Risk factors of infant and child mortality in rural Burkina Faso

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Objective The aim of the study was to quantify the effect of risk factors for childhood mortality in a typical rural setting in sub-Saharan Africa.

Methods We performed a survival analysis of births within a population under demographic surveillance from 1992 to 1999 based on data from a demographic surveillance system in 39 villages around Nouna, western Burkina Faso, with a total population of about 30 000. All children born alive in the period 1 January 1993 to 31 December 1999 in the study area (n = 10 122) followed-up until 31 December 1999 were included. All-cause childhood mortality was used as outcome variable.

Findings Within the observation time, 1340 deaths were recorded. In a Cox regression model a simultaneous estimation of hazard rate ratios showed death of the mother and being a twin as the strongest risk factors for mortality. For both, the risk was most pronounced in infancy. Further factors associated with mortality include age of the mother, birth spacing, season of birth, village, ethnic group, and distance to the nearest health centre. Finally, there was an overall decrease in childhood mortality over the years 1993–99.

Conclusion The study supports the multi-causation of childhood deaths in rural West Africa during the 1990s and supports the overall trend, as observed in other studies, of decreasing childhood mortality in these populations. The observed correlation between the factors highlights the need for multivariate analysis to disentangle the separate effects. These findings illustrate the need for more comprehensive improvement of prenatal and postnatal care in rural sub-Saharan Africa.

Keywords Infant mortality; Maternal mortality; Twins; Age factors; Birth intervals; Ethnology; Seasons; Health services accessibility; Risk factors; Survival analysis; Burkina Faso (*source: MeSH, NLM*).

Mots clés Mortalité nourrisson; Mortalité maternelle; Jumeaux; Facteur âge; Intervalle entre naissances; Ethnologie; Accessibilité service santé; Saison; Facteur risque; Analyse survie; Burkina Faso (*source: MeSH, INSERM*).

Palabras clave Mortalidad infantil; Mortalidad materna; Gemelos; Factores de edad; Intervalo entre nacimientos; Etnología; Accesibilidad a los servicios de salud; Estaciones; Factores de riesgo; Análisis de supervivencia; Burkina Faso (*fuente: DeCS, BIREME*).

Arabic

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Voir page 272 le résumé en français. En la página 272 figura un resumen en español.

Introduction

A total of 10.5 million children under 5 years of age were estimated to have died worldwide in 1999, and the great majority of these deaths occurred in developing countries (*1*). Most childhood deaths have been attributed to diarrhoea, acute respiratory illness, malaria, measles, and malnutrition — conditions that are either preventable or treatable with low-cost interventions (*2*). The highest mortality rates worldwide are still in sub-Saharan Africa (SSA), where approximately 15% of newborn children are expected to die before reaching their fifth birthday (*1*).

Childhood mortality rates have declined considerably over the past few decades in most of SSA, but since the 1990s mortality rates have started to increase again in parts of the continent (*1*). This new trend has been attributed mainly to the effects of the AIDS epidemic and to the spread of chloroquine-resistant malaria (*3–5*).

In all of SSA except South Africa, reliable information on birth rates, death rates, and causes of deaths are lacking because of a poor public health infrastructure and non-existence of vital registration systems (*6*). Existing mortality estimates including approaches to identify relevant risk factors are thus based on data from Demographic and Health Surveys (DHSs), research sites with established Demographic Surveillance Systems (DSSs), and specific epidemiological studies (*4*, *7–21*). Risk factors for childhood mortality can be grouped as follows: socioeconomic status, fertility behaviour, environmental health conditions, nutritional status and infant feeding, and the use of health services (*20*).

Here, we present findings from a comprehensive analysis of risk factors for mortality and their varying effects by age in a cohort of 10 122 liveborn children followed over a period of 7 years in a rural area of Burkina Faso, West Africa, and we compare these with results from the most recent DHS in Burkina Faso from 1998 to 1999 (*22*).

Study population and methods

Study area

The study was conducted in the research zone of the Centre de Recherche en Santé de Nouna (CRSN) in the Nouna Health District in north-western Burkina Faso (*23*). Today, the study

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area comprises 41 villages and Nouna town. Subsistence farming is the main socioeconomic activity of the population. Formal health services in the CRSN study area comprise a hospital in Nouna town and four local health centres. Malaria, diarrhoea, and respiratory infections are major causes of childhood mortality. Malnutrition is highly prevalent in young children living in the study villages and has been associated with childhood mortality (*24*). Malaria transmission intensity is high but markedly seasonal (*25*).

Demographic Surveillance System

The database for this study is based on the DSS of the CRSN (*21*, *24*, *26*). A baseline census had been undertaken in 1992, and two control censuses were done in 1994 and 1998. During the time of the second control census a cross-sectional study of all mothers within the study region regarding maternity health issues was performed; all births and deaths were also recorded. The average population size in the study period was about 30 000 inhabitants. Registration of vital events was by trained field staff who routinely collected the relevant information from specific village informants. The interval for data collection varied between 1 and 3 months (*21*). The variables registered include births, deaths, pregnancies, and migration in and out of the household, as well as information on all the dates related to these events. The DSS database also contains several other tables of data on various topics such as household economics and maternal health.

Study population

All children born between 1 January 1993 and 31 December 1999 in 39 villages of the CRSN study area were included. We identified a total of 10 122 births, of which 1043 children were identified in a cross-sectional study on maternal health in 1998. Of these, 162 children were reported to have died either "within the first week" or "within week 2 to 4". For these children, we assigned arbitrary survival times of 2 and 15 days, respectively.

Statistical analysis

The main end-point for the analysis was overall survival. For the survival analysis, a proportional hazards model was used to investigate simultaneously the relative effect of demographic, ethnic, and reproductive factors on childhood survival rates (27, 28). The effects are given as hazard rate ratios. For each child, the observation time t was taken as the time from birth until death, the date of fifth birthday, or the date of 31 December 1999, whichever came first. For emigrated individuals the observation time was taken as the time from birth until the date of emigration. For all risk factors it may be assumed that the effect is different at infant and childhood age, therefore we used separate models. For infant age (<1 year) modelling, the observation time t was truncated at the first birthday. For childhood (age 1–5 years) mortality modelling, all children were included from their first birthday and the underlying time variable in the Cox model was set to (t–1). In the final model all variables that showed a significant impact in either of the two age groups were included. These are "year of birth", "sex", "ethnic group", "religion", "age of mother at birth of child", "season of birth", "twin birth", "birth order", "distance to health centre", "time to birth of next sibling", "time since last sibling was born and vital status of last sibling", and "vital status of mother".

The covariates "time to birth of next sibling" and "vital status of mother" entered the model as time-dependent covariates as follows: time to next sibling (birth spacing) — if a sibling was born before the respective child reached the age 18 months, the covariate was set to 1 from the date of birth of the next sibling; vital status of mother — if the mother died, the corresponding variable was set to 1 from the date of death.

For analysis we used the SAS-procedure PHREG (SAS Institute, Cary, NC, USA) (*29*), which allows the analysis of continuous and time-dependent covariates.

Results

Data description

Table 1 shows the distribution of variables by vital status. A total of 10 122 live births with 1340 deaths were analysed. The male/female ratio shows that the frequency of male births was slightly higher than that of female births (50.4% vs 49.3%; 0.3% with missing information; sex ratio 1.02). Birth frequency was not uniformly distributed over the observation time, and was significantly higher in 1997 compared with each of the other years. The median ages of mothers and fathers at birth of the child were 25 and 34 years, respectively. Dafing and Bwaba were the two most dominant ethnic groups, and Muslim was the dominant religion (60.2%). Table 2 shows the strong correlation between ethnic group and religion in the study population.

Only a small proportion of mothers and fathers were reported dead before the child reached 3 years of age, but there was no information on the vital status of a high proportion of fathers. The median time of birth spacing between siblings was 28 months, the frequency of twins was 3.0%, and the births were evenly distributed over the year). In all, 64.6 % of the children were living less than 10 km away from a health centre compared with 34.8 % living far away. The overall mean follow-up time for the children of the study was 2.6 years.

Survival analysis

Table 3 shows the results of the multivariate Cox model. Generally, the magnitude of effect for the factors considered here was stronger for infants (<1 year) than for children (1–5 years). In terms of hazard rate ratio, the strongest factor was the death of the mother. Although death of the mother is a rare event, among those 18 children whose mother died within their first year of life, 9 died within the follow-up period; the rate ratio for infants was 15.6 (95% confidence interval (CI) = 7.61–31.8) and 5.35 for children (95% CI = 1.69–16.9).

Twins also experienced an increased mortality risk. The rate ratio for the first 6 months of life was 4.33 (95% CI = 3.22–5.83) and about twofold for the following 6 months.

Overall, we observed a highly significant reduction in mortality over the observation period. This trend was observed both for infants and for children up t o the age of 5 years. The effect, however, was much stronger for infants. There is some confounding with other factors in the full model. When considering year of birth separately, the yearly hazard ratio is 0.856, which yields a 61% reduction over the 7-year observation period. Although other data from Burkina Faso support the general trend, the magnitude of reduction found here is surprising and suggests an underreporting of infant deaths (see Discussion).

Ethnicity was shown to be strongly associated with infant mortality, with infants in Bwaba, Mossi, and Samo having a significantly lower mortality than those in the Dafing or Peulh

Table 1. **Distribution of demographic variables and risk factors of children born around Nouma, western Burkina Faso, 1993–99**

Characteristic	No. of children who died in first year of life[a]	No. of children who died in second, third, fourth, or fifth year of life[a]	No. of children alive at end of follow-up[a]	Total
Sex				
Male	351; *6.9*	356; *7.0*	4396; *86.1*	5103
Female	297; *6.0*	320; *6.4*	4371; *87.6*	4988
Unknown	16; *51.6*	0; *0*	15; *48.4*	31
Year of birth				
1993	124; *10.0*	159; *12.8*	956; *77.2*	1239
1994	134; *10.2*	140; *10.6*	1043; *79.2*	1317
1995	111; *7.1*	146; *9.4*	1297; *83.5*	1554
1996	92; *7.4*	68; *5.5*	1087; *87.2*	1247
1997	90; *5.0*	112; *6.2*	1614; *88.9*	1816
1998	48; *3.4*	51; *3.6*	1331; *93.1*	1430
1999	65; *4.3*	0; *0*	1454; *95.7*	1519
Age of mother at birth of child (years)				
<18	102; *11.4*	68; *7.6*	726; *81.0*	896
18–35	400; *5.9*	459; *6.8*	5929; *87.3*	6788
36+	85; *7.2*	86; *7.3*	1004; *85.4*	1175
Unknown	77; *6.1*	63; *5.0*	1123; *88.9*	1263
Age of father at birth of child (years)				
<20	6; *5.3*	11; *9.7*	96; *85.0*	113
20–40	213; *5.4*	366; *9.4*	3331; *85.2*	3910
41+	71; *4.8*	142; *9.6*	1265; *85.6*	1478
Unknown	374; *8.1*	157; *3.4*	4090; *88.5*	4621
Ethnic group				
Dafing	315; *7.8*	288; *7.1*	3437; *85.1*	4040
Bwaba	149; *5.5*	170; *6.3*	2377; *88.2*	2696
Mossi	75; *4.1*	110; *6.0*	1645; *89.9*	1830
Peulh	94; *8.7*	78; *7.2*	910; *84.1*	1082
Samo	10; *3.9*	15; *5.8*	232; *90.3*	257
Others	5; *3.5*	13; *9.1*	125; *87.4*	143
Unknown	16; *21.6*	2; *2.7*	56; *75.7*	74
Religion				
Muslim	425; *7.0*	434; *7.1*	5238; *85.9*	6097
Catholic	123; *4.8*	142; *5.6*	2292; *89.6*	2557
Protestant	32; *6.1*	33; *6.3*	460; *87.6*	525
Animiste/other	68; *7.9*	64; *7.4*	733; *84.7*	865
Unknown	16; *20.5*	3; *3.8*	59; *75.6*	78
Mother died before child reached 3 years				
No	614; *6.5*	624; *6.6*	8158; *86.8*	9396
Yes	9; *21.4*	6; *14.3*	27; *64.3*	42
Unknown	41; *6.0*	46; *6.7*	597; *87.3*	684
Father died before child reached 3 years				
No	295; *5.3*	525; *9.5*	4714; *85.2*	5534
Yes	2; *2.3*	4; *4.6*	81; *93.1*	87
Unknown	367; *8.2*	147; *3.3*	3987; *88.6*	4501
Spacing to next sibling				
No younger sibling or >36 months	298; *4.8*	313; *5.0*	5623; *90.2*	6234
<18 months	133; *25.6*	49; *9.4*	337; *64.9*	519
18–36 months	192; *7.2*	268; *10.0*	2225; *82.9*	2685
Unknown	41; *6.0*	46; *6.7*	597; *87.3*	684

(Table 1, cont.)

Characteristic	No. of children who died in first year of life[a]	No. of children who died in second, third, fourth, or fifth year of life[a]	No. of children alive at end of follow-up[a]	Total
Spacing to previous sibling				
No elder sibling or >36 months	322; *6.7*	296; *6.2*	4163; *87.1*	4781
<18 months	40; *8.8*	38; *8.4*	377; *82.9*	455
18–36 months	239; *6.1*	277; *7.0*	3428; *86.9*	3944
Unknown	63; *6.7*	65; *6.9*	814; *86.4*	942
Birth order				
First	209; *8.7*	124; *5.2*	2058; *86.1*	2391
Second, third, or fourth	247; *5.7*	302; *7.0*	3747; *87.2*	4296
Fifth or higher	167; *6.1*	204; *7.4*	2380; *86.5*	2751
Unknown	41; *6.0*	46; *6.7*	597; *87.3*	684
Twin birth				
Yes	59; *19.3*	40; *13.1*	206; *67.5*	305
No	605; *6.2*	636; *6.5*	8576; *87.4*	9817
Season of birth				
Dry	313; *5.6*	407; *7.2*	4901; *87.2*	5621
Rainy	189; *6.5*	192; *6.6*	2533; *86.9*	2914
Unknown	162; *10.2*	77; *4.9*	1348; *84.9*	1587
Distance to health centre				
<10 km	384; *5.9*	427; *6.5*	5723; *87.6*	6534
>10 km	267; *7.6*	248; *7.0*	3009; *85.4*	3524
Unknown	13; *20.3*	1; *1.6*	50; *78.1*	64
Total	**664**	**676**	**8782**	**10122**

[a] Figures in italics are row percentages.

Table 2. **Distribution of ethnic group by religion**

Religion	Ethnic group						Total
	Dafing	Bwaba	Mossi	Peulh	Samo	Other	
Muslim	3467	58	1210	1078	181	103	6097
Catholic	356	1608	504	0	50	39	2557
Protestant	66	351	80	2	23	3	525
Natural religion[a]	144	666	31	2	3	2	848
Other/NA[b]	7	13	5	0	0	70	95
Total	**4040**	**2696**	**1830**	**1082**	**257**	**217**	**10122**

[a] Indigenous beliefs.
[b] NA = information not available.

(rate ratios were close to 0.5). The mortality of infants from the two major religions, Muslim and Catholic, was similar when using the multivariate model. However, because there was a strong association between ethnic group and religion, these two variables must be considered jointly. Without ethnic group in the model, Muslims appear to have a highly significant increased risk compared with Catholics and Protestants.

The time between the birth of the child and the birth of the next younger or older sibling was associated with mortality. However, because mortality within family is correlated with birth spacing, our results must be considered with caution (see Discussion). For the next older sibling, this effect was apparent only for infants with a rate ratio (RR) of 1.36. Here, the vital status of the older sibling was of additional relevance. If it had died before age 1 or before the birth of the index child, this independently increased the risk by a factor of 1.45. This suggests a clustering effect of infant mortality within families. The effect of birth spacing to the next youngest child was obviously restricted to children older than 1 year. Here, we observed a very pronounced effect RR 1.54).

Both the age of the mother and birth order have a significant independent impact on mortality. These two variables are strongly correlated, and again, only a multivariate model allows the independent effect of either factor to be estimated. Both low age (<18 years) of mother and being the first child were found to be associated with an increased infant mortality

Table 3. **Rate ratios for infant and childhood survival, Nouna Demographic Surveillance System, Burkina Faso, using a proportional hazards regression model**

Variable	Infants (<1 year)			Children (1–5 years)		
	Rate ratio	*P*-value	95% CI[a]	Rate ratio	*P*-value	95% CI
Sex						
Female	1.0			1.0		
Male	1.12	0.16	0.96–1.30	1.07	0.41	0.92–1.24
Birth spacing to next youngest sibling						
Born after age 18 months or no younger sibling in follow-up period		(not applicable)		1.0		
Born before age 18 months				1.54	0.01	1.10–2.16
Birth spacing to next oldest sibling						
Next oldest sibling older than 18 months at birth of index child or no older sibling	1.0			1.0		
Born before older sibling reached age 18 months	1.36	0.05	0.99–1.87	1.16	0.33	0.86–1.57
Older sibling died before birth or before age 1 year						
No, or no older sibling	1.0					
Yes	1.45	0.02	1.06–1.96	1.11	0.44	0.85–1.45
Mother's vital status						
Alive	1.0			1.0		
Died	15.6	<0.0001	7.61–31.8	5.35	0.004	1.69–16.9
Single/twin						
Single	1.0			1.0		
Twin (0–<6 months)	4.33	<0.0001	3.22–5.83			
Twin (6–<12 months)	2.28	0.02	1.12–4.66			
Twin (12–60 months)				2.38	<0.0001	1.72–3.29
Year of birth (years)	0.80	<0.0001	0.77–0.84	0.95	0.07	0.90–1.00
Age of mother (years)						
<18	1.40	0.01	1.09–1.79	1.41	0.02	1.05–1.89
18–35	1.0			1.0		
⩾36	1.29	0.07	0.98–1.70	1.05	0.71	0.80–1.38
NA[b]	0.80	0.23	0.55–1.16	0.58	0.03	0.35–0.95
Religion						
Muslim	1.0			1.0		
Catholic	1.03	0.85	0.79–1.34	0.73	0.02	0.56–0.95
Protestant	1.40	0.11	0.93–2.10	0.88	0.52	0.59–1.31
Natural or other/NA[b]	1.66	0.002	1.21–2.27	0.96	0.82	0.69–1.35
Ethnic group						
Dafing	1.0			1.0		
Bwaba	0.59	0.0003	0.45–0.79	1.02	0.90	0.77–1.36
Mossi	0.51	<0.0001	0.39–0.66	0.87	0.25	0.69–1.10
Peulh	1.14	0.26	0.90–1.45	0.99	0.92	0.77–1.27
Samo	0.52	0.04	0.28–0.98	0.75	0.29	0.45–1.27
Other/NAb	0.94	0.80	0.57–1.54	1.23	0.44	0.72–2.09
Distance to health centre						
<10 km	1.0			1.0		
>10 km	1.33	0.0006	1.13–1.57	1.11	0.22	0.94–1.30
Birth order						
First	1.32	0.01	1.07–1.64	0.80	0.07	0.63–1.02
Second, third, or fourth[c]	1.0			1.0		
Fifth or higher	1.10	0.39	0.89–1.37	1.03	0.78	0.85–1.25
Season of birth						
Dry	1.0			1.0		
Rainy	1.21	0.04	1.01–1.46	0.95	0.57	0.80–1.13

[a] CI = confidence interval.
[b] NA = information not available.
[c] Individuals with missing information in baseline category.

risk (RR 1.40, 95 % CI = 1.09–1.79 and RR 1.32, 95 % CI = 1.07–1.64, respectively). Low age of mother also remained a risk factor for ages 1–5 years. There was no risk observed with age of the father.

Being born during the rainy season was associated with a significantly higher risk of mortality during the first year of life compared with being born during the dry season (rate ratio 1.21, $P = 0.04$).

As a surrogate measure for the availability of formal health services, the distance to the nearest health centre was used as the only available variable. We found 33% significantly increased infant mortality if the nearest health centre was more than 10 km away.

Discussion

Infant and childhood mortality in sub-Saharan Africa

There are numerous studies on infant and childhood mortality risk factors in rural SSA, often based on DHSs — for example, for Burkina Faso (*30*), Ghana (*31*), Benin (*32*), or others. In the present study we used survival modelling techniques with time-dependent covariates based on longitudinal data from a DSS.

We showed a continuous reduction in childhood mortality rates over most of the study period, which confirms the overall trend in West Africa (*1*, *11*, *16*). Data for Burkina Faso report a decline from 122.2 per 1000 for 1985–89 to 93.7 per 100 for 1990–94 (*30*). It is unlikely that HIV/AIDS already plays a big role in childhood mortality in our study area, because clinical cases are still rare and because mortality in both fathers and mothers was still low compared with areas of high HIV/AIDS endemicity (*4*). Resistance to chloroquine, the main drug used for malaria treatment in the area, is still relatively low in this part of Burkina Faso (*33*). Nevertheless, the observed reduction in mortality in our data is surprisingly high. There is some confounding with the other factors considered, and if the time trend is analysed in a univariate model, then the yearly hazard RR for infants is 0.856, which yields a 61% reduction over a 6-year period. Such a large reduction could only be achieved by a drastic improvement of the health care system or living conditions in the study area, which did not take place. The implementation of a national vaccination programme in the study area on polio, measles, and vitamin A supplementation, as well as the increasing health system research activities at the CRSN since 1993, may have had some beneficial effect; however, we think that our results on time trends should be considered with caution. Improved field conditions have been implemented in 1999 after some problems in field management during 1996–98, and we conclude that underreporting of infant deaths in the years 1996–99 contributed to the observed reduction in mortality.

Major risk factors

Major risk factors for childhood mortality identified in our study are death of the mother and twin birth. Both are more pronounced in the first year of life. We considered the death of the mother only if it occurred within the observation time of the child. Therefore, the finding can be seen as a consequence of several factors such as reduced childcare, no breastfeeding, and improper bottle feeding, rather than an overall indication for a family specific mortality risk. Koblinski and colleagues (*34*) report that among infants who survive the death of the mother, fewer than 10% live beyond their first birthday. However, because these factors are not very frequent, they contribute only to a small proportion of all childhood deaths, despite the high relative risk. Other factors such as a birth spacing of less than 18 months, birth during the rainy season, and belonging to certain ethnic groups and religions were also associated with childhood mortality and account for a larger overall proportion of deaths.

We showed a marked age dependency of mortality risk in twins. The mortality risk was very high only during the first 6 months; thereafter it was still twice as high as that of singles. This finding confirms the particularly high mortality risk of twins and calls for special attention towards twins during their first year of life (*19*). Lower birth weight in twins and lower intensity of breastfeeding is likely to contribute to the observations.

The strong effect of the death of the mother before the first birthday of a child confirms the importance of the mother during the early life of a child in rural Africa (*35*). This effect is furthermore likely to explain a considerable proportion of childhood mortality in areas of high HIV/AIDS endemicity (*36*).

Sufficient birth spacing has been promoted through mother–child health programmes in many countries, as this is perceived to be beneficial for the health and well-being of both mother and children (*12–14*). Our data indicate that educating families on the importance of sufficient birth spacing would have a large impact in reducing childhood mortality in the still highly fertile populations of rural Africa (*20*). We found a 50% increased risk of death for a child (age 1–5 years) if the next sibling was born within 18 months. The effect of the birth spacing to the next oldest sibling is more complex since if this sibling has died early, the subsequent interval is usually shorter because of curtailment of lactation and because of a replacement effect — that is, the family has another child sooner to replace the one that has died. In our data we found a mean birth interval of 2.5 years if the older sibling is alive, and of 1.8 years if it died before age 1 year, a difference which is highly significant. The vital status of the older sibling also has an effect on the mortality of the child, with an independent rate ratio of 1.4 (95% CI = 1.1–2.0). This is likely to be a familial cluster effect and points to the effect of family specific factors such as nutrition and other lifestyle factors. This factor was investigated in the latest DHS in Burkina Faso of 1998/99 (*22*) and yielded similar results: for infants, the mortality ratio was 1.7 (154.6/91.1) for an interval less than 2 years compared with an interval of 2–3 years. For children over 1 year the corresponding ratio was 1.3.

Other variables analysed in the DHS in relation to childhood death are sex, age of the mother, birth order, and weight at birth. We do not have data on birth weight; however, the other variables showed very similar patterns. The age categories were slightly different: in the DHS young age at birth of the mother (<20 years) vs 20–29 years showed a 34% increased risk for infant death compared with a 40% increased risk for <18 years vs 18–35 years found in our data.

The Burkina Faso DHS analyses, however, are all univariate and thus do not account for confounding between the factors. For example, there is a strong correlation between birth order and age at birth of mother. In our study population, the univariate rate ratio of the first birth vs second to fourth birth is 1.56 (95% CI = 1.29–1.87), whereas in the full model adjusted for all covariates the independent effect under this model is only 1.32. We can therefore conclude that the risks as reported in the DHS must be treated with some caution because the confounding effects are not taken into account, and it is likely that a full multivariate analysis of the DHS data would yield lower RRs.

The sex ratio found in our data corresponds closely to the reported sex ratio (male/female) of 1.03 for Burkina Faso (*37*). Also, for blacks in the United States of America a ratio 1.03 was observed in the preceding years (*38*), which is significantly lower than in whites. We can therefore conclude that this finding does not suggest a selection bias.

In most of West Africa, the rainy season coincides with an increased incidence of malaria and other diseases and with a shortage of food. Thus, in the Gambia more children die during and shortly after the rainy season than in the rest of the year (*15*). However, the possible role of season of birth regarding respective short-term and long-term consequences for health and survival is controversial (*39*, *40*). We found an association between being born in the rainy season and mortality, but only with mortality during the first year of life. Thus, our findings are not very different from the non-significant effect observed in the Gambia (*40*).

We observed a significant effect of distance to the nearest health centre on mortality for infants whose parents live more than 10 km away. The effect of this factor is somewhat stronger if considered separately for births occurring in the rainy season, where a greater distance to a health centre is more difficult to manage; however, this difference is not significant. We did not find an effect for children after their first birthday. This finding provides some evidence for the importance of having access to functioning health services in rural SSA. In the case of Burkina Faso, the uninterrupted availability of affordable quality drugs at all peripheral health centres over the past decade may possibly have a role in the observed effect on mortality.

Finally, the observed associations between childhood mortality and ethnicity and religion show the diversity of mortality risk factors in a given population, which are likely to be explained by several cultural, educational, socioeconomic, and environmental differences (*10*). Because religion and ethnic group are strongly correlated with each other, it is difficult to disentangle their effects with the data available. However, there was no difference between the two dominant religions, Muslim and Catholic, in the multivariate model with adjustment for ethnic groups. For these, strong differences were observed. The groups with low infant mortality (Bwaba, Mossi, and Samo) are those with the highest proportions of Christians. These groups also have a higher average social class. In a study in Ghana (*31*), the effect of ethnic group disappeared after controlling for socioeconomic variables. Because these variables are not available in our dataset, we cannot parallel this analysis.

Data quality and validity

The fact that we identified several births in a separate cross-sectional study that were not included in the DSS gives rise to the question of completeness of the database. Assuming that both surveys may be considered as independent, which is in our view a reasonable assumption, we estimated the number of missing children through common capture–recapture methods (*41*), which yielded 3.4% of all births. We consider it unlikely, however, that these are linked to specific risk factors under consideration here, therefore we see no reason for bias in the results (*42*).

We do not have an explanation for the differences in number of births in the different years. Although some random variation naturally occurs, the database contains a high peak for 1997 and a low peak in 1996. We cannot exclude with certainty an underreporting of births in one year; however, this does not easily explain the high peak in 1997. We checked whether some children born in 1996 were erroneously assigned a birth year 1997, but found no evidence for this. It also appeared that all villages in the study show a similar pattern. Therefore, we consider an unknown error in data collection procedure as the most probable explanation. To check whether this may have an impact on the overall results, we also analysed the data separately by year of birth. However, because the results were consistent, we believe that the data deficiencies had little effect on the overall analysis.

For the analysis, we used the Cox proportional hazards model, which is common for survival analysis and which easily allows a simultaneous analysis of time-dependent covariates. Because it can be assumed that the effect of most covariates is not constant, we chose to analyse infant and childhood (up to 5 years) age in separate models. An additional complication arises from the fact that the children are considered as independent observations, although there are several possible cluster effects within the data, the most relevant being clustering of deaths within the same household. Other sources of clustering effects such as the village also exist. To approach that, we did an analysis by randomly selecting one child per family and fitted the same model repeatedly. The results confirmed those from the full model. For example, the mean estimated RR for twins in the first 6 months, a variable on which the clustering effect is likely to be strong, from a small simulation with 10 randomly selected datasets is 4.31 compared with 4.33 from the full dataset. It is somewhat reassuring that no severe bias in the estimation has occurred .

Conclusion

Our study in a rural area of Burkina Faso confirms the importance of all five major risk groups for childhood mortality: socioeconomic status, fertility behaviour, environmental health conditions, nutritional status and infant feeding, and the use of health services. These findings call for a broader approach to future child health programmes to enable further reductions in childhood mortality in rural Africa. Such programmes need to include improvements of accessibility to formal health services, specific attention towards twins during their first year of life, emphasis on educating whole families in birth spacing, and efforts to improve the nutritional status of young children, as well as continuing with improvements in the control of malaria, diarrhoea, respiratory diseases, HIV/AIDS, and vaccine-preventable diseases. ■

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Résumé

Facteurs de risque de mortalité infanto-juvénile dans les régions rurales du Burkina Faso

Objectif L'étude avait pour but de quantifier l'effet des facteurs de risque de mortalité infanto-juvénile dans un contexte rural typique d'Afrique subsaharienne.

Méthodes Nous avons effectué une analyse de survie chez les enfants d'une population couverte par un système de surveillance démographique de 1992 à 1999, en utilisant les données de ce système pour 39 villages situés autour de Nouna, dans l'ouest du Burkina Faso. La population totale de la zone d'étude s'élevait à environ 30 000 personnes. Tous les enfants nés vivants pendant la période du 1er janvier 1993 au 31 décembre 1999 dans cette zone (n = 10 122) et suivis jusqu'au 31 décembre 1999 ont été inclus dans l'étude. La variable considérée était la mortalité toutes causes confondues chez l'enfant.

Résultats Au cours de la période d'observation, 1340 décès ont été enregistrés. L'utilisation d'un modèle de Cox pour obtenir une estimation simultanée du risque relatif associé à chaque facteur a montré que les facteurs de risque de mortalité les plus importants étaient la mort de la mère et le fait d'être issu d'une naissance gémellaire. Dans les deux cas, le risque était plus prononcé pendant la première enfance. Parmi les autres facteurs associés à la mortalité figuraient l'âge de la mère, l'intervalle entre les naissances, la saison de naissance, le village, le groupe ethnique et la distance au centre de santé le plus proche. On a enfin observé une diminution globale de la mortalité infanto-juvénile sur la période 1993-1999.

Conclusion L'étude confirme la multiplicité des causes de décès chez l'enfant dans les régions rurales d'Afrique de l'Ouest pendant les années 1990 et la tendance générale, déjà observée dans d'autres études, à une diminution de la mortalité infanto-juvénile dans ces populations. La corrélation observée montre qu'une analyse multivariée serait nécessaire pour distinguer les effets individuels de chaque facteur de risque. Ces résultats illustrent la nécessité d'améliorer de façon plus complète les soins pré- et postnatals dans les régions rurales d'Afrique subsaharienne.

Resumen

Factores de riesgo de mortalidad infantil y en la niñez en una zona rural de Burkina Faso

Objetivo El objetivo del estudio fue cuantificar el efecto de los factores de riesgo de mortalidad en la niñez en un entorno rural típico del África subsahariana.

Métodos Realizamos un análisis de supervivencia de los niños nacidos en una población sometida a vigilancia demográfica entre 1992 y 1999 basándonos en los datos de un sistema de vigilancia demográfica implantado en 39 aldeas cercanas a Nouna, en el oeste de Burkina Faso, con una población total de aproximadamente 30 000 habitantes. Se incluyó a todos los niños nacidos vivos durante el periodo del 1 de enero de 1993 al 31 de diciembre de 1999 en el área de estudio (n = 10 122) y sometidos a seguimiento hasta el 31 de diciembre de 1999. Como variable de resultado final se usó la mortalidad en la niñez por todas las causas.

Resultados Durante el periodo de observación se registraron 1340 defunciones. En un modelo de regresión de Cox, una estimación simultánea de las tasas de riesgo mostró que los factores de riesgo de mortalidad más importantes eran la muerte de la madre y el hecho de ser gemelo. Para ambos, el riesgo era máximo durante la lactancia. Otros factores asociados a la mortalidad fueron la edad de la madre, el tiempo transcurrido desde el último parto, la época del año en que tuvo lugar el nacimiento, la aldea, el grupo étnico y la distancia al centro de salud más cercano. Por último, se produjo una disminución general de la mortalidad en la niñez a lo largo de los años 1993–1999.

Conclusión El estudio respalda la idea de multicausalidad de las defunciones en la niñez en el África Occidental rural durante los años noventa, así como la tendencia general, observada en otros estudios, de disminución de la mortalidad en la niñez en esas poblaciones. La correlación observada entre los factores subraya la necesidad de realizar análisis multifactoriales para desimbricar los distintos efectos. Estos resultados ilustran la necesidad de una mejora más integrada de la atención prenatal y posnatal en el África subsahariana rural.

Arabic

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