.070	42.722	2.897
2 - 3	2	65	0.030	0.021	0.742	0.022	45.689	2.755
3 - 4	5	65	0.074	0.032	0.719	0.053	46.101	2.653
4 - 5	3	63	0.047	0.026	0.666	0.031	48.749	2.310
5 - 10	3	283	0.052	0.029	0.635	0.033	50.103	1.934
10 - 15	3	1442	0.010	0.006	0.602	0.006	47.695	1.419
15 - 20	5	1185	0.021	0.009	0.596	0.012	43.167	1.407
20 - 25	7	993	0.035	0.013	0.583	0.020	39.034	1.383
25 - 30	8	837	0.047	0.016	0.563	0.026	35.345	1.341
30 - 35	6	712	0.041	0.016	0.537	0.022	31.953	1.280
35 - 40	8	734	0.053	0.018	0.515	0.027	28.221	1.226
40 - 45	8	763	0.051	0.018	0.488	0.025	24.662	1.185
45 - 50	20	643	0.144	0.020	0.463	0.067	20.855	1.171
50 - 55	11	517	0.101	0.029	0.396	0.040	18.750	1.146
55 - 60	19	428	0.196	0.040	0.356	0.070	15.798	1.131
60 - 65	14	383	0.167	0.041	0.286	0.048	14.034	1.136
65 - 70	14	281	0.222	0.052	0.238	0.053	11.354	1.184
70 - 75	14	150	0.378	0.090	0.186	0.070	8.873	1.316
75 - 80	3	40	0.316	0.151	0.115	0.036	7.752	1.658
80 - 85	2	12	0.500	0.267	0.079	0.066	5.176	1.735
Both sexes								
0 - 1	37	176	0.190	0.028	1.000	0.190	36.100	2.048
1 - 2	14	151	0.089	0.022	0.810	0.072	43.463	2.015
2 - 3	7	133	0.051	0.019	0.738	0.038	46.640	1.877
3 - 4	6	127	0.046	0.018	0.700	0.032	48.134	1.725
4 - 5	4	124	0.032	0.016	0.668	0.021	49.439	1.531
5 - 10	5	610	0.040	0.018	0.647	0.026	50.043	1.355
10 - 15	13	2606	0.025	0.007	0.621	0.015	47.033	1.090
15 - 20	8	2201	0.018	0.006	0.606	0.011	43.157	1.062
20 - 25	16	1820	0.043	0.011	0.594	0.026	38.903	1.048
25 - 30	20	1540	0.063	0.014	0.569	0.036	35.539	1.012
30 - 35	9	1412	0.031	0.010	0.533	0.017	32.757	0.951
35 - 40	12	1460	0.040	0.011	0.516	0.022	28.736	0.924
40 - 45	18	1466	0.060	0.014	0.496	0.030	24.837	0.906
45 - 50	33	1217	0.127	0.023	0.466	0.059	21.251	0.900
50 - 55	17	908	0.089	0.021	0.407	0.036	18.978	0.897
55 - 60	29	687	0.191	0.032	0.371	0.071	15.597	0.895
60 - 65	26	564	0.207	0.036	0.300	0.062	13.697	0.904
65 - 70	23	416	0.243	0.044	0.238	0.058	11.602	0.941
70 - 75	13	224	0.335	0.064	0.180	0.060	9.521	1.038
75 - 80	7	81	0.355	0.108	0.120	0.043	8.051	1.159
80 - 85	4	33	0.444	0.166	0.077	0.034	6.111	1.077

(1) ${}_1q_0$ is a cohort measure for the generations born after the first census, ${}_nq_x$ when $x > 0$ is a cross-sectionnal measure, derived from death rates.

(2) standard deviation of q.

(3) the life-expectancy at age 85, the end of the last closed interval, has been chosen equal to 4 years.

(4) standard deviation of the life-expectancy.

Table 5

Life-table. All populations.

Interval exact age in years	DATA: Number of deaths	DATA: Number of year-persons	LIFE-TABLE: Probability of dying within the interval q[1]	(st. dev.)[2]	Survivors at the beginning of the interval l	Deaths within the interval d	Life-expectancy at the beginning of the interval e[3]	(st. dev.)[4]
Males								
0 - 1	249	1057	0.211	0.012	1.000	0.211	31.444	0.939
1 - 2	110	914	0.114	0.010	0.789	0.090	38.706	1.034
2 - 3	80	805	0.095	0.010	0.700	0.066	42.599	1.055
3 - 4	39	729	0.052	0.008	0.633	0.033	46.001	1.045
4 - 5	20	674	0.029	0.006	0.600	0.018	47.502	1.023
5 - 10	43	3078	0.067	0.010	0.583	0.039	47.918	1.003
10 - 15	21	3927	0.026	0.006	0.544	0.014	46.205	0.942
15 - 20	23	3369	0.034	0.007	0.529	0.018	42.390	0.932
20 - 25	19	2412	0.039	0.009	0.511	0.020	38.775	0.918
25 - 30	23	2096	0.053	0.011	0.492	0.026	35.232	0.892
30 - 35	19	2120	0.044	0.010	0.465	0.020	32.079	0.855
35 - 40	19	1996	0.046	0.010	0.445	0.021	28.435	0.836
40 - 45	23	1685	0.066	0.013	0.424	0.028	24.699	0.825
45 - 50	32	1451	0.105	0.017	0.396	0.041	21.268	0.816
50 - 55	34	1147	0.138	0.022	0.355	0.049	18.458	0.814
55 - 60	31	873	0.163	0.027	0.306	0.050	16.013	0.818
60 - 65	29	630	0.206	0.034	0.256	0.053	13.646	0.830
65 - 70	15	360	0.189	0.044	0.203	0.038	11.545	0.853
70 - 75	18	192	0.380	0.070	0.165	0.063	8.648	0.861
75 - 80	13	137	0.383	0.084	0.102	0.039	7.412	0.812
80 - 85	10	67	0.543	0.116	0.063	0.034	5.467	0.755
Females								
0 - 1	230	998	0.207	0.012	1.000	0.207	31.341	0.939
1 - 2	97	854	0.107	0.010	0.793	0.085	38.374	1.023
2 - 3	79	763	0.098	0.011	0.708	0.070	41.935	1.036
3 - 4	44	708	0.060	0.009	0.638	0.038	45.460	1.017
4 - 5	29	672	0.042	0.008	0.600	0.025	47.343	0.985
5 - 10	46	3066	0.072	0.010	0.575	0.042	48.409	0.950
10 - 15	19	4096	0.023	0.005	0.533	0.012	46.988	0.866
15 - 20	24	3478	0.034	0.007	0.521	0.018	43.032	0.852
20 - 25	16	3036	0.026	0.006	0.503	0.013	39.455	0.831
25 - 30	20	2419	0.041	0.009	0.490	0.020	35.441	0.816
30 - 35	25	2137	0.057	0.011	0.470	0.027	31.832	0.789
35 - 40	20	1945	0.050	0.011	0.443	0.022	28.599	0.753
40 - 45	23	1816	0.061	0.012	0.421	0.026	24.976	0.727
45 - 50	47	1721	0.128	0.017	0.395	0.051	21.446	0.707
50 - 55	31	1498	0.098	0.017	0.345	0.034	19.223	0.685
55 - 60	46	1243	0.169	0.023	0.311	0.053	16.048	0.677
60 - 65	36	971	0.170	0.026	0.258	0.044	13.810	0.682
65 - 70	37	684	0.238	0.034	0.214	0.051	11.121	0.704
70 - 75	35	349	0.401	0.052	0.163	0.065	8.817	0.772
75 - 80	12	153	0.328	0.078	0.098	0.032	8.045	0.899
80 - 85	6	45	0.500	0.144	0.066	0.033	5.750	0.938
Both sexes								
0 - 1	479	2055	0.209	0.008	1.000	0.209	31.409	0.662
1 - 2	207	1768	0.111	0.007	0.791	0.088	38.564	0.725
2 - 3	159	1568	0.097	0.007	0.704	0.068	42.297	0.736
3 - 4	83	1437	0.056	0.006	0.636	0.036	45.762	0.725
4 - 5	49	1346	0.036	0.005	0.600	0.021	47.454	0.705
5 - 10	89	6144	0.070	0.007	0.579	0.040	48.195	0.686
10 - 15	40	8023	0.025	0.004	0.538	0.013	46.629	0.634
15 - 20	47	6847	0.034	0.005	0.525	0.018	42.743	0.625
20 - 25	35	5448	0.032	0.005	0.507	0.016	39.148	0.612
25 - 30	43	4515	0.047	0.007	0.491	0.023	35.345	0.597
30 - 35	44	4257	0.050	0.007	0.468	0.024	31.947	0.574
35 - 40	39	3941	0.048	0.008	0.445	0.021	28.509	0.555
40 - 45	46	3501	0.064	0.009	0.423	0.027	24.829	0.541
45 - 50	79	3172	0.117	0.012	0.396	0.046	21.346	0.529
50 - 55	65	2645	0.116	0.014	0.350	0.041	18.849	0.520
55 - 60	77	2116	0.167	0.017	0.309	0.052	15.968	0.515
60 - 65	65	1601	0.184	0.021	0.258	0.048	13.688	0.518
65 - 70	52	1044	0.221	0.027	0.210	0.047	11.216	0.532
70 - 75	53	541	0.393	0.042	0.164	0.064	8.695	0.562
75 - 80	25	290	0.355	0.057	0.099	0.035	7.714	0.597
80 - 85	16	112	0.526	0.091	0.064	0.034	5.579	0.589

(1) $_1q_0$ is a cohort measure for the generations born after the first census. $_nq_x$ when $x > 0$ is a cross-sectionnal measure, derived from death rates.

(2) standard deviation of q.

(3) the life-expectancy at age 85, the end of the last closed interval, has been chosen equal to 4 years.

(4) standard deviation of the life-expectancy.

(Cantrelle and Leridon, 1971; Molineaux and Gramiccia, 1980; Garenne, 1981a and 1982b). The peak in the mortality rates is observed in general in the second part of the rainy season.

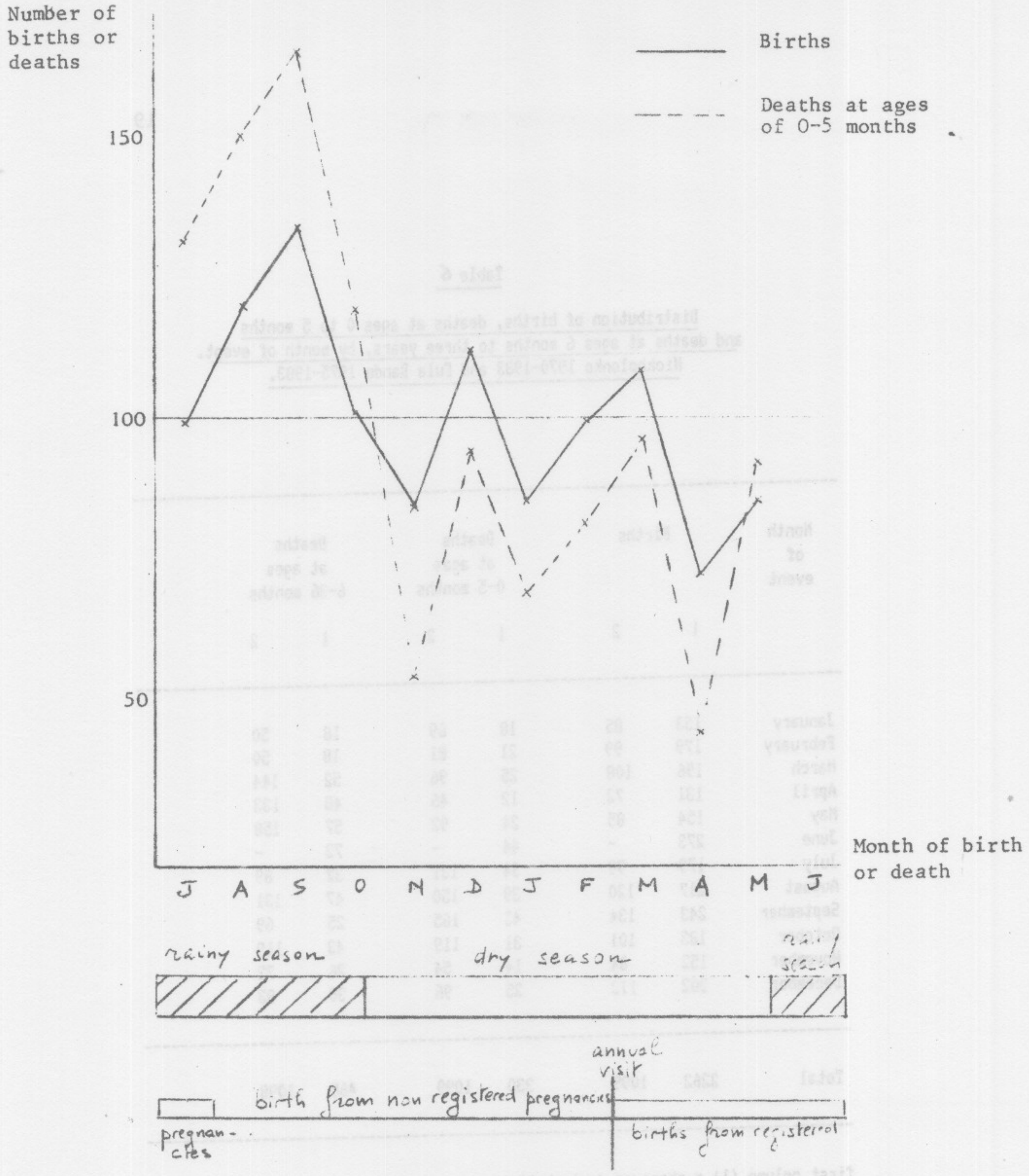
The distribution of deaths of young children registered during the Niokholonko and the Fula Bande follow-up surveys, by month of death, is shown in Table 6. We added in the same Table the corresponding distribution of births, since seasonality of births may be in part responsible for seasonality of child deaths. We made the distinction between early deaths, deaths before 6 months, and deaths at 6 to 36 months, since we know that the very young children, before 6 months, are protected by maternal antibodies from several infectious agents, for example measles. The peak of births or deaths in June (Table 6) is in part related to a bias in the data: when there was no information on the month of an event (in approximately 5% of all events), it was coded systematically as June. Though this bias introduces a difficulty in the study of seasonality, it may be dealt with simply by excluding the events in June. The resulting distributions are shown in Table 6 and are illustrated in Figures 2 and 3. Part of the variation from month to month are caused by preference for some particular months and avoidance of others: March, May and December seem to be preferred; January, April and November seem to be avoided. Beside this preference pattern, Figure 2 shows a clear seasonality of births, with a peak during the rainy season and a deficit at the end of the dry season. It should be noted that the months with low conception rates, July and August, correspond to the period of most intensive agricultural

Table 6

Distribution of births, deaths at ages 0 to 5 months
and deaths at ages 6 months to three years, by month of event.
Niokholonko 1970-1983 and Fula Bande 1975-1983.

Month of event	Births		Deaths at ages 0-5 months		Deaths at ages 6-36 months	
	1	2	1	2	1	2
January	153	85	18	69	18	50
February	179	99	21	81	18	50
March	196	108	25	96	52	144
April	131	72	12	46	48	133
May	154	85	24	92	57	158
June	273	-	44	-	72	-
July	179	99	34	131	32	89
August	217	120	39	150	47	131
September	243	134	43	165	25	69
October	183	101	31	119	43	119
November	152	84	14	54	26	72
December	202	112	25	96	30	83
Total	2262	1099	330	1099	468	1098

first column (1) = observed distribution.
second column (2) = computed distribution for a total of 1100 events in 11 months.
Events in June are disregarded since when there was no information on the month of an event, it was codified as in June.



<u>Figure 2</u> : Seasonality of births and of deaths at ages 0-5 months, in Bandafassi. Data from the Niokholonko (1970-1983) and the Fula Bande (1975-1983) multi-round surveys. Events in June are not considered here, since some of them are misreported.

work.

The seasonality of early deaths, from birth to age 6 months, follows in part the seasonality of births. Such a result is to be expected, since most early deaths occur in the first week or the first month of life. But the number of deaths is proportionally higher during the rainy season and lower during the dry season. This pattern may result from two phenomena: first, an increase in mortality risks during the rainy season and, second, some biases in the data. The first phenomenon corresponds to what has been observed in the former studies mentioned above, and very probably does exist in Bandafassi. But the observed seasonality in infant mortality may also result from a bias in the data related to the timing of the visits in the Bandafassi multi-round surveys. As mentioned above, pregnancies were registered at each visit, and the visits, one each year, occurred at the beginning of March. All the pregnancies registered at one visit result in births which occur within a period of approximately five months after the visit[2] (see Figure 2); this period corresponds to the end of the dry season and the first half of the rainy season. On the other hand, children whose mother's pregnancy was not registered were born on average in the second half of the rainy season and during the part of the dry season preceding the visit. The risk of omission of a birth is almost zero when the pregnancy was registered previously. It may not be zero

[2]The ratio between the number of registered pregnancies and the number of registered deliveries (live births, still-births and abortions) is close to 40% in the multi-round data.

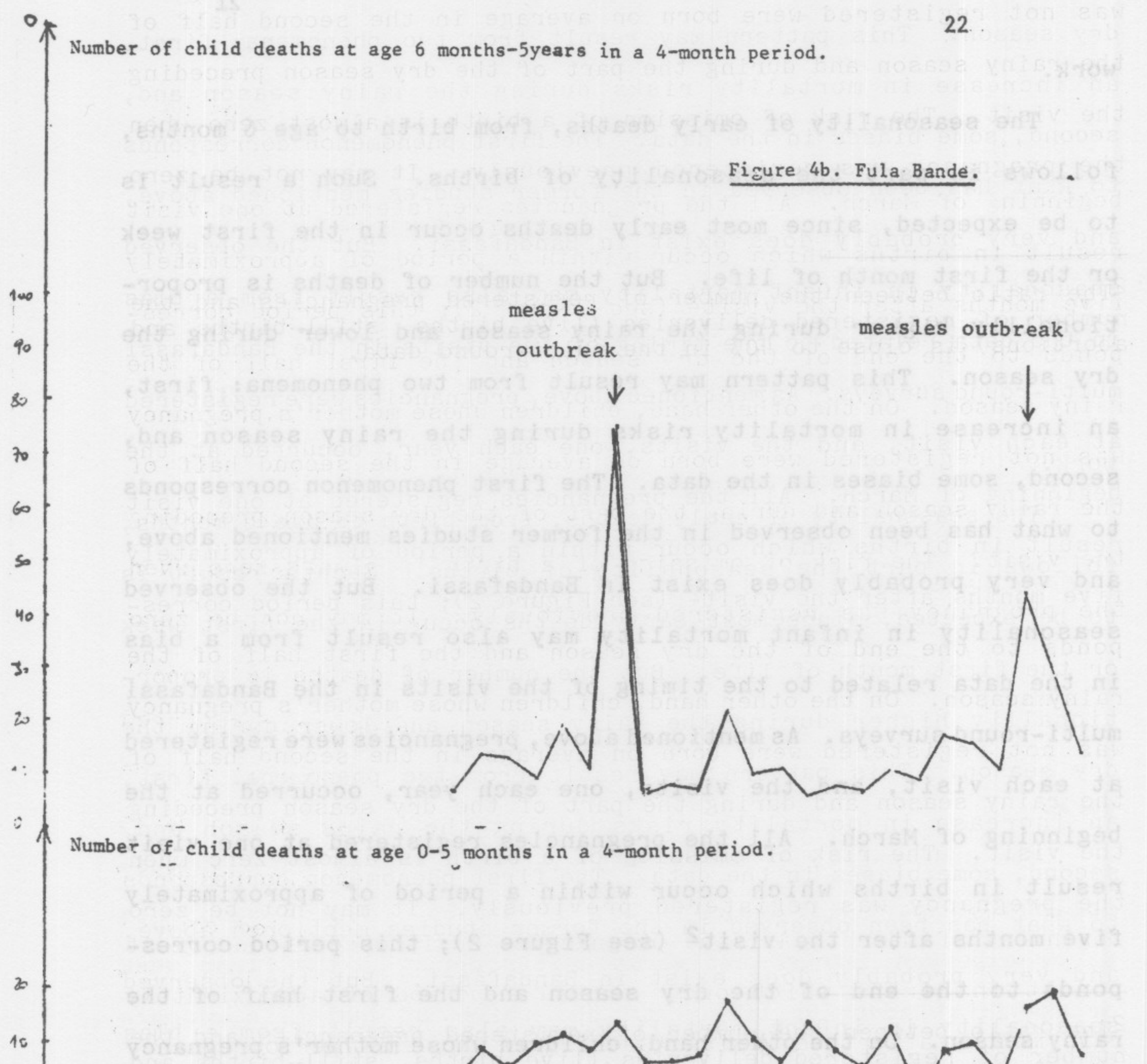


Figure 4. Variation of the number of child deaths by period.
b. Fula Bande.

In one year, three 4-month periods are considered : from March to June, from July to October and from November to February. The July-October period corresponds to the rainy season and the other ones, to the dry season.

in the other case, when no pregnancy was registered, in particular when the birth was followed by an early death. The risk of omission is probably different for the two groups of births. However the difference may be slight, since the births for the second group are recent, occurring less than 7 months before the visit.

If the mortality was not affected by seasonal variation, such a difference in the risk of omission of births would result in an apparent seasonality, with a high level from about March to the end of July, and a low level from August to February. Figure 2 shows that the observed seasonality does not fit this pattern. In particular, the observed numbers of deaths in March and April are relatively small. We cannot infer from this that there are no differences between the risks of omission from one group of children to the other. We can only observe that it is small, and that here we cannot separate its effect from the effect of the seasonality of mortality.

The seasonal pattern of mortality for older children, from 6 to 36 months (Figure 3), seems different from that observed for early deaths. There is also an increase in the number of deaths during the rainy season, but a new peak appears from March to May; it corresponds to measles outbreaks, which almost always develop at the end of the dry season, and only in certain years (see Figure 4). The absence of this peak in Figure 2 is an illustration of the passive immunity of young babies to measles.

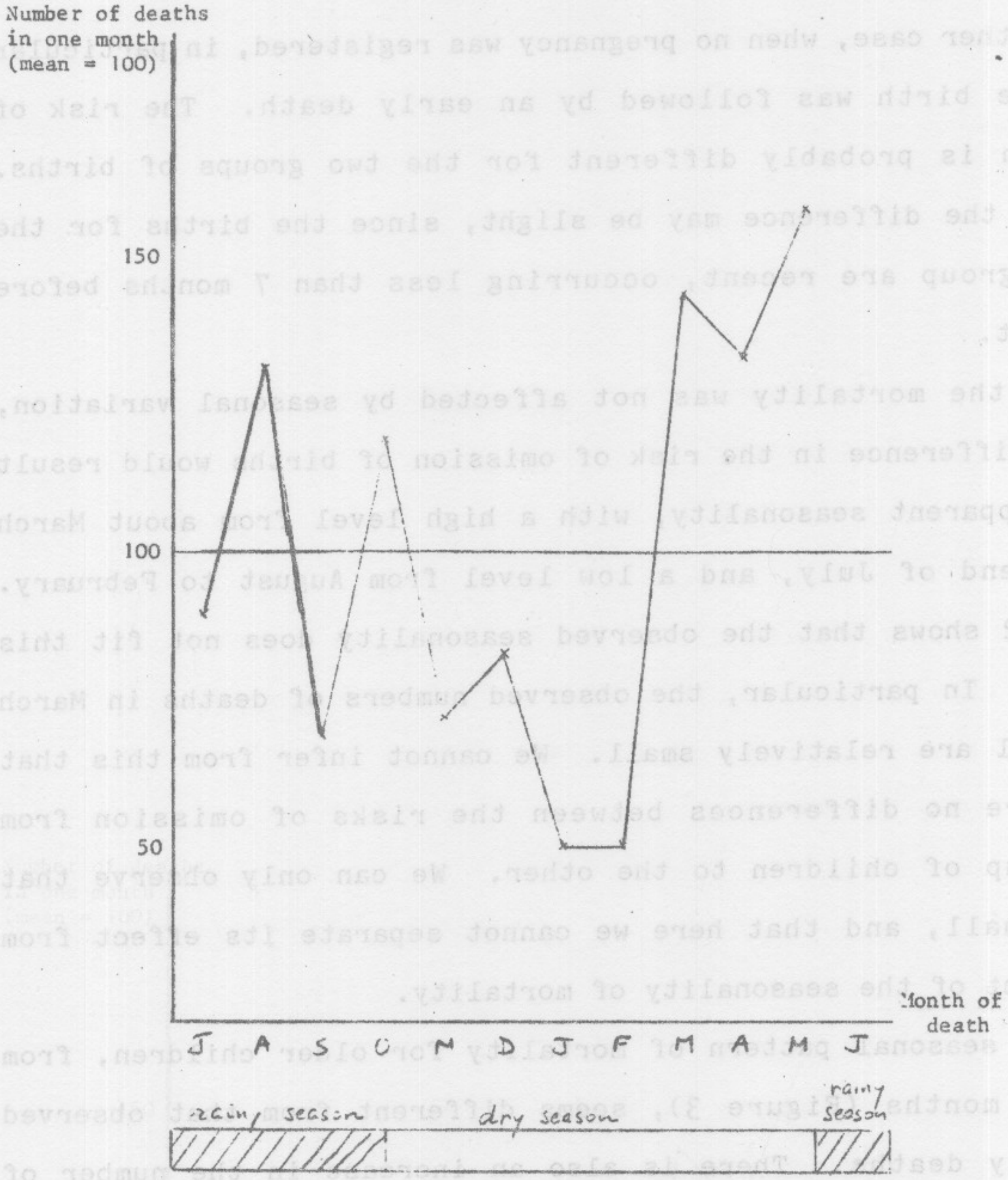


Figure 3 : Seasonality of deaths at ages 6-36 months in Bandafassi. Data from the Niokholonko (1970-1983) and the Fula Bande (1975-1983) multi-round surveys. Events in June are not considered here since some of them are misreported.

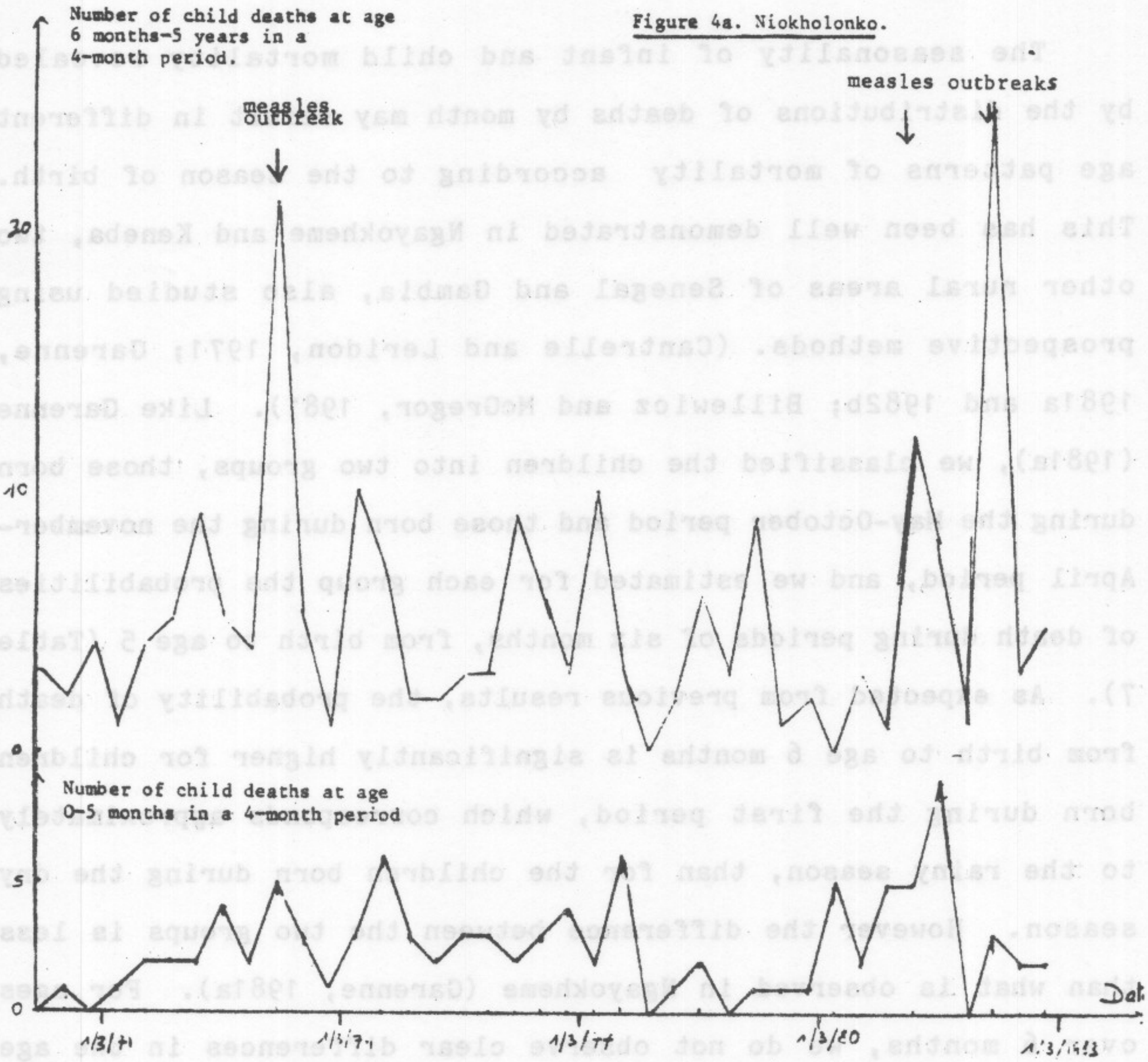


Figure 4. Variation of the number of child deaths by period.
a. Niokholonko.

In one year, three 4-month periods are considered : from March to June, from July to October and from November to February. The July-October period corresponds to the rainy season and the other ones, to the dry season.

The seasonality of infant and child mortality revealed by the distributions of deaths by month may result in different age patterns of mortality according to the season of birth. This has been well demonstrated in Ngayokheme and Keneba, two other rural areas of Senegal and Gambia, also studied using prospective methods. (Cantrelle and Leridon, 1971; Garenne, 1981a and 1982b; Billewicz and McGregor, 1981). Like Garenne (1981a), we classified the children into two groups, those born during the May-October period and those born during the november-April period, and we estimated for each group the probabilities of death during periods of six months, from birth to age 5 (Table 7). As expected from previous results, the probability of death from birth to age 6 months is significantly higher for children born during the first period, which corresponds approximately to the rainy season, than for the children born during the dry season. However the difference between the two groups is less than what is observed in Ngayokheme (Garenne, 1981a). For ages over 6 months, we do not observe clear differences in the age pattern of mortality between the groups. The alternation of a high risk season (the rainy season) and a low risk season (the dry season) observed for the years without measles outbreaks, is completely disturbed when there is a measles outbreak.

The seasonality of infant and child mortality in Bandafassi is the result of the combination of two effects: the increase in mortality risks during the rainy season, which seems to affect children of all age-groups, and outbreaks of measles, mostly in the second part of the dry season, which affect only children

Table 7

The life table from birth to age 5 years by season of birth, from data on children of all populations, born after the first enumeration.

Age interval in months x,x+6	Probability of dying within interval, season of birth: rainy season (May-October) $_6q_x$	n (1)	dry season (November-April) $_6q_x$	n (1)	all $_6q_x$	n (1)
0- 6	.175	200	.128	149	.151	349
6-12	.073	63	.064	60	.068	123
12-18	.057	43	.071	56	.064	99
18-24	.055	35	.053	36	.054	71
24-30	.048	27	.076	43	.062	70
30-36	.052	25	.023	11	.037	36
36-42	.033	14	.031	13	.032	27
42-48	.028	10	.013	5	.020	15
48-54	.016	5	.015	5	.016	10
54-60	.022	6	.007	2	.014	8

(1) number of deaths.

over a certain age.

We have already mentioned one source of error that may affect the infant mortality estimates, the omission of live births. Cantrelle (1969) has suggested a way of estimating the rate of omission, so as to correct the bias. It consists of calculating the probability of death in the first year for two groups of children: the first group, composed of children whose mothers' pregnancies were registered at the visit preceding the visit when the births were registered; and the second group consisting of the children whose mothers' pregnancies were not registered before. The comparison of the two infant mortality rate (IMR) estimates makes it possible to compute the rate of omission of children in the second group, assuming that the risk of death is the same for both groups. We know that this assumption does not hold in the Bandafassi case, and, as explained above, it is almost impossible to separate the true effects of seasonality in the observed seasonality of mortality from the effects of omission.

Two other sources of error may affect the infant mortality estimates: (a) still-births are sometimes reported as live births; (b) dates of birth or death are misreported. The confusion between still-births and live births has been investigated on the Niokholonko data (Lecomte-Enselme, 1983). The comparison between the data from the retrospective interviews of women and those from the multi-round survey shows that probably a few still-births (between 1 and 2% of the total births) are wrongly reported as live births by the multi-round survey. Curiously, this overcount of live births is approximately balanced by the few omissions of live births. The reported birth and death dates are subject to some uncertainty. Though the error in most cases may not exceed 1 or 2 months, it is another source of error in the IMR estimates. It prevents us from computing a reliable detailed life table, month by month for example. The imprecision is of course considerably reduced when considering longer intervals, such as one year.

The high values of the infant mortality rate in Bandafassi are not surprising considering the results of studies of other rural populations from tropical regions with little medical assistance. The high values of the probability of death from age 1 to 5, and especially from age 1 to 3 are more unusual. This pattern of infant and child mortality can be compared with similar patterns observed by Cantrelle (1969) and McGregor (1979), and reviewed by Garenne (1982b) for Ngayokheme (Senegal) and Keneba (Gambia). The estimates of the probabilities of death from birth to age 5 in these areas are presented in Table 8 and Figure 5, along with similar estimates for the three Bandafassi populations and the corresponding values of a model life table: the Brass African life table with $_1q_0$ = 0.200 and with the parameter beta equal to 1. Only measures for both sexes are considered here. Mortality measures for the Bedik are based at these ages on a particularly small data set, and random variation is greater for them than for the other populations.

Table 8

Mortality from birth to age 5 for both sexes.
Results from prospective studies in Senegal and Gambia.

e interval exact ages in years)	Probability of dying in interval						
	Fula Bande	Niokholonko	Bedik	Ngayokheme [1]	Keneba [1]	Model life-table	
	1975-1983	1970-1983	1980-1983	1963-1971	1972-1981	1951-1975	Brass African [2]

e interval exact ages in years)	Fula Bande 1975-1983	Niokholonko 1970-1983	Bedik 1980-1983	Ngayokheme [1] 1963-1971	Keneba [1] 1972-1981	1951-1975	Model life-table Brass African [2]
0-1	0.200	0.234	0.190	0.219	0.157	0.239	0.200
1-2	0.099	0.145	0.089	0.200	0.095	0.155	0.086
2-3	0.103	0.095	0.051	0.100	0.096	0.121	0.044
3-4	0.055	0.061	0.046	0.065	0.057	0.076	0.027
4-5	0.042	0.023	0.032	0.017	0.029	0.042	0.013
1-5	0.269	0.290	0.201	0.360	0.250	0.342	0.161
0-5	0.415	0.456	0.353	0.500	0.368	0.499	0.329

1) source : Garenne 1982.
2) with $_1q_0$ = 0.200, a value in the middle of the range of variation for these populations, and beta = 1.

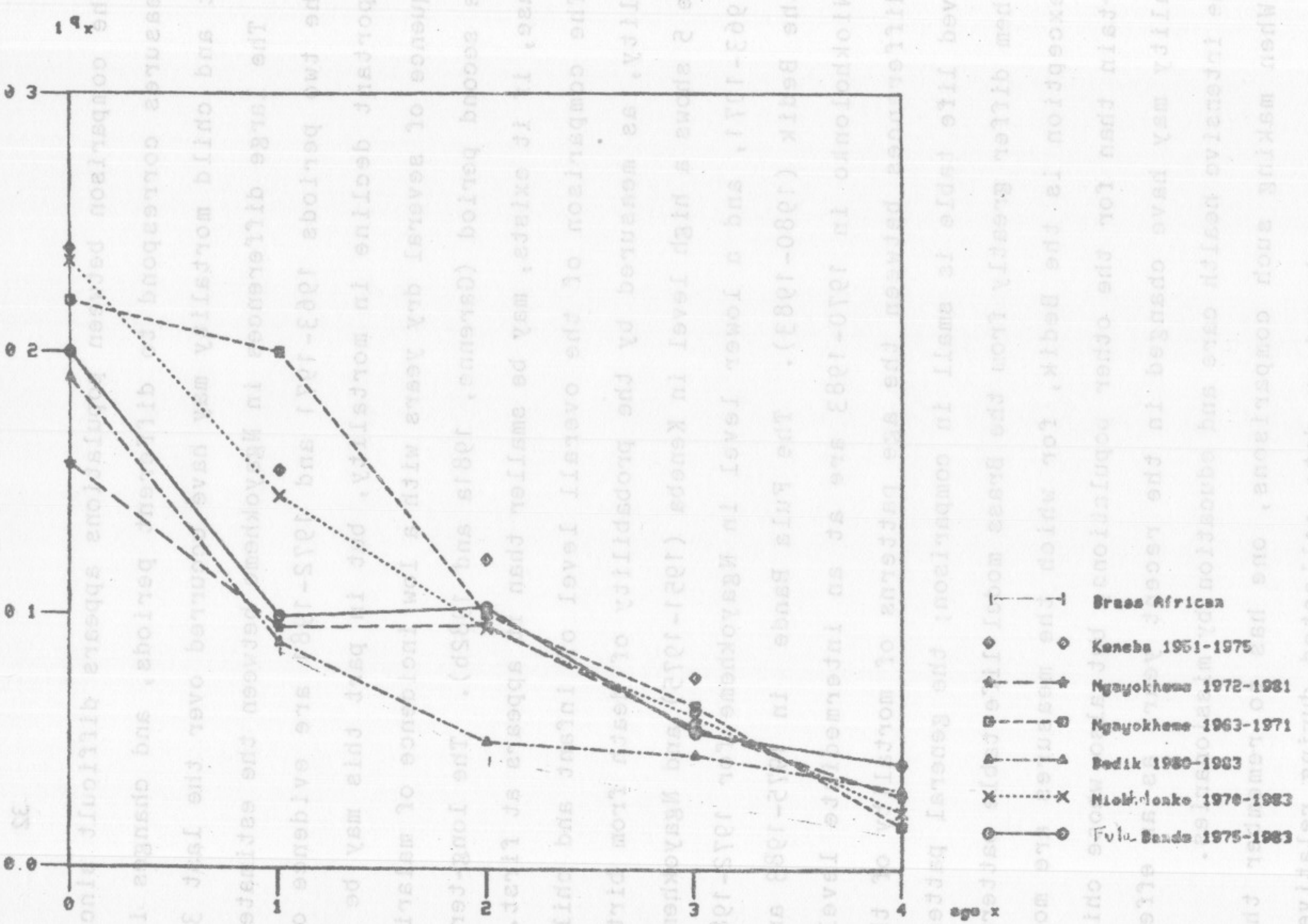


Figure 5. Mortality from birth to age 5. Comparison between measures from several prospective studies in Senegal and Gambia.

The comparison between populations appears difficult since the measures correspond to different periods, and changes in infant and child mortality may have occurred over the last 30 years. The large differences in Ngayokheme between the estimates for the two periods 1963-1971 and 1972-1981 are evidence of an important decline in mortality, but in part this may be a consequence of several dry years with a low incidence of malaria in the second period (Garenne, 1981a and 1982b). The long-term decrease, if it exists, may be smaller than it appears at first.

The comparison of the overall level of infant and child mortality, as measured by the probability of death from birth to age 5 shows a high level in Keneba (1951-1975) and Ngayokheme for 1963-1971, and a lower level in Ngayokheme for 1972-1981 and the Bedik (1980-1983). The Fula Bande in 1975-1983 and the Niokholonko in 1970-1983 are at an intermediate level. The differences between the age patterns of mortality of the observed life table is small in comparison; the general pattern for them differ greatly from the Brass model life table pattern. One exception is the Bedik, for which the measures are more uncertain than for the other populations, but also whose child mortality may have changed in the recent years as an effect of the intensive health care and education by missionaries.

When making such comparisons, one has to remember that these measures are based on data collected during relatively short periods of time and which are therefore very dependent upon particular events. Some factors of infant and child mortality show important variations from one year to the next. We have mentioned the relation between the rainfall in a given year and the risk of mortality, which has been well demonstrated by Garenne (1982b), for the children aged between 6 and 17 months in the Ngayokheme area. The relation is interpreted in this area as the result of an increase of the number of malaria cases in the years with an excess of rainfall. Measles is another example of a factor affecting infant and child mortality that may present great variations from year to year, especially in low density or isolated populations. In the villages of the Bandafassi area, measles is typically absent for several years, and then develops in all households during a short period of time. This is partly illustrated by Figure 4. The major epidemics observed in the area in 1973, 1977 and 1982 resulted in the death of approximately 25% of the children aged under 5 years within less than a month in the affected villages. The dynamics of measles epidemics in Bandafassi will be examined in detail in a forthcoming publication. Note that all the villages of the area were not affected at the same time. The 1977 outbreak hardly touched the Niokholonko villages, which are in the north part of the studied area (Figure 1), and affected severely only one group of Fula Bande villages, those around the village of Lande Baitil. These examples suggest that the estimates of infant and child mortality in follow-up studies may vary according to factors such as the number of dry or rainy years or the number of measles outbreaks in the reference period.

If we take into account the influence of the temporal events affecting mortality measures, the pattern of mortality from birth to age 5 in Bandafassi is not very different from those observed in Ngayokheme and in Keneba. We should note that the risk of mortality between 1 and 5 years, relative to the IMR, is lower in the Bandafassi area. The Ngayokheme and Keneba areas are around 500 km from the Bandafassi area, and have a much drier climate. Under these conditions, the observation of a similar age pattern of infant and child mortality reinforces the suggestion that the pattern described in nearly all the model life tables developed until now, may not be the right pattern for a large number of West African rural populations with a high level of mortality. The collection of accurate demographic data in different regions could help to define the geographical and ecological distribution of this pattern, and to describe its determinants.

B. THE ADULT MORTALITY PATTERN

The directly estimated life-tables for each population for sexes combined above 10 years of age are presented in Figure 6. In the figure, we adopt a length of ten years for the intervals so as to reduce the random variations of the estimates. We do not present the age pattern of mortality for each population and each sex separately for two reasons: first, the random variations of the estimates, greater than for both sexes together, would make the figures more difficult to read; and second, the mortality measures for each sex are similar. The life expectancy at age 10 in all cases is in the range 45-48 years, with no significant differences between populations and sexes.

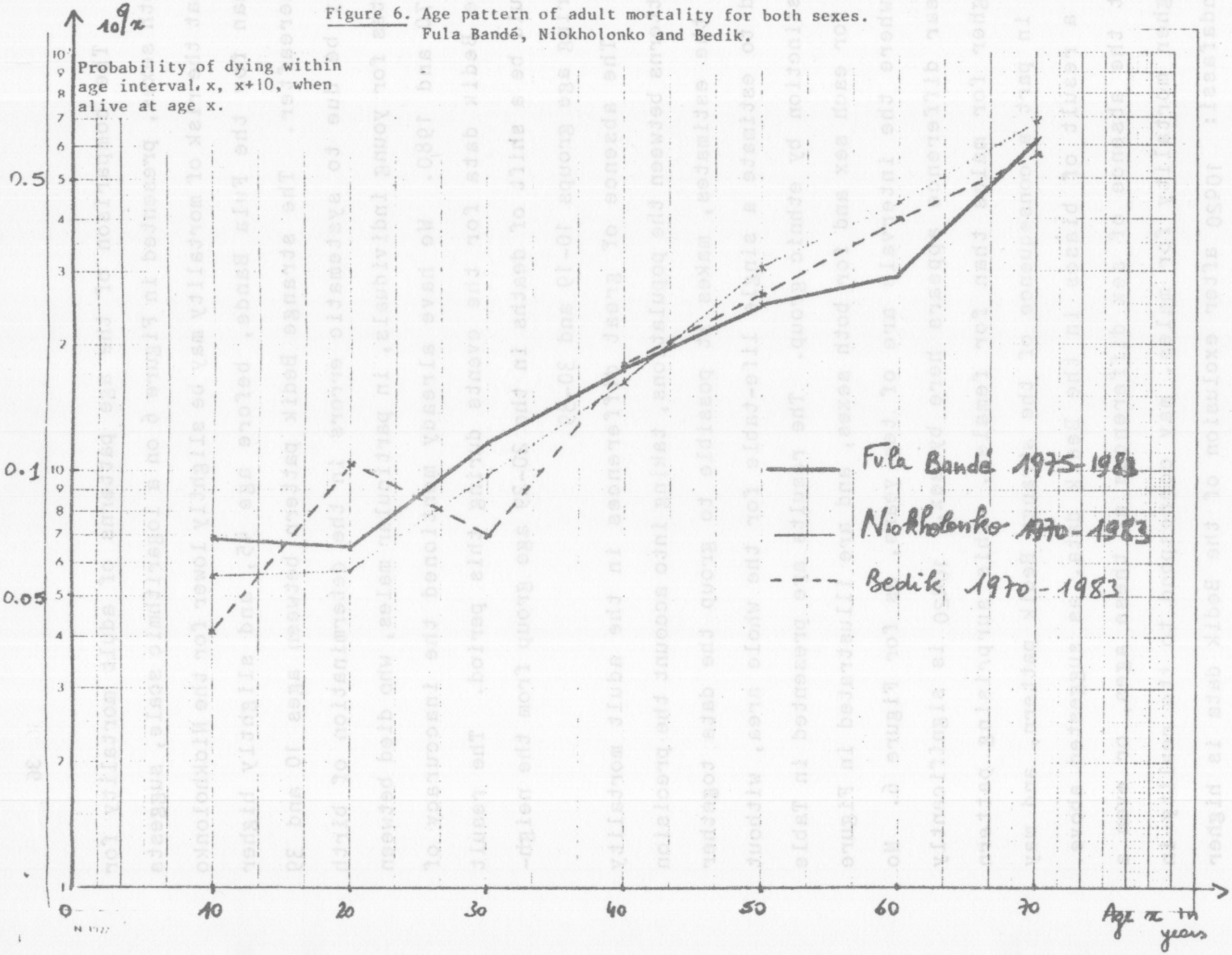
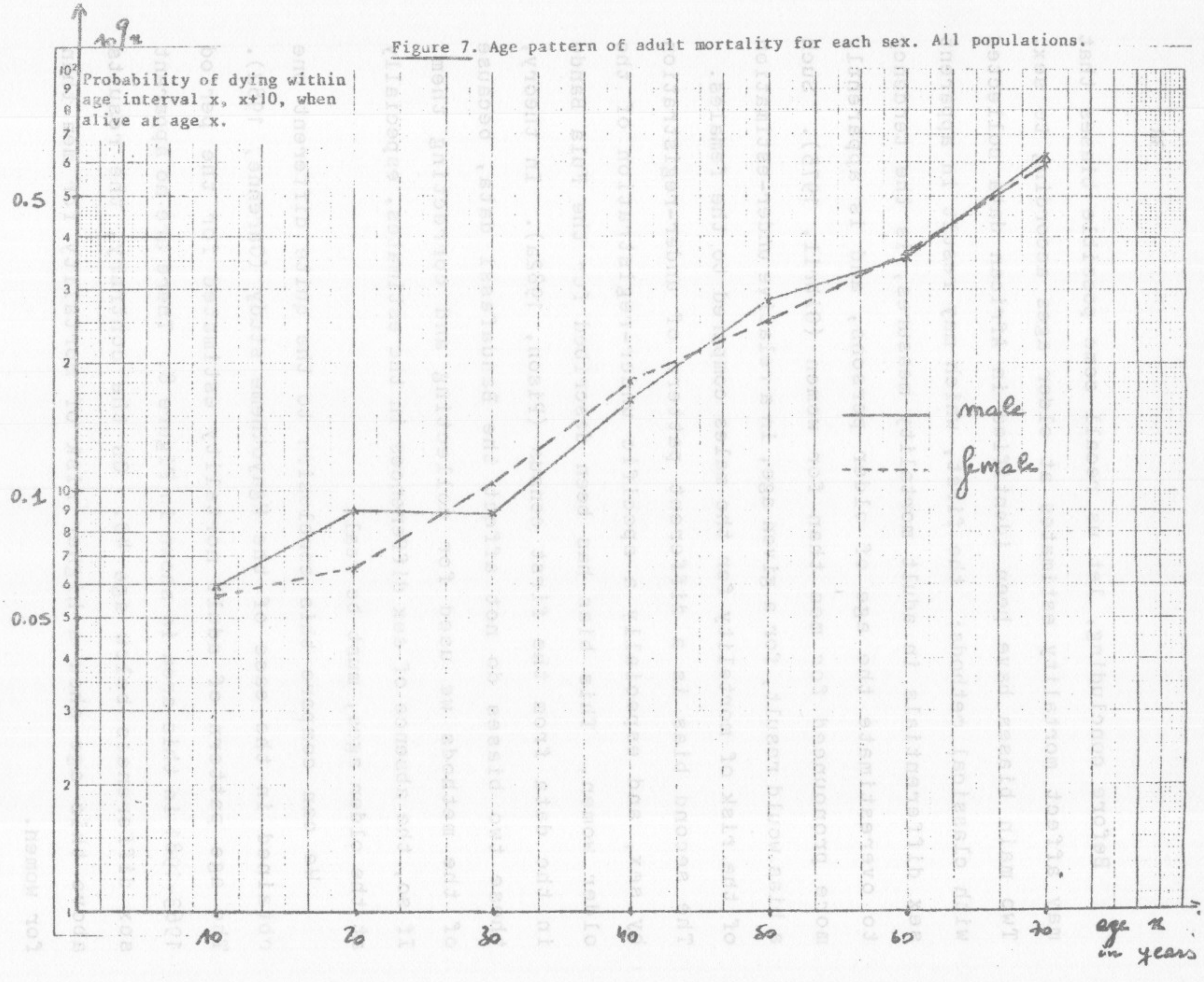


Figure 6. Age pattern of adult mortality for both sexes. Fula Bandé, Niokholonko and Bedik.

The comparison of the age patterns of adult mortality for both sexes, presented in Figure 6 on a logarithmic scale, suggests that the risk of mortality may be slightly lower for the Niokholonko than for the Fula Bande, before age 45, and slightly higher thereafter. The strange Bedik pattern between ages 10 and 39 may be due to systematic errors in the determination of birth dates for young individuals, in particular males, who died between 1970 and 1980. We have already mentioned the inaccuracy of the Bedik data for the events during this period. The result would be a shift of deaths in the 20-29 age group from the neighboring age groups 10-19 and 30-39.

The absence of great differences in the adult mortality patterns between the populations, taking into account the precision of the estimates, makes it possible to group the data together and to estimate a single life-table for the whole area, without distinction by ethnic group. The results are presented in Table 5, for each sex and for both sexes, and are illustrated in Figure 7 where the intervals are of ten years, as for Figure 6. No clear difference appears here by sex. $_{10}q_{20}$ is significantly higher for males than for females. This surprising pattern is in part a consequence of the strange Bedik pattern, and may be a result of biases in the Bedik data, as suggested above. But the absence of sex differences at these ages, or even a higher mortality for males, may correspond to the reality in Bandafassi: $_{10}q_{20}$ after exclusion of the Bedik data is higher for males than for females, though the difference by sex is no longer significant.

Figure 7. Age pattern of adult mortality for each sex. All populations.



Before concluding, let us recall some possible biases that may affect mortality estimates at older ages according to sex. Two main biases have been identified in African data collected with classical methods: the first, which may result in apparent sex differentials in adult mortality measures, is the tendency to overestimate the age of older persons, and is apparently more pronounced for men than for women (Gibril, 1975). Such a bias would result, for a given age, in a relative under-estimation of the risk of mortality for the males compared to the females. The second bias is a different pattern of under-registration by sex, and especially a specific under-registration of the older women. This bias has been described for the Fula Bande in the data from the first census (Pison, 1982a). In theory, these two biases do not affect the Bandafassi data, because of the methods we used for collecting and correcting them. If so, the absence of sex differences in the estimates, especially at the older ages, must be real.

We can compare this conclusion to the quite different one obtained in the case of the Ngayokheme study (Garenne, 1982). The age pattern of adult mortality estimated for the period 1963-1981 in this area is shown in Figure 8. There are no apparent sex differences below age 40. On the contrary, the results above this age show a higher risk of mortality for men than for women.

The apparent absence of important sex differences in Bandafassi allow us to group the data and retain only the estimates for both sexes together. Random variations in $_5q_x$ remain high,

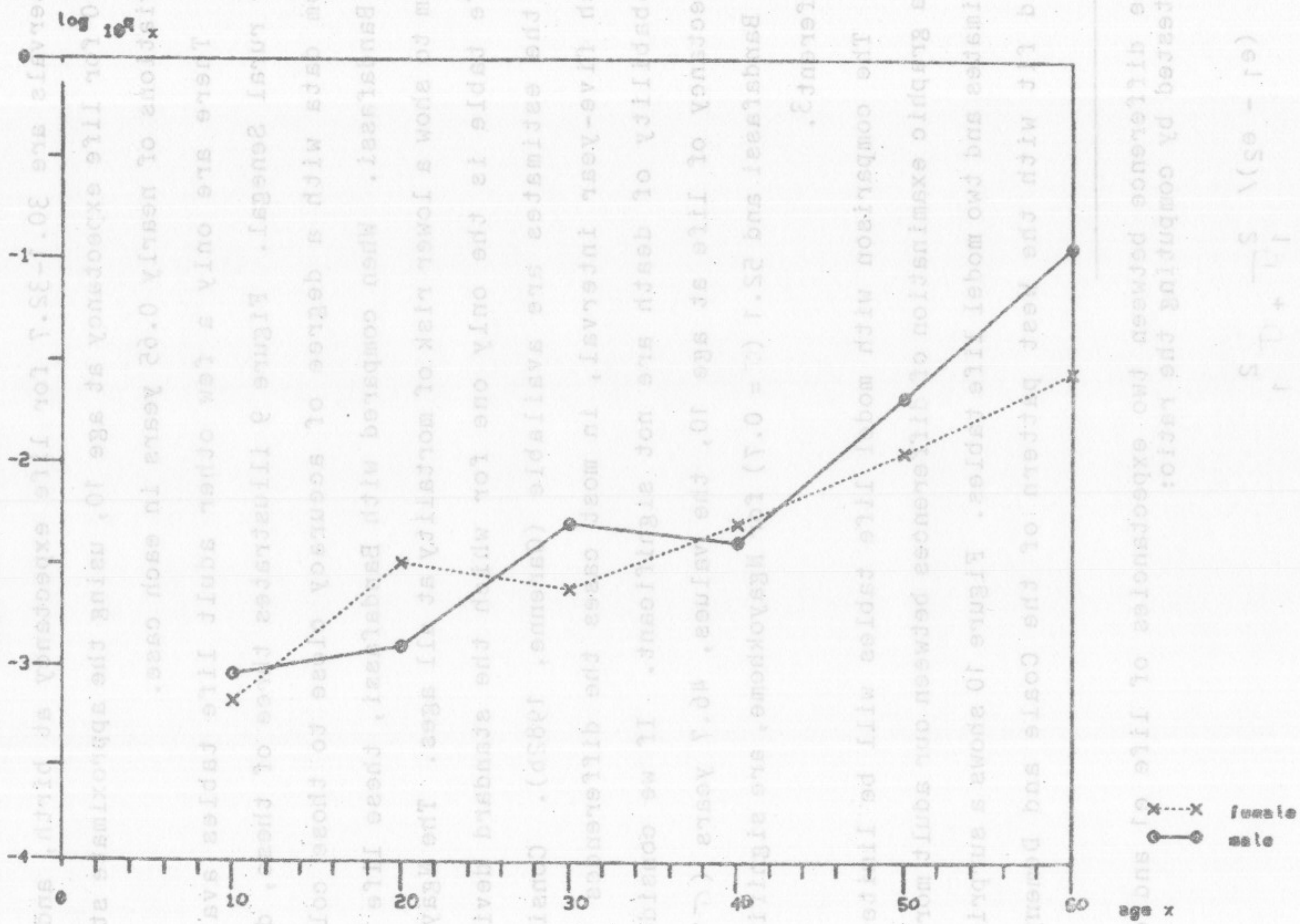


Figure 8. Age pattern of adult mortality, Ngayokheme 1963-1981. Comparison between sexes.

even when the two sexes and the populations are combined. If we consider only life expectancy, the approximate 95% confidence intervals are 30.1-32.7 for life expectancy at birth, and 45.4-48.0 for life expectancy at age 10, using the approximate standard deviations of nearly 0.65 years in each case.

There are only a few other adult life tables available for rural Senegal. Figure 9 illustrates three of these, derived from data with a degree of accuracy close to those collected in Bandafassi. When compared with Bandafassi, these life tables seem to show a lower risk of mortality at all ages. The Ngayokheme life table is the only one for which the standard deviations of the estimates are available (Garenne, 1982b). Considering each five-year interval, in most cases the differences in the probability of death are not significant. If we consider the expectancy of life at age 10, the values, 46.7 years ($\sigma = 0.7$) for Bandafassi and 52.1 ($\sigma = 0.7$) for Ngayokheme, are significantly different[3].

The comparison with model life tables will be limited here to a graphic examination of differences between our adult mortality estimates and two model life tables. Figure 10 shows a surprisingly good fit with the West pattern of the Coale and Demeny life

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[3]The difference between two expectancies of life e1 and e2 can be tested by computing the ratio:

$$(e_1 - e_2) / \sqrt{\sigma_1^2 + \sigma_1^2}$$

which is assumed to be distributed as a normal probability function. In the case of the comparison of the life expectancy at age 10 between Bandafassi and Ngayokheme, this ratio equals 5.9.

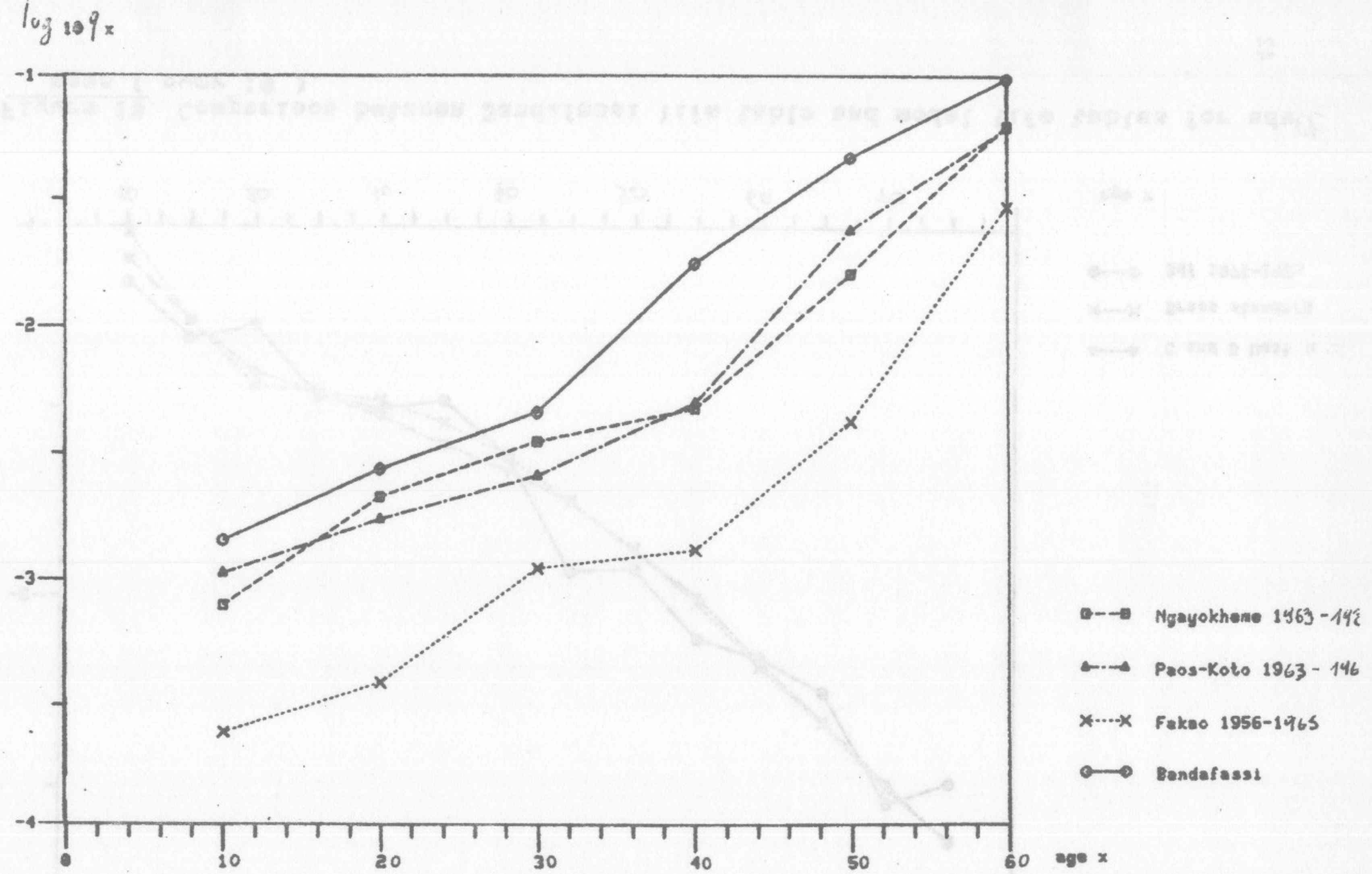

Figure 9. Age pattern of adult mortality for both sexes. Comparison between Bandafassi and other rural areas of Senegal.

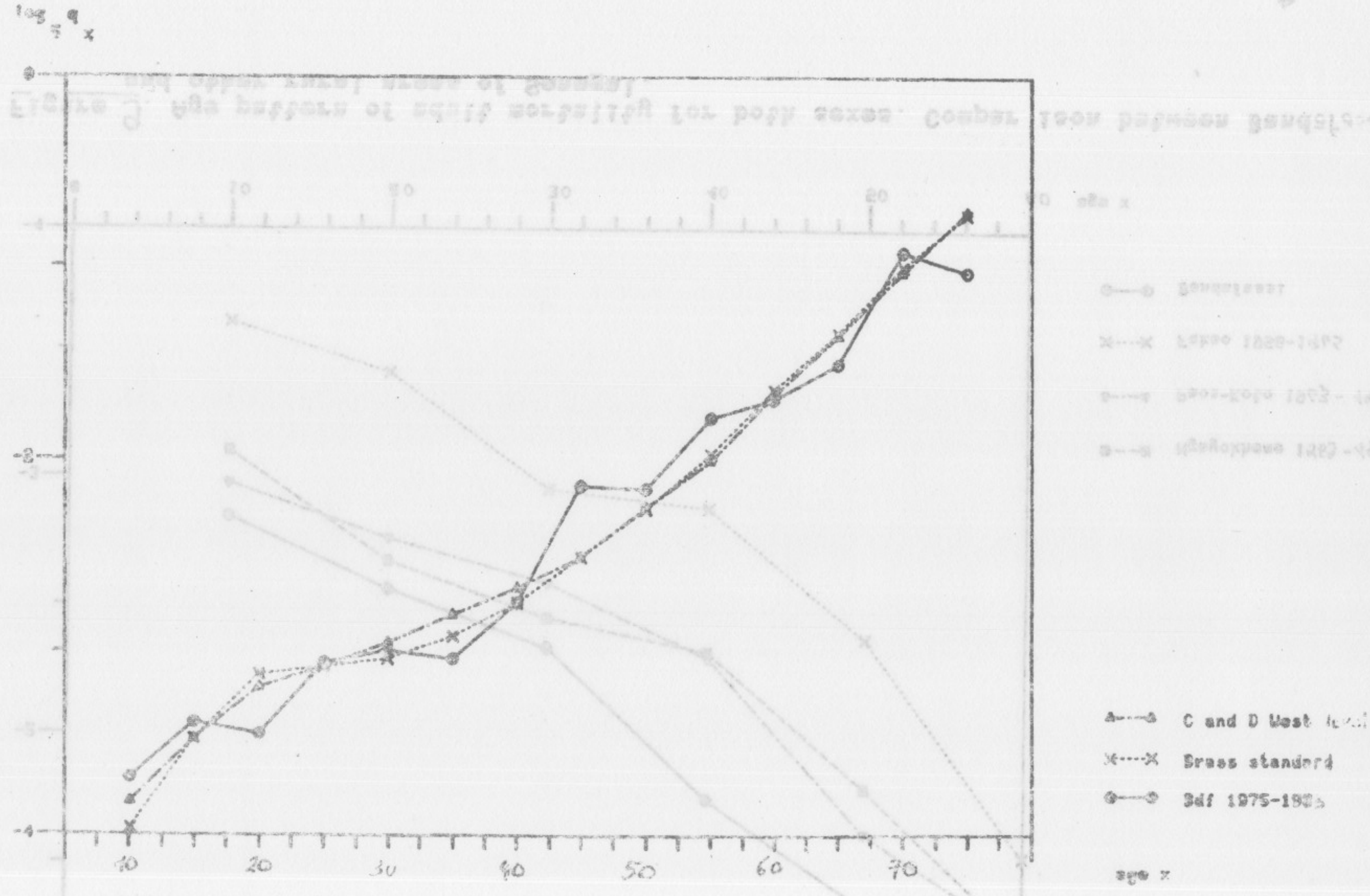

Figure 19. Comparison between Sandafassi life table and model life tables for adult ages (over 10).

table with a life expectancy at age 10 for both sexes equal to 46.7 years (level 10), identical to that observed in Bandafassi. A good fit exists also with the brass standard life table (e_{10} = 47.4), without any prior adjustment.

We shall not discuss differences for young ages, before age 10, since the inadequacy of nearly all the model life tables when considering West African Mortality, has already been demonstrated in detail. It is well illustrated here by the fact that the observed adult mortality corresponds approximately to the model life tables whose life expectancy at birth are equal to 41.1 (Coale and Demeny) and 43.6 (Brass African standard), although the estimated life expectancy at birth is 31.4 years. The balance between child mortality and adult mortality in Bandafassi, and in a few other areas, is quite different form that proposed by models until now.

CONCLUSIONS

Our knowledge of the age pattern of mortality in most areas of sub-Saharan Africa is very poor. Most effort has been concentrated on measuring mortality at the early ages, and mainly in the first year of life. For many populations, even at these ages the estimates remain uncertain. For most populations, the age pattern of adult mortality is a "terra incognita", and we must depend upon models to derive it. Under these conditions of scant information,any new measure is extremely valuable. The main characteristic of the life table we have estimated for the populations of the Bandafassi area in Eastern Senegal is that it is based on high quality data, compared to African standards, but in limited quantity. A question that arises about this empirical life table is: is it representative of other populations? Expressed in other terms, the question is: Can this life table be considered a model?

Some reasons seem to us to recommend prudence when applying this life table to other populations. The first reason lies in the highest level of mortality observed. Due both to the relative isolation of the area from other parts of the country, and also to the environment which favours many diseases, this high level of mortality may be specific to the Southern part of Eastern Senegal. Secondly, the risks of mortality are affected by temporal variations due to epidemics and famines. These factors have a particularly strong influence at the early ages. Measures obtained from a short period of observation may therefore reflect temporary risks rather than a long term average level of mortality.

Though our estimates of mortality for the Bandafassi area must not be extended without caution, they provide answers to several questions about West African mortality patterns.

(a) The very high level of child mortality between ages 6 months and 3 years, already described for a few West African rural areas, has once again bean identified.

(b) The seasonality of child mortality is characterized by two periods of higher risk: the rainy season, and the second part of the dry season. The first period is associated with a high level of malaria transmission, and the second, with periods of measles outbreaks.

(c) The age pattern of adult mortality does not differ from the age pattern described by the model life tables, which relies mainly on the experience of traditional European populations of the past.

(d) There are no perceptible sex differences at any age.

Some methodological conclusions about the small-scale and intensive approach can also be drawn from the Bandafassi example. The objectives of the Bandafassi population study were wider than that of a demographic survey in a country with a defective vital registration system. Anthropological data, such as genealogies, were collected, which demographers are not usually interested in. The data were collected with special care; for example the ages have been estimated using an original method, so as to prevent some classical biases. These methods probably result in a better quality of demographic measures compared to usual methods. Of course we have no absolute proof of this, because we do not know the true values.

Such methods cannot be applied to large-scale studies, because of the prohibitive costs, and of the necessity, with these methods, to adapt to the cultural diversity of the population. However we may mention a way of improving demographic measurements on a large scale using a method, which would consist of setting up several population laboratories distributed so as to cover, as much as possible, the whole country. Two kinds of results could be derived: first correction of some of the errors attached to large surveys, either directly by comparing the measures from different sources, or indirectly by proposing models if one uses indirect estimation techniques; second, the continuity in the observation methods over a long period is necessary for the description of demographic trends. The drawback of such a network would be its non-representativeness. One can partly remedy this weakness by intelligent choice of the areas observed, to represent as much as possible the range of geographic, economic and cultural variations in the country.

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